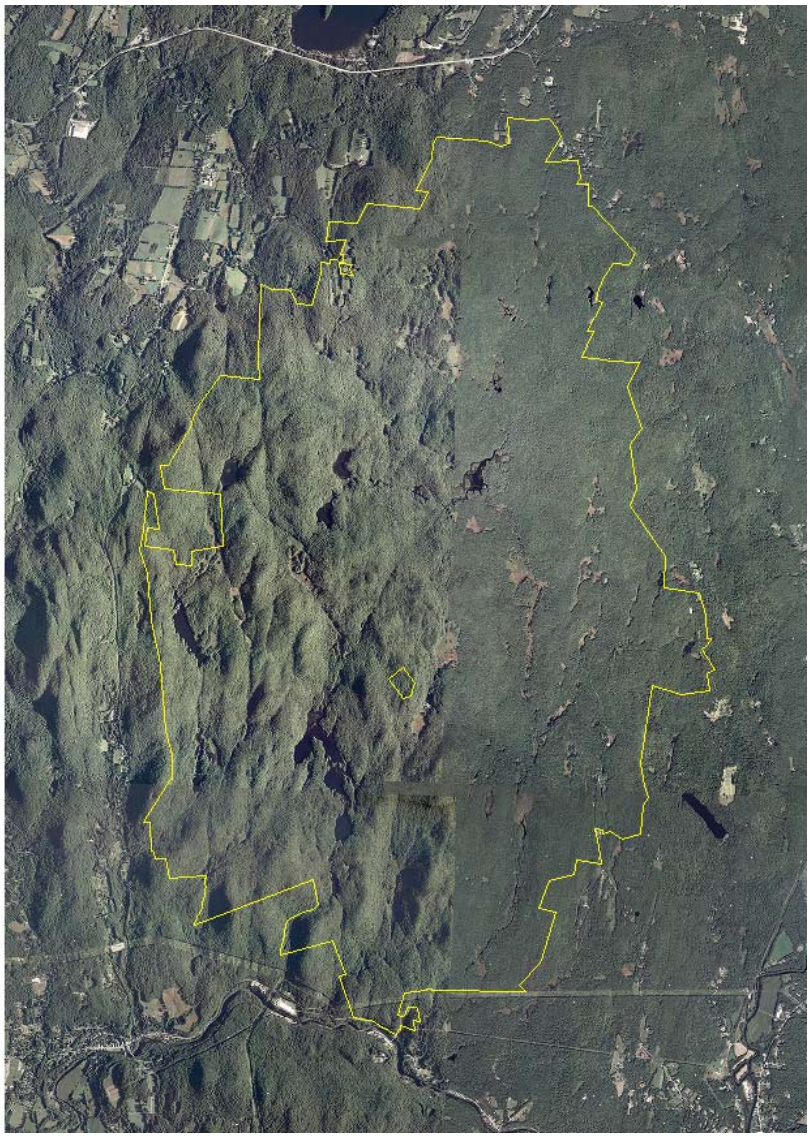
STATE OF NEW HAMPSHIRE
DEPARTMENT OF RESOURCES AND ECONOMIC DEVELOPMENT

MANAGEMENT PLAN

for

PISGAH STATE PARK

Chesterfield, Hinsdale and Winchester, New Hampshire



JUNE 2011

STATE OF NEW HAMPSHIRE
DEPARTMENT of RESOURCES and ECONOMIC DEVELOPMENT
OFFICE of the COMMISSIONER
172 Pembroke Road P.O. Box 1856 Concord, New Hampshire 03302-1856

GEORGE M. BALD
Commissioner

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I hereby approve the Pisgah State Park Management Plan

George M. Bald, Commissioner

June 16, 2011
Date

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for

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STATE OF NEW HAMPSHIRE

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172 Pembroke Road

PO Box 1856

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Division of Forests and Lands

Division of Parks and Recreation

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CHAPTER 1: INTRODUCTION

Pisgah State Park and Its Managers

Pisgah State Park is a New Hampshire state reservation managed by the Department of Resources and Economic Development (DRED). Located in the towns of Winchester, Hinsdale and Chesterfield, the reservation consists of 13,361 acres of fee ownership by the state and 60 acres of easement with the Roads End Farm. State Reservation purpose and management are described under RSA 227-H and 227-G:2.

> *RSA 227-H:1 Declaration of Purpose. – It is hereby recognized and declared that state-owned reservations contribute to the conservation of natural resources and distinctive quality of life in the state. The public welfare of this state is served by the prudent acquisition and management of reservations to provide forest benefits and for the purposes of demonstrating sound forestry principles, protecting habitat for plants, animals, and other organisms, conserving forested watersheds, preserving areas of rare and exemplary natural beauty and ecological value, and providing for perpetual public access and use.*

The above mentioned forest benefits are defined in RSA 227-G:2 and include, but are not limited to, forest products, a viable forest-based economy, recreation opportunities, scenic values, healthful surroundings, climate mitigation, clean water, and biologically diverse populations of plants and animals.

The intent of the legislature concerning state ownership of reservations is clearly for multiple-use of the resources. State reservations are managed by two divisions within DRED; the Division of Parks and Recreation and the Division of Forests and lands.

Division of Parks and Recreation

The Division of Parks and Recreation is responsible for managing recreation activities on state reservations and else where. The mission of the Division of Parks and Recreation is

…to provide New Hampshire's citizens and guests with outstanding recreational, educational, and inspirational experiences through the responsible management and cooperative stewardship of the state's natural, recreational, and cultural resources.

Within DRED, the Division of Parks and Recreation generally focuses on the operation and maintenance of developed recreation areas and other public use areas including trails. Developed recreation areas are places that offer amenities to the recreating public beyond that of simple outdoor space including campgrounds, picnic areas, ski areas, waterfront areas, short trail loops associated with specific features such as geological sites (The Flume and Chesterfield Gorge) and facilities. Many of these developed recreation areas charge a fee for admission, which supports the operation of the State Park system which is an operationally self-funded agency.

The Division has several bureaus including the Bureau of Trails. This bureau within the Division of Parks and Recreation is charged with the management of recreational trails on public and private lands. Much of this bureau's focus is on motorized recreational trails for snowmobiles and all-terrain vehicles.

Registration fees collected support the maintenance of motorized recreational trails and program staff. Most non-motorized trails on State Reservations do not require a fee for use.

Division of Forests and Lands

The Division of Forests and Lands is responsible for management of the natural resources on state reservations. The division's mission is to

…protect and promote the values provided by trees and forests.

Various bureaus within the division of forests and lands oversee different aspects of forest management on state reservations. The Land Management Bureau is responsible for activities that generally involve non-biological uses such as maintaining the property boundaries, issuing special use permits and leases, and maintaining databases for payments in lieu of taxes.

The Forest Management Bureau manages the natural resources on state reservations. Typical activities include conducting natural resource inventories, silvicultural operations and timber harvests, wildlife habitat improvement projects and other activities that involve the biological aspects of state reservations. The bureau also maintains roads as needed to provide access for these activities.

The Natural Heritage Bureau conducts and maintains inventories of rare and endangered plants and exemplary natural communities.

Pisgah State Park Background and History

In the late 1960's it was observed that few public recreation opportunities were available to residents and visitors in the southwest region of the state. It was decided to seek federal grant funding to purchase land to develop a state park in that area. A large and mostly undeveloped assemblage of properties was targeted to form a state park, referred to at that time as Southwest State Park.

The area of focus was known to local residents as the "Pisgah Wilderness" because much of the area had remained wooded and un-settled except for an area to the east along Old Chesterfield Road and Broad Brook Road where considerable human habitation had taken place in the 1800's and first half of the 1900's. This area contained farmsteads and mills. Camps were located near the present day Pisgah Reservoir.

The remaining area was rarely settled. The area was primarily owned by 3 large land owners and was often logged for forest products. Some culling took place. Culling is generally understood to be the extraction of individual trees that contain good quality and value while retaining most of the remaining stems. However maps purchased by forester Tim Hill from the companies show that many stands had been extensively harvested especially after the 1938 hurricane. Old woods roads cover the area very thoroughly and testify to the extent that loggers were able to access the land for logs. Some small pockets of old growth timber were not harvested and remain to this day.

Purchase of the land began in 1968 using federal Land and Water Conservation Fund money. Some of the land was taken through eminent domain. By mid 1988 most of the land purchases were completed although a few additional tracts were purchased after this.

DRED conducted a natural resource inventory on the property in the early and mid 1980's. In 1998 the first wildlife habitat projects were begun along Old Chesterfield Road by restoring old abandoned fields

and regenerating aspen. This work was followed by additional wildlife habitat work in the northern portion of the park. In 2007 DRED conducted its first commercial timber harvest at Pisgah and a second harvest planned for 2011.

State reservations management and operation are financially supported in several ways; State general fund appropriation, timber stumpage and public use fees. At Pisgah State Park, other than timber stumpage from recent harvests, the state reservation has not generated revenue to support management for itself and relies on the other state reservations to support it. Basic services such as boundary maintenance and resource inventories are funded from forest management income from harvests on other tracts and the State's general fund appropriation for forestry. Funding for basic park operations comes from the State Park Fund (RSA 216-A3-i). Parks staffing at Pisgah was as high as 3 full time employees but due to funding problems is now currently 1 employee.

On February 15, 2006 DRED received a letter from the Friends of Pisgah asking for permission to harvest timber from the park and direct the timber and / or revenue to the park for maintenance. This letter began a series of discussions, first with the Friends of Pisgah then with area natural resource academics, about how Pisgah State Park should be managed.

Planning Teams

It is important to DRED to get public input into its management planning for state reservations. The importance of the planning teams is to ensure that the public is being well served, that as many interests as possible are being addressed, that conflicts are being minimized and that the public is a partner in the management of the park. If decisions are made by DRED that certain individuals in the public are not in agreement with, they will at least have the opportunity to make their case and receive adequate consideration in the decision making process.

Steering Committee

Pisgah State Park receives much public use and public interest. In order to ensure that Pisgah's management plan accommodates all users as best as possible, a steering committee was assembled made up of various users of the Park. The steering committee includes representatives from the three local towns – Winchester, Hinsdale and Chesterfield, a State Senator and a State Representative. The steering committee also includes representatives for motorized recreation, non-motorized recreation, forestry and timber harvesting, wildlife habitat, a member of the technical team, somebody from the regional planning commission, a representative from the Friends of Pisgah, the general public, a local land trust and a representative of a local conservation group.

The task of the group as set forth by the Commissioner of DRED was:

> *… advise the Department of Resources and Economic Development in the preparation of a comprehensive management plan for 13,000 acre Pisgah State Park.*

Vision

The steering committee spent considerable time developing a vision statement for Pisgah State park. The vision statement is:

> Pisgah State Park will be managed to protect and enhance those important characteristics found on the land including…

- A large undeveloped area in the southwest portion (see Harvard Bulletin) that was never farmed and supports several old-growth stands "where nature not the hand of man is clearly dominant".

Management will protect this area from active human impact and degradation and will promote natural changes and development;

- Pisgah's large size can be considered a landscape in itself. This vastness and remoteness makes the property tremendously valuable for fish, wildlife, water, air, plants, natural communities and other ecological and social resources. Management of Pisgah should work to maintain or enhance these resources on the property and throughout the region. To further enhance these resources across the Pisgah region, the management of the park should provide opportunities for collaboration with surrounding landowners;

- Pisgah offers unique opportunities for a variety of recreational activities. These activities should be managed in a way that minimizes conflicts among recreational users and doesn't have a significant negative impact on the park's natural resources;

- Pisgah has a strong and well documented history of human use, the evidence of which is still observable within the park. The historic resources should be protected and utilized as an educational resource to help citizens and visitors keep in touch with their heritage.

- Pisgah contains thousands of acres of productive forest lands that can produce jobs, forest products and sources of energy to sustain the local community in a thoughtful, respectful manner. Management of the forest resources at Pisgah should also contribute to the value of other ecological resources within the park.

Therefore, the management of Pisgah State Park will strive within the next 25 years to:

- Designate a natural area(s) that is dedicated to developing old growth and mature ecosystem conditions by permitting natural ecological processes to occur with minimal human intervention, and where active management is employed only to protect the area(s) from human caused degradation.
- Ensure recreational use is protected, well planned and sited in appropriate places and meet the needs of residents and visitors when appropriate for the land conditions and are maintained and monitored.
- Encourage educational programs to help park visitors enjoy and understand the park more fully.
- Practice sustainable forestry where deemed appropriate that produces forest products, provides a diversity of wildlife habitats and conditions, and protects documented occurrences of rare species and exemplary natural communities
- Identify, document, study and interpret historical and cultural resources for the public. Key historic resources are preserved and protected from damaging activities.

The technical work of taking the principles of the vision and applying them to the day to day activities at Pisgah was done by the technical team. The steering committee oversaw the work to be sure it was progressing in the right direction and in the spirit of the Vision.

State statutes and policies direct and guide the management of state reservations. The oversight of the steering committee was used as an objective third party to navigate management of the park through the web of state statutes and policies.

The steering committee sponsored public input sessions in conjunction with the efforts of the technical team. Public input included regular work meetings with time devoted to hearing public comment, public forums on particular topics including forest management work and recreation. When the plan was drafted,

it sponsored public listening sessions to gauge public sentiment, making adjustments as necessary to accommodate public needs.

The final job of the steering committee was to oversee the final completion of the proposed plan and recommend it to George Bald, the Commissioner of DRED. In making a recommendation of its acceptance by DRED, the steering committee would be confirming that multiple interests had participated in the development of the plan and that the plan being proposed best serves the public under present conditions.

Technical Team

The technical team was assembled from mostly technical natural resource professionals, both practitioners and academics from state agencies and local colleges and universities. The task of the technical team was to develop implementation strategies to accommodate the directives of the steering committee. The technical team met regularly to address the principles of the vision statement and construct the body of the management plan. The technical team was the principle writers of the plan under the oversight of the steering committee. Unlike the steering committee, the make up of the technical team changed slightly from time to time to reflect the technical needs of the plan.

Lifespan of the Plan

The intended lifespan of this plan is 25 years ending in AD 2035. Within the plan's lifespan the Commissioner of DRED may choose to revisit the contents of the plan. At his direction DRED will periodically review the plan's goals and recommendations. Thus the plan may see periodic alterations and adjustments as necessary in a changing environment.

CHAPTER 2: NATURAL AND CULTURAL RESOURCES

Landscape Analysis of Pisgah State Park[1]

Almost any map of southwestern New Hampshire will show a solid line around the large block of land that is Pisgah State Park. However, for most of reality no such demarcation exists—rather animals, people, insects, seeds, and wind flow in and out of the park to a greater or lesser extent without concern as to who owns the land. Because of the porous nature of its boundaries, Pisgah State Park is not an island—rather, whatever happens on one side of the property line impacts the other side, either increasing or decreasing the States' ability to care for this unique natural, recreational, and cultural resource.

The Pisgah State Park Steering Committee's Vision Statement declares that "The State of New Hampshire and its partners will manage Pisgah State Park to protect and enhance its inherent natural and recreational resources." In order to make this vision a reality, it is vital that the resource managers "think outside the Park" and consider both the effects of surrounding lands on the park, and the park's effects on the surrounding lands when creating, implementing, and adapting management plans. The benefits of considering the surrounding lands include:

- Better protection for the park from the negative effects of permanent land use change, invasive species, forest pests, and inappropriate recreational use,
- Longer, more enjoyable trails for hikers, equestrians, off-road vehicle riders, winter recreationists, and hunters,
- More, high-quality wildlife habitat,
- More efficient management and more management options,
- Better relationships with landowners in the region, and
- Ensuring that the overall management objectives are wise within the context of surrounding lands and relative to the special role that Pisgah has within the region and within the portfolio of DRED lands.

The main reason to consider the region surrounding the park is that a larger perspective offers more options for reaching sustainability and other recreational and economic goals both inside and outside the park. As part of the process, partnerships with local stakeholders can be fostered and would eventually become mutually advantageous. Specific benefits of a partnership include:

- More collaboration between landowners and resource managers not only assures that objectives are not opposed to each other, but potentially furthers both owners' goals by assuring that their activities are compatible or even synergistic,
- The effects of residential and commercial development or external forest harvests near the park can be considered in determining the best management regimes within the park,
- Greater awareness of the connectivity to other forests and how they may act as sources and sinks,
- Awareness of external pests and pathogens will inform management decisions and practices,
- Fostering community partnerships with local conservation commissions, conservation groups, friends groups, researchers and students:
    - increases the mutual understanding of management objectives,

[1] Brian Hall, Harvard Forest, and Cynthia Nichols, Antioch University

- enhances limited manpower resources with on-the-ground volunteers,
- creates partnerships with local experts,
- increases research and education opportunities.

The Landscape Around Pisgah State Park

For the rest of this chapter, we define the Pisgah region as an area approximately 130,000 acres which is almost ten times the size of the Pisgah State Park focus area discussed in this manuscript's other chapters. This 16.5 by 12.5-mile rectangular area is bounded on the southwest by the Connecticut River and southeastern Vermont (just past Hinsdale) and bounded on the northeast by the city of Keene (Figure 1). This extent was selected because: a) it encompasses the most densely populated parts of the three towns where Pisgah State Park is located as well as Keene and Brattleboro which are important for the region's economy, b) it is a size considered appropriate for landscape-level analyses given the size of the Pisgah State Park focus area (e.g. O'Neill et al., 1996), c) it encompasses a relatively homogenous, and predominantly forested, landscape, d) there is a recreational trail network throughout the area, and e) the area encompasses the large block of forest between Pisgah and Keene

Land cover

The 2001 National Land Cover Data (Homer et al., 2004) in Figure 1 shows that forest covers 81% of the region, open water and wetlands cover 3%, agricultural lands cover 6%, higher-density development covers 3% and occurs in the town centers of Keene, North Swanzey, West Swanzey, Winchester, Hinsdale, and Brattleboro, Vermont. Lower-density development covers 7% of the landscape and occurs around the higher-density development areas and is dispersed along major roads such as Routes 10, 119, 63, and 9.

Forest Blocks

Conservationists, biologists, ecologists, and many recreational users value large blocks of contiguous forest because they have proportionately less contact with developed areas than smaller or more fragmented forests and therefore have less of the negative impacts from development and "edge" effects including: fewer invasive plant species, less predation on wildlife by cats and dogs, less noise from roads, greater abundance of species that require forest interior habitats, fewer trees blown down by wind, greater habitat connectivity, greater resilience/recovery from natural or anthropogenic disturbance, and many others.

Since there are relatively few roads and residential or commercial development in the region compared to much of southern New Hampshire, the park is part of the largest unfragmented, or contiguous, forest block in the Ashuelot River watershed according to "A Land Conservation Plan for the Ashuelot River Watershed" written by members of The Nature Conservancy, Monadnock Conservancy, Society for the Protection of New Hampshire Forests, and the Southwest Region Planning Commission (Zankel et al., 2004). In fact, there is a large swath from the Connecticut River to Keene, including Pisgah that was identified as among the highest-ranked matrix forests in the state (top 15%) by the Wildlife Action Plan (Figure 2) due to its landscape diversity, landscape integrity, and minimal human influence (NH Fish and Game Department, 2005 and 2010). An analysis of forest block size in New Hampshire conducted by The Society for the Protection of New Hampshire Forests and The Nature Conservancy (SPNHF, 2005) showed that the Pisgah area is one of the few blocks larger than 10,000 acres in the southwestern part of the state (Figure 3). The authors of that report considered 10,000 acres the minimum size needed to "ensure that ecological structure, function, and processes such as soil nutrient accumulation and formation of old growth forests have sufficient framework to foster true ecological stability over the long term."

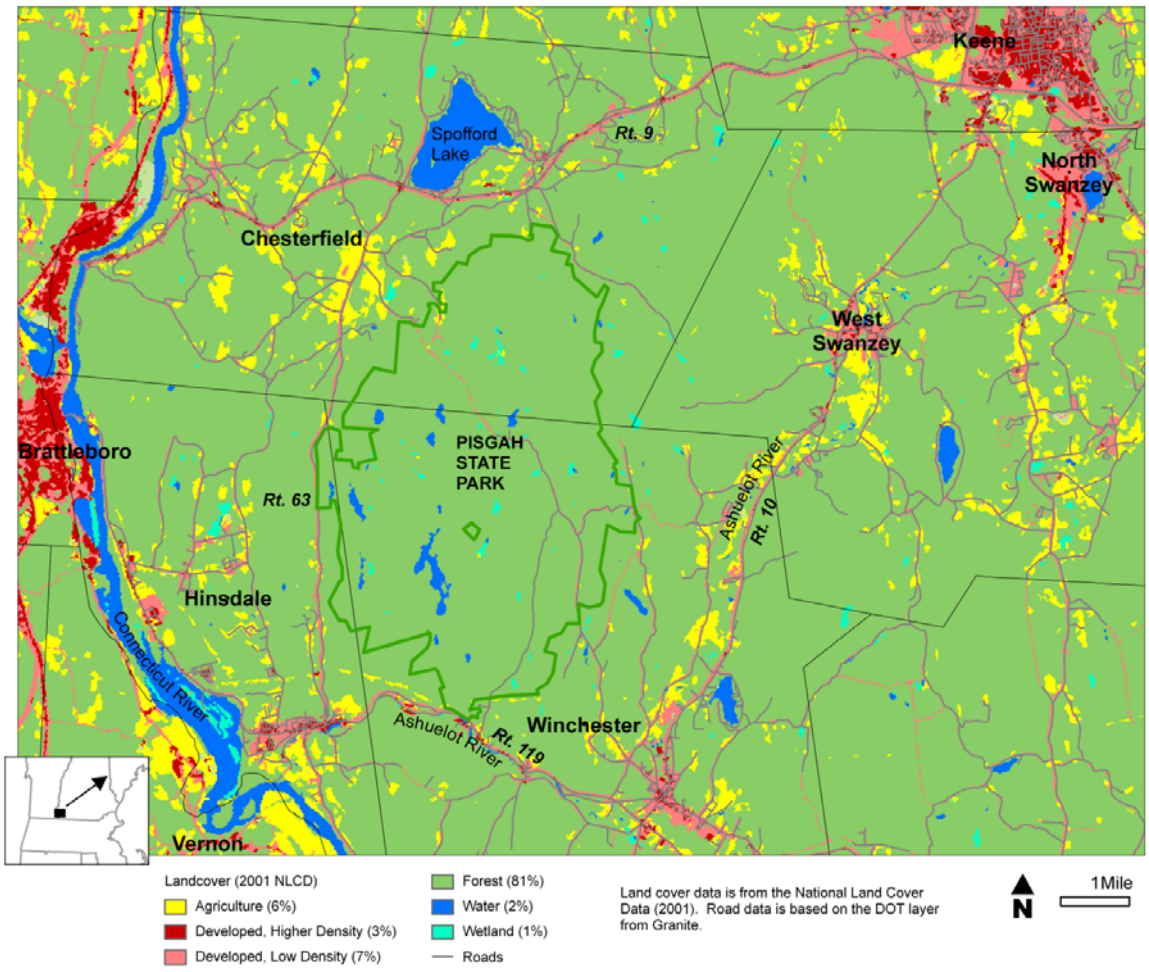

Figure 1. Land area surrounding Pisgah State Park showing the 2001 National Land Cover Data (Homer et al., 2004) over a 16.5 by 12.5-mile rectangular area. Forest covers 81% of the region, open water and wetlands cover 3%, agricultural lands cover 6%, higher-density development covers 3%. Lower-density development covers 7% of the landscape.

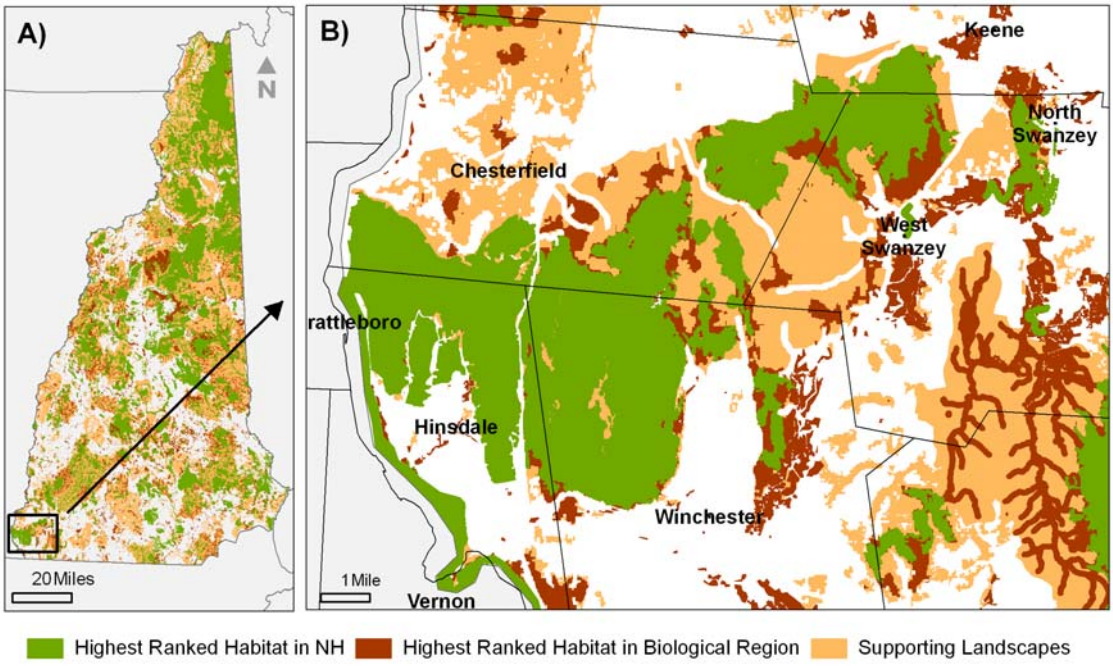

Figure 2. A) Highest ranked wildlife habitat by ecological condition map from New Hampshires Wildlife Action Plan 2010 map updates.The block of natural lands between the Park and Keene is identified as among the highest ranked habitat areas in all of New Hampshire. B) Detail of the Pisgah region.

Sources:
http://www.wildlife.state.nh.us/Wildlife/Wildlife_Plan/highest_ranking_habitat.htm

In general, numerous landscape ecologists and planners have recognized the importance of large blocks of natural vegetation to the wildlife, forest products industry, and ecology of a region. In fact, large blocks are often cited as the most important features to protect in regional conservation plans (Forman, 1995; Duerksen et al., 1997; Turner et al., 2001; Foster et al., 2005; Lindenmayer and Fischer, 2006; and many others).

Protected Open Space

Over 19% (24,681 acres) of the region is permanently protected from development (hereafter referred to as "protected") or managed as protected land and most is available for certain recreational uses by the general public (Figure 4). There are 124 parcels of protected land with an average size of 199 acres, owned or managed by more than 50 unique individuals or organizations within the region.

Grouping together all adjacent parcels of protected land regardless of ownership results in 84 blocks of protected land (as opposed to forest blocks discussed above) with a mean size of approximately 300 acres. The Pisgah State Park/Hinsdale Town Forest/Harvard Forest block of protected land is the largest at approximately 13,800 acres. Other large blocks include the greater Wantastiquet Mountain area (~1,840 acres) comprised of the Wantastiquet Mountain Natural Area, Madame Sherri Forest, O'Neil Town Forest, the Stokes, Bear Mountain Connector, and Daniels Mountain conservation easements. To the southwest of Keene several large blocks are nearly connected including the Yale-Toumey Forest/Carpenter and French easement block (1,417 acres) which is near a block (1,057 acres) formed by the Horatio Colony Preserve, City of Keene lands, Lacey easement, Yale-Toumey, Hall easement, and Colony Memorial Trust easement which in turn is near a block (756 acres) formed by the Haley, Hanna, Forecastle, Trask, and Houghton easements held by the Monadnock Conservancy.

Pisgah State Park likely plays the dominant role within the ecological processes and recreational opportunities of the region for several reasons: at 13,361 acres, the Park accounts for 55% of the total protected land within the region; it is by far the largest single block of protected forest even if adjacent protected lands are considered together regardless of ownership; its location between the Wantastiquet Mountain area block and the blocks of protected parcels to the southwest of Keene make it an important potential connector between the two conservation areas; since Pisgah State Park is owned by one entity, major planning and management efforts can have a greater impact on the region and can better accommodate competing interest groups' concerns than smaller or multi-owner blocks of protected forest.

Recreational Trails

The diverse people who live and play near southwestern New Hampshire have greatly benefited from numerous, well-connected recreational trails and trail systems both within and beyond our focus area (Figure 5). It is, or soon may be, possible for hikers to traverse all the way from Mt Wantastiquet through Pisgah State Park to Keene; or from the Connecticut River to Keene to Mt Monadnock, or even all the way to southern Connecticut via the Metacomet-Monadnock-Mattabesset Trail, portions of which in Massachusetts and Connecticut are a nationally recognized scenic trail. Snowmobile riders can take Corridor 5 from Pisgah State Park north to Canada or south to Pennsylvania (not shown on map).

Many sections of long-distance trails in this region are on state parks such as Pisgah, Bear Mountain, Rhododendron, and Mt. Monadnock, but these trails are often connected by other sections on private lands, thus they rely on private landowners' willingness to allow public access to their lands. Of course the landowners can change their minds or public access can be denied when property changes hands (see Irland, 1999).

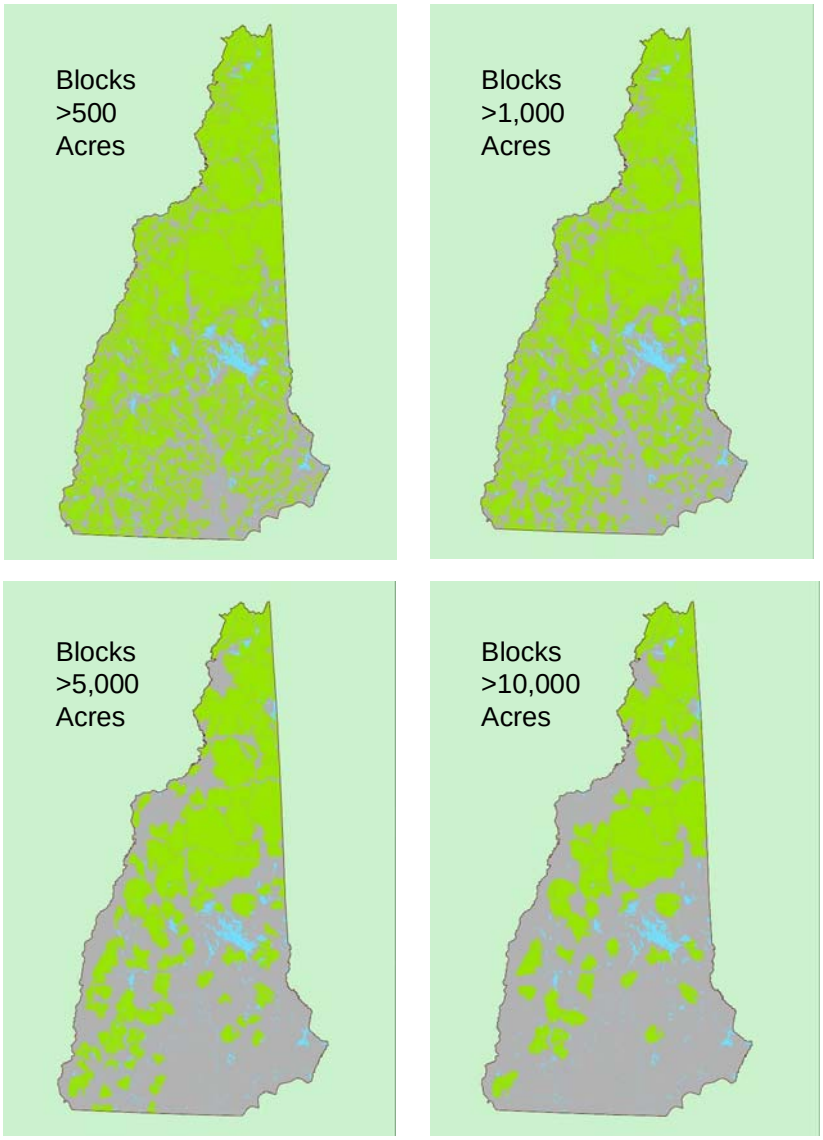

Figure 3. An analysis of forest block size in New Hampshire conducted by The Society for the Protection of New Hampshire Forests (SPNHF, 2005). The Pisgah area is one of the few blocks larger than 10,000 acres in the southwestern part of the state.

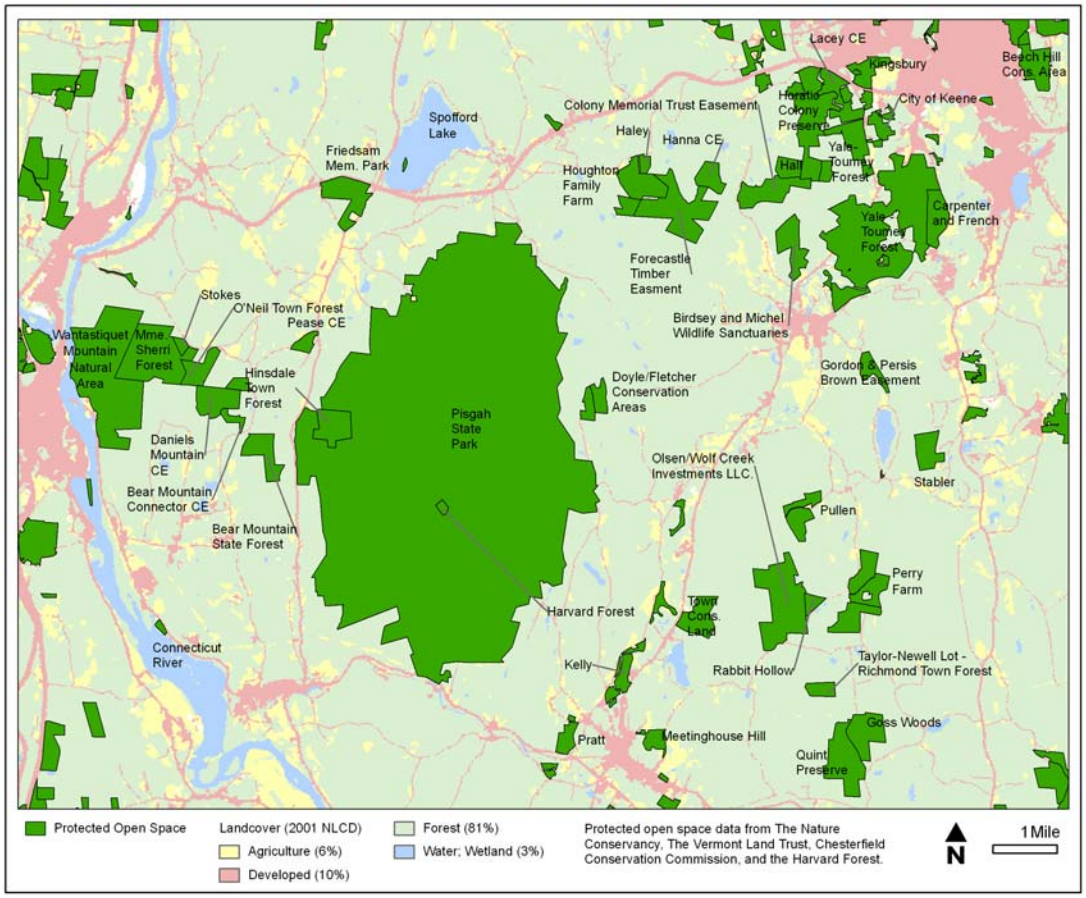

Figure 4. Protected open space in the Pisgah region. Nineteen percent (24,681 acres) of the region is permanently protected from development or managed as protected land with most available for certain recreational uses by the general public Shown are the Pisgah State Park/Hinsdale Town Forest/Harvard Forest block (13,800 acres), and the greater Wantastiquet Mountain area (1,866 acres) comprised of the Wantastiquet Mountain Natural Area, Madame Sherri Forest, the Stokes, O'Neil Town Forest, and Bear Mountain Connector and Daniels Mountain conservation easements. Also shown are the nearly connected blocks of the Yale-Toumey Forest/Carpenter and French easement (1,415 acres), the Horatio Colony Preserve, City of Keene lands, Lacey easement, Yale-Toumey, Hall easement, and Colony Memorial Trust easement (1,113 acres) and the Hanna, Forecastle, and Houghton easements held by the Monadnock Conservancy.(672 acres)

Recreation trails outside but near Pisgah State Park are important for providing access to the park itself and for providing loops so that users, especially equestrians and motorized recreationists, don't have to backtrack along the same route twice. Additional loops have been explicitly requested by riders at public meetings and can reduce the amount of horse or motorized vehicle use on trails not designed or designated for their use within the Park.

Recent Population and Land Cover Changes

As people move into an area, forestland and farmland are converted to developed lands such as residential or commercial properties, and roads; this results in permanent forestland loss. Since land development can have such negative effects on wildlife, forestry, ecological processes, and recreation potential, it is important that resource managers be aware of where development is occurring. We downloaded the 1995 (1988-1990 land cover data) and 2001 (1990-1999 land cover data) NH Land Cover Assessment GIS layers from New Hampshire's GRANIT website and identified those locations in the region that were developed on the 1990-1999 (later) layer but not on the 1988-1990 (earlier) layer, resulting in GIS layer of recent development (Figure 6). In the New Hampshire portion of the region, 1,688 acres, or 1.4% of that area was developed between the two time periods. As can be seen, most of this development was along routes 9, 10, 119 and to a lesser extent along Route 63; some of it was very close to the Park's southern and northwestern borders. There has also been development in the California Brook area between Pisgah and Keene. Between 1990 and 2000, a time period somewhat contemporary with the new development shown in Figure 5, the populations of Chesterfield, Hinsdale, and Winchester increased by 14%, 4%, and 3% respectively (SWRPC, 2003a).

Projected Population and Land Cover Changes

The Southwest Region Planning Commission projects that between 2005 and 2025 the populations of Chesterfield, Hinsdale, and Winchester will increase by 23%, 20%, and 21% respectively (SWRPC, 2003b). If we compare the amount of new development in Figure 6 (1989-1998) associated with the somewhat contemporary 1990-2000 population increases (14%, 4%, and 3%) we can conclude that under the higher projected population increases there will be much more development in these three towns in the coming decades. In fact, the Society for the Protection of New Hampshire Forests estimates that between 2001 and 2025, Hinsdale will lose 2.5-5% of its current forestlands and Chesterfield and Winchester will lose up to 2.5% of theirs (SPNHF, 2005). Much of the recent development shown in Figure 6 is of a dispersed, large-lot nature; this may be the most detrimental form of residential growth because it greatly decreases the size of the surrounding land block size (Forman, 1995, page 423) and is unfortunately encouraged by large-lot zoning commonly employed by many rural towns in an attempt to protect their rural atmosphere.

The amount and physical locations of future land development should be of major concern to Pisgah State Park's users and managers. It is not too early to be concerned about forest loss in the region. Ecological models by Jerry Franklin and Richard Forman, two of the world's preeminent landscape ecologists, concluded that for forest block size and edge metrics: "… most big ecological changes occur in the first half of a land transformation. Furthermore, the most-critical time for land planning and conservation appears to be when the landscape has 60 to 90% of its area in natural vegetation" (Forman, 1995, pages 416-417)–as noted above, the Pisgah region currently has approximately 81% forest cover and 3% in open water and wetlands. Connectivity and the ability of wildlife to move across a landscape, has been shown in modeling experiments to decline precipitously when the primary habitat was reduced to 10-40% of the landscape (depending on the dispersal ability of species and how suitable the alternative land cover type was to the species). At higher values of natural land cover, the primary negative effect of

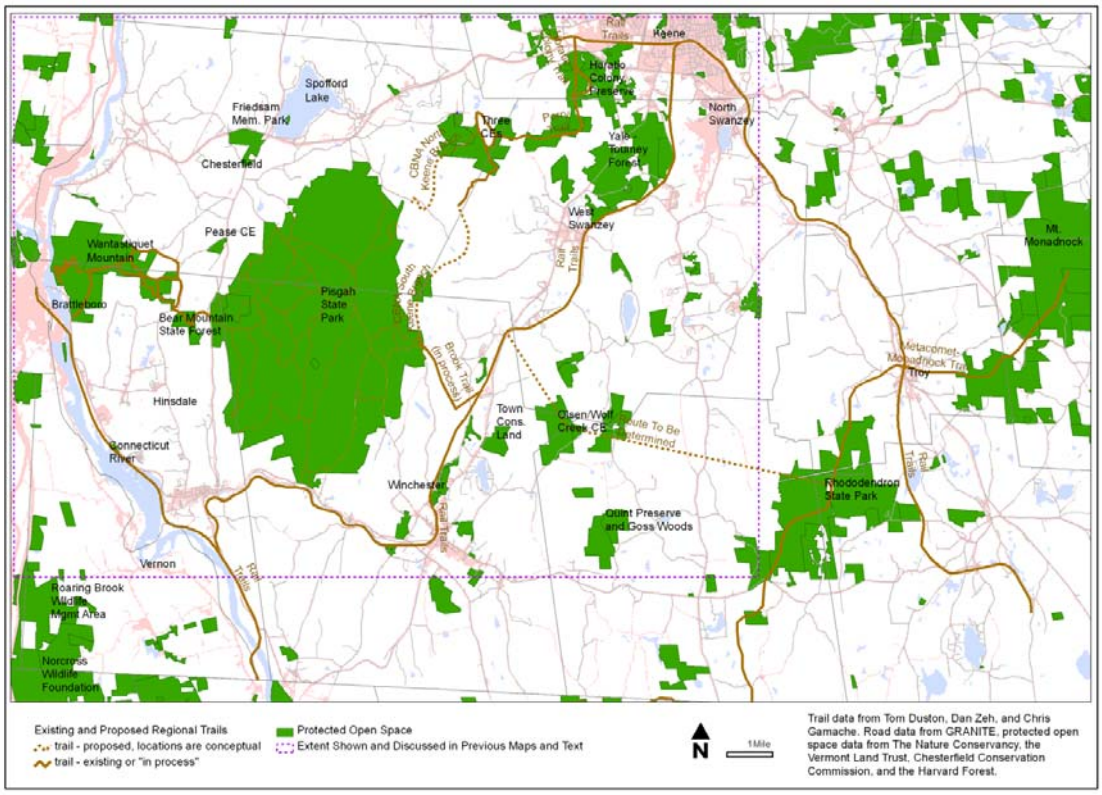

Figure 5. Long-distance recreational trails in the Pisgah region and beyond. Shown are the trails that lead from Mt Wantastiquet through Pisgah State Park to Keene; the Connecticut River to Keene to Mt Monadnock; and southern Connecticut via the Metacomet-Monadnock-Mattabesset Trail.

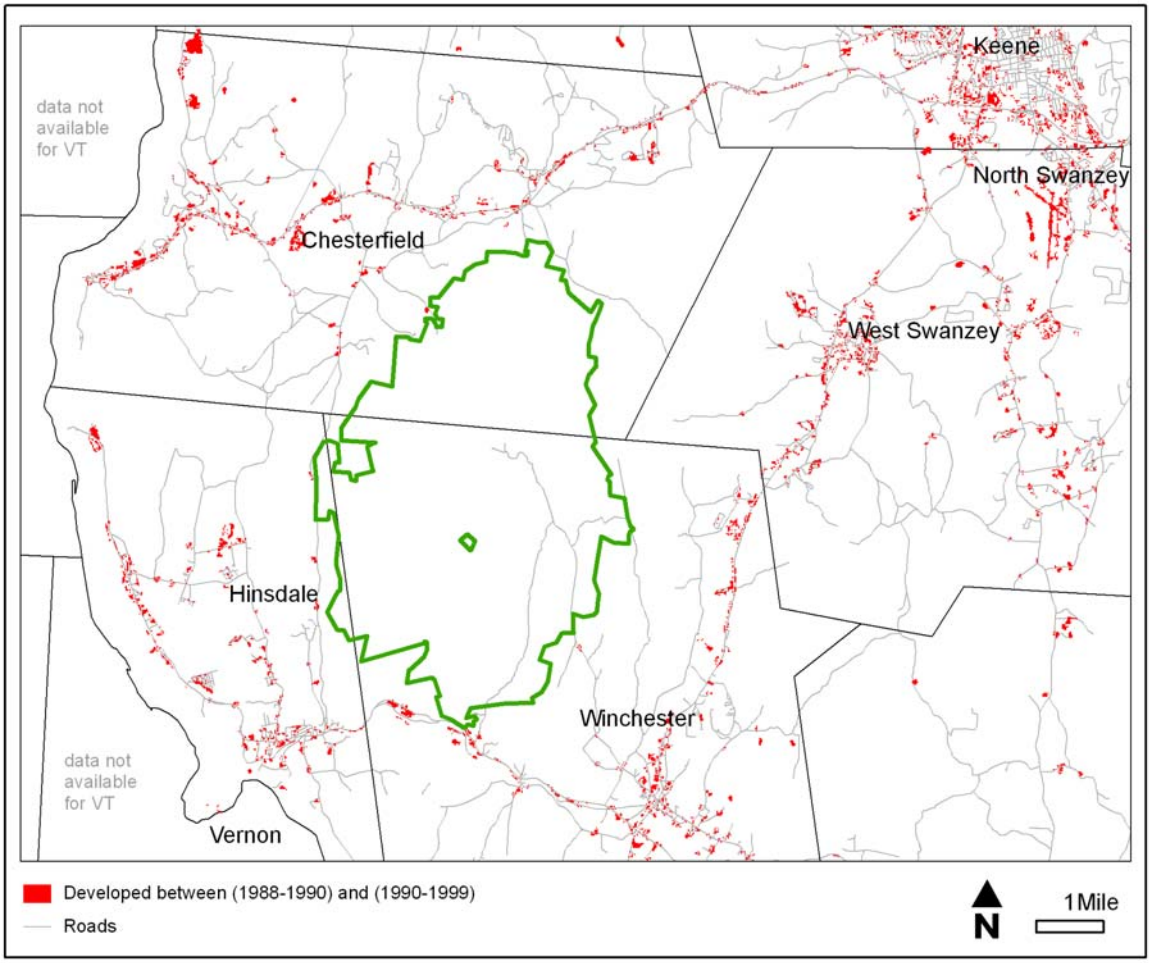

Figure 6. New development between approximately 1988 and 1999 in the Pisgah region. 1,688 acres, or 1.4% was developed between the two time periods. Map is based on comparison of the 1995 (1988-1990 landcover data) and 2001 (1990-1999 landcover data) NH Land Cover Assessment GIS layers from New Hampshire's GRANIT. Shown in red are the locations in the region that were developed on the 1990-1999 layer but not on the older 1988-1990 layer.

development or fragmentation is generally habitat loss (see discussion in Turner et al., 2001, pages 234-235).

Biological Threats from the Surrounding Land

To protect the integrity of the park's plant and animal communities, as well as the ecosystem functions, managers must be aware of invasive plant and forest pest species (such as Hemlock Woolly Adelgid) located on the lands around Pisgah because of the potential for them to enter the park. Invasive plants are probably most likely to occur in areas where the vegetation has been cleared, or the soil disturbed in the historical past or in the present times from agriculture, ornamental plantings in yards, along roadways, etc. These are the same types of environments where invasive plants already exist in the park (see Invasive plant chapter in this report). The Invasive Plant Atlas of New England (IPANE) is a useful "first stop" for information on invasive plant locations (http://nbii-nin.ciesin.columbia.edu/ipane/), although local plant surveys outside the park with rigor comparable to the in-park AVEO survey (Moon et al., 2009) would be more useful to resource managers. Information on the locations of non-native forest pests can be found at University of New Hampshire Cooperative Extension Program Forests and Trees website at http://extension.unh.edu/Forestry/Forestry.htm (see Forest Health chapter).

Regional Conservation and Land-Use Planning Groups

There are many local organizations protecting and managing conservation lands in the region who participated in this management planning process. They include the Monadnock Conservancy, The Nature Conservancy, UNH Cooperative Extension, Cheshire County Conservation District, the Southwest Regional Planning Commission, and the Town Conservation Commissions of Hinsdale, Winchester and Chesterfield. Regional educational institutions, ecologists, and non-profit citizen scientist groups that have participated in the current process include: Ashuelot Valley Environmental Observatory, Franklin Pierce University, Antioch University, Keene State College, the Harris Center for Conservation Education, and Moosewood Ecological LLC. In addition, there is a very active Friends group, The Friends of Pisgah (FoP) who has participated. FoP was organized in 1987 and since then has contributed much time and money in maintaining the park buildings and trails, conducting habitat improvement and supporting research.

Key Findings

- The region around Pisgah State Park is mostly forest (81%), with lesser amounts of developed land (10%) and agricultural land (6%).

- According to the New Hampshire Wildlife Action Plan (WAP) and the Society for the Protection of New Hampshire Forests, the area between Pisgah's southern border and Keene is one of the largest blocks of natural land and most important wildlife habitats in southern New Hampshire.

- Large blocks of natural land cover (forests, open water, and wetlands) are the single most critical component of regional conservation.

- Approximately 19% of the region is protected from development as conservation land; 55% of this protected land is within Pisgah State Park.

- The region currently has many diverse and interconnected recreational trails and a great many additional opportunities in the future. These trails rely on private landowners who are willing to let others use their land.

- Recent and future land development could have detrimental effects on recreational capabilities and the ecology of the region and Pisgah especially if such development is located close to the park, in large forest blocks, or near recreational trails.

- There are many different organizations protecting and managing conservation lands in the region.

- There are many invasive species in the region and non-native forest pests that could enter the park from the surrounding lands.

Recommendations

DRED should continue, as resources are available, to collaborate with local and regional non-government organizations as well as other federal, state and local agencies to discuss management issues such as invasive species control, forest harvest practices, development pressures, wildlife movement, species and plant communities of concern, cultural resources and recreational trail systems

Some research suggestions for DRED and/or its collaborators:

- Conduct landscape ecology studies to identify: important areas of wildlife habitat; areas of concentrated wildlife movement (corridors); features that inhibit wildlife movement; locations of species or plant communities of special concern; locations of other important biological, ecological, or cultural features.

- Identify critical unprotected lands and protected lands that could be, and are most likely to be impacted by activities on nearby unprotected lands.

- Monitor the surrounding lands and park boundaries for: invasive species; non-native forest pests; land cover change; and identify parcels or areas that are most likely to be developed in the near future.

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Bedrock Geology[2]

In this chapter, we first will consider the geology of the Monadnock Region, in general, as a background to understanding the geology of Pisgah State Park, in particular. The geology of the Monadnock Region can be understood, in a general way, by a consideration of the rocks underlying it, by a consideration of the tectonic forces operating on it from about 460,000,000 years ago to about 150,000,000 years ago, and by a consideration of the effects on the region of the continental glaciations of the last 2,000,000 years, especially the effects of the last of these glacial episodes, culminating a mere (geologically speaking!) 20,000 years or so ago, when the Laurentide Ice Sheet covered our area. The ice sheet even overrode the summit of Mount Washington, not to mention the summit of our own Mount Monadnock. The advance and subsequent retreat of the ice sheet provided the "finishing touch" on the present topography of our region and on the present distribution and nature of its lakes, ponds, and wetlands. In short, the combined effects, over the eons, of these various geologic processes have resulted in the picturesque landscapes of the Monadnock Region, in general, and of Pisgah State Park, in particular.

Rocks

There are three main kinds of rocks: igneous, sedimentary, and metamorphic. Igneous rocks are those that have formed from the cooling and crystallization of molten rock. Molten rock found below the Earth's surface, within the lithosphere of the Earth, is known as magma, while molten rock that has erupted onto the ocean floor or onto the surface of a continent is known as lava. Igneous rocks that have formed from the slow cooling and crystallization of magmas at depth within the Earth are known as intrusive, or plutonic, igneous rocks (for example, granite and a related rock that underlies most of Pisgah State Park, granodiorite), while those that have formed from the rapid cooling and crystallization of lavas erupted onto the ocean floor or onto the surface of a continent are known as extrusive, or volcanic, igneous rocks (for example, basalt).

When an igneous rock or a sedimentary rock or a metamorphic rock is exposed at the Earth's surface, it begins to be broken down by various kinds of physical weathering processes (for example, frost wedging) and various kinds of chemical weathering processes (for example, oxidation) into whole rock fragments, individual mineral grains, chemically-altered mineral grains, and ionic constituents. Collectively, these particles are known as the "products of weathering." These products of weathering then are eroded and transported away from their site of origin, usually by streams, and are deposited downstream, ultimately in the oceans, as layers of sediment (for example, layers of sand). Eventually, these layers of sediment may be buried under a great thickness of overlying layers of sediment causing the grains that make up the deeply-buried layers to be compacted and cemented together to form a sedimentary rock (for example, the compaction and cementation of deeply-buried layers of sand produces layers of sandstone).We refer to this process of compaction and cementation of sediments into sedimentary rocks as lithification, or "turning to stone." It is in sedimentary rocks that we find most of our important metal ores and fossil fuels and the sequences of fossils of once-living organisms that record the history of life on Earth - in short, sedimentary rocks are of enormous economic and scientific value.

When a pre-existing igneous or sedimentary rock or metamorphic rock is caught up in a collision between continents (we will discuss plate tectonic processes below), that rock is subjected to a new set of conditions of temperature and pressure. The new temperatures and pressures transform the original rock into a new kind of rock known as a metamorphic rock. This metamorphic rock typically has a different texture and mineral composition than the rock from which it is derived, called the "parent rock", because

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the minerals of the parent rock are no longer in chemical equilibrium with the new conditions of temperature and pressure - the elements making up the parent rock's minerals typically re-equilibrate into new chemical combinations and structures to form new minerals and, by definition, a new rock.

The rocks of the Monadnock Region, in general, mostly are metamorphic rocks called schists and gneisses (derived from pre-existing volcanic igneous rocks and marine sedimentary rocks) and associated intrusive igneous rocks (mostly granites or various granite-like rocks such as the granodiorite that underlies Pisgah State Park). Analysis of the textures and mineral compositions of the rocks of our region tell us about the conditions of temperature, pressure, and tectonic activity to which they were subjected in the course of their formation. These analyses, therefore, help us to reconstruct the geologic and tectonic history of the Monadnock Region.

Tectonic Processes

The modern theory of plate tectonics - a theory that is only about 40 years old - allows us to explain, in a comprehensive way, the origins of ocean basins, continents, and mountain ranges by reference to the motions of large portions of the lithosphere, called plates, relative to one another. It is through various plate tectonic processes that we will tell an important part of the story of the geologic history of the Monadnock Region. However, in order to understand plate tectonic processes, we must first preface our story with a look at the interior of the earth and a look at the different kinds of relative motions that can occur between plates.

Prior to the last few decades, and based on a variety of lines of geophysical evidence, we looked at the earth as consisting of three basic layers, differentiated from one another on the basis of chemical composition and density: (1) the inner layer was called the core (it consists mostly of iron and nickel and is of high density); (2) the middle layer was called the mantle (it consists mostly of silicate minerals - that is, minerals containing as their basic "building block" atoms of silicon and oxygen arranged in a particular kind of geometrical relationship called a silicon-oxygen tetrahedron - and with lower density than the core); and (3) an outer layer called the crust (also consisting of silicate minerals and of lower density than the mantle). We now look at the earth's layers in a somewhat different way, based not only on chemistry and density, but based also on the state of matter or the structural behavior of the materials within those layers. We now conceive of the earth as consisting of five basic layers: (1) an innermost, solid, iron- and nickel-rich inner core; (2) overlying that, a liquid, iron- and nickel-rich outer core; (3) overlying that, a solid silicate-rich mesosphere; (4) overlying that, a structurally ductile ("plastic" - think of how "Silly Putty" behaves when pressed between your fingers), silicate-rich asthenosphere; and, finally, (5) an outer, structurally-brittle ("rigid"), silicate-rich lithosphere. The lithosphere, in turn, consists of three different layers: (1) a lower "uppermost mantle" layer; (2) a middle "oceanic crust" layer (consisting mostly of basalt); and (3) an outer "continental crust" layer (consisting mostly of granite and related kinds of rocks). The inner core plus outer core are what we used to call simply the core; the mesosphere plus the asthenosphere plus the uppermost mantle are what we used to call simply the mantle; and the oceanic crust plus the continental crust are what we used to call simply the crust.

For our purposes, it is the two outer layers, the structurally-rigid lithosphere and the structurally-plastic, underlying asthenosphere that are important - it is the lithosphere that is the layer that is broken into a series of structurally-rigid plates that are rafted about on currents flowing through the underlying, plastic asthenosphere. These currents, in turn, are generated by an important mechanism by which the earth's interior dissipates its largely radiogenically-produced heat - by convective transfer. In other words, the lithospheric plates are like so many giant "Kon Tikis" being rafted about on the currents of the world's oceans, or, if you will, they are like so many giant pieces of an even more gigantic jigsaw puzzle, all the pieces, by virtue of their motions, jostling one another in various ways along their boundaries.

We now are in a position to consider the three main kinds of plate motions: (1) divergent; (2) convergent; and (3) transform. Associated with each of these three different kinds of relative motions that are observed along plate boundaries are particular kinds of geologic phenomena and particular kinds of geologic features specific to that particular kind of plate boundary. For example, where we observe divergent (pull-apart) relative motions between plates (in response to divergent convection currents in the asthenosphere directly underlying the plate boundary, and, thus, setting up tensional stresses in the lithosphere along that boundary), we have divergent plate boundaries. These divergent boundaries are marked, in the middle of ocean basins, by mid-ocean ridges and rises (for example, the Mid-Atlantic Ridge) and, where they occur on continents, by incipient mid-ocean ridges and rises called rift valleys (for example, the East Africa Rift Valley, where humankind was born), and by the creation of new sea floor along these ridges as the plates pull away from one another. A mid-ocean ridge or rise is marked by normal faults (the main response of the lithosphere where tensional stresses are applied to it) and by other kinds of fractures out of which are extruded lavas that cool and crystallize into the dark-colored, fine-grained igneous rock called basalt, thus creating new sea floor when the basalt solidifies. This new sea floor then is conveyed away from the ridge axis at right angles, thus making way for even newer sea floor - this process is called sea-floor spreading.

Where we observe convergent (collisional) plate motions (in response to converging convection currents in the asthenosphere directly underlying the plate boundary, and, thus, setting up compressional stresses in the lithosphere along that boundary), we have convergent plate boundaries. There are three different kinds of convergent plate boundaries: (1) ocean-ocean convergent boundaries (where the oceanic lithosphere of one plate collides with the oceanic lithosphere of another plate); (2) ocean-continent convergent boundaries (where oceanic lithosphere of one plate collides with continental lithosphere of another plate); and (3) continent-continent convergent boundaries (where continental lithosphere of one plate collides with continental lithosphere of another plate).

An ocean-ocean convergent boundary is marked by an oceanic trench, and, paralleling the trench, a volcanic island arc. For a modern example of this kind of tectonic setting, think of the Mariana Trench and the associated volcanic islands making up the Mariana Islands. The trench marks the line along which there is on-going destruction of old sea floor as the oceanic lithosphere of one plate (the Pacific Plate in this example) plunges back down into the asthenosphere beneath the oceanic lithosphere of the other plate (the Philippine Plate in this example), a process known as subduction. Where the subducting slab of the one plate plunges beneath the other plate, it partially melts at depth, thus supplying the lava for the eruptions that ultimately produce the overlying volcanic island arc that is growing up off the sea floor parallel to the trench - the rocks of the island arc thus actually are examples of new continental lithosphere. (We believe that, early in the Earth's history, the original "nuclei" of the continents grew by accretion of volcanic island arc rocks.)

An ocean-continent convergent boundary also is marked by an oceanic trench, and, parallel to the trench, an "on-shore volcanic island arc"; that is, an on-shore range of volcanic mountains. For a modern example, think of the western margin of South America, marked offshore by the Peru-Chile Trench and on-shore by the Andes Mountains. As was the case with the ocean-ocean convergent boundary tectonic setting, the slab of oceanic lithosphere (the Nazca Plate in this example) subducting under the continental lithosphere (the South American Plate in this example) that it is colliding with partially melts, thus supplying the magmas that erupt at the surface as lavas that ultimately build the overlying range of volcanic mountains.

Finally, a continent-continent convergent boundary is marked by major fold-and-thrust belt mountains formed in response to the shallow under-thrusting of one plate of continental lithosphere beneath the other plate of continental lithosphere (no true subduction in this particular case) along with extreme buckling and telescoping of the lithosphere of both plates in the form of thrust faults and folds. Both of these kinds

of deformation of the lithosphere, also seen along the other two kinds of convergent plate boundaries, are in response to the compressional stresses that are being applied to it. A modern example of this kind of plate tectonic setting is the on-going collision, resulting in the Himalayas, the Tibetan Plateau, and the general up-warping of the Asian continent, between India (part of the Indian-Australian Plate) and Asia (the largest part of the Eurasian Plate) - think of a gigantic train wreck occurring before your eyes, in extreme slow motion, over the course of tens of millions of years!

Where we observe lateral sliding (transform) plate motions, arising as a response to shear stresses being applied to the lithosphere along the plate boundary and as a side consequence of divergent motions and convergent motions elsewhere along the margins of the plate in question, we have a transform plate boundary. A transform boundary is marked by large strike-slip faults (and associated large earthquakes) along which the plates grind past one another. A familiar example of a transform plate boundary is the San Andreas Fault Zone, in California, marking the boundary along which the Pacific Plate and the North American Plate grind past one another.

While we believe that plate tectonic processes have been at work shaping the Earth -creating ocean basins, continents, and mountain ranges - over at least the last 2,500,000,000 years of Earth history, it is "only" the last 500,000,000 years, or so, of Earth history that need concern us for the story we are about to tell here. This last ninth of Earth history (The Earth is ancient indeed!) is the interval of time during which New Hampshire and the surrounding New England and upstate New York area, in general, and the Monadnock Region, in particular, were assembled into the template for their modern form.

The Tectonic Events that Have Shaped the Monadnock Region

During the interval of geologic time spanning from about 650,000,000 years ago to about 460,000,000 years ago, the ancestral North American continent (called "Laurentia"; our continent had a different size, shape, location, and orientation then than it does now - nevertheless, for the sake of simplicity, we will refer to the relative positions of North America and the other continents and oceans relevant to our story by using modern compass directions) lay on the western shore of an ancient ocean, the proto-Atlantic Ocean, or Iapetus Ocean. The modern Atlantic Ocean did not exist at this time! To the east of this ancient North American continent, and lying on the eastern shore of the Iapetus Ocean, were the ancestral European continent (called "Baltica") and, south of that, a roughly Madagascar-sized micro-continent called "Avalonia". (Avalonia probably was associated with the ancestral African continent which, at that time, was a part of the southern super-continent of "Gondwanaland". As was the case with ancient North America, both Europe and Africa had different sizes, shapes, locations, and orientations then than they do now.)

Beginning about 460,000,000 years ago, and ending about 440,000,000 years ago (an interval of geologic time that we call the "Taconian Mountain Building Cycle" or "Taconic Orogeny"), subduction was initiated within the western half of the Iapetus Ocean basin, off the eastern margin of North America. This tectonic process, involving Iapetus seafloor along the western margin of the ocean basin subducting in an eastward direction under the seafloor of the ocean basin to the east (an ocean – ocean convergent boundary) ultimately resulted in the development of a volcanic island arc we call the "Bronson Hill Volcanic Island Arc". As Iapetus seafloor was consumed in the subduction zone, the convergent motions between the volcanic island arc and North America resulted in the island arc colliding with the eastern margin of North America, with which it "docked" and to which it "welded." The resulting deformation of the rocks - the various kinds of breaking and telescoping (that is, thrust faulting - there is an estimated total of 600 miles of crustal shortening involved!), bending (that is, folding), and "pressure cooking" (that is, metamorphism) of the rocks - both the rocks making up the eastern margin of North America and those of the island arc itself, caused the uplift of the Taconic Mountains of easternmost New York State and westernmost Vermont and the Green Mountains of central Vermont, both ranges of greater stature then

than the “mere” erosional remnants that we see today. The portion of New Hampshire that now forms the highlands just to the east of the Connecticut River Valley, and, thus, also forms the western margin of the Monadnock Region, is the original core of the Bronson Hall Volcanic Island Arc. These island arc complex rocks form a structural upwarp in the lithosphere called the Bronson Hill Anticlinorium. Just to the west, along the line along which the island arc welded to North America, is a structural downwarp called the Connecticut Valley-Gaspe Synclinorium, forming much of the Connecticut River Valley. It is along this synclinorium that much of the modern Connecticut River between Vermont and New Hampshire flows.

The interval of geologic time from about 440,000,000 years ago until about 420,000,000 years ago was a period of relative tectonic quiet for the eastern margin of North America - but this situation would begin to change toward the end of this interval of time. The initiation of eastward-directed subduction of Iapetus sea floor, along the eastern margin of the Iapetus Ocean (that is, eastward-directed subduction initiated along and under the western margin of Europe and the western margin of Avalonia), was closing the Iapetus Ocean basin. The resulting convergent plate motions were sending Europe and Avalonia on a collision course with North America, resulting in an evolution from an ocean-continent convergent boundary tectonic setting to a continent – continent convergent boundary tectonic setting. This collision occurred over an interval of at least 70,000,000 years, from about 420,000,000 years ago until about 350,000,000 years ago, an interval of geologic time that we call the “Acadian Mountain-Building Cycle” or “Acadian Orogeny”. Although plate collisions occur exceedingly slowly, in terms of a human lifetime, ultimately, they release tremendous amounts of energy and effect profound changes in the Earth’s configuration, topography, and climate, and, as well, probably affect the course of the evolution of life. This particular collision resulted in the buckling of the lithosphere along the eastern margin of North America and along the western margin of Europe and the western margin of Avalonia, as these three blocks of continental crust welded together to form the northern super-continent of “Laurussia” (a.k.a. “Laurasia” or “Euramerica”). These tectonic events were a part of the set of tectonic events by which all of the continents ultimately welded together (Laurussia ultimately collided with, and welded to, Gondwanaland) to form the one giant super-continent that we call Pangaea - “All Lands.” Pangaea, in turn, was surrounded by one giant ocean, Panthalassa - “All Seas.”

The intense deformation (again, in the form of thrust faulting, folding, and metamorphism) of the lithosphere within the zone of this titanic collision resulted in the formation of the Acadian Mountains. These mountains, which, at the time, in stature rivaled the modern Alps and possibly even the Himilayas, were the ancestors of our modern Appalachian Mountains. The Appalachians are, in fact, the modern erosional remnants - the “root zone,” if you will - of the Acadian Mountains. Material eroded from this once-mighty mountain range was transported into the adjacent epicontinental seaway. (An epicontinental seaway is a relatively shallow seaway overlying granitic, continental crust, rather than a true ocean filling an ocean basin overlying basaltic, oceanic crust. In the past, epicontinental seas have covered large areas of North America and the other continents; they form at times of high global sea level.) This adjacent epicontinental seaway occupied a subsiding portion of the crust known as the Appalachian Basin, to the west of the Acadian Mountains, and filled up with a thick wedge of sediments called the Catskill Delta. (It is worth noting that these geologic events were going on during the interval of time when some major biological events also were unfolding - the evolution of the first true forests and the evolution of the first amphibians.) Some of the sedimentary rocks ultimately derived from the compaction and cementation of these sediments are preserved as erosional remnants - the Catskill Mountains of eastern New York State.

The assembly of Pangaea essentially was complete by about 250,000,000 years ago; however, the super-continent began to break up by about 150,000,000 years ago. In other words, by about 150,000,000 years ago, Pangaea began to rift apart in earnest, this rifting process resulting in the opening of the modern Atlantic Ocean basin, an ocean basin that to this day is still in the process of widening. (This widening of the Atlantic Ocean comes at the expense of the Pacific Ocean, which presently is being consumed by

subduction around the Pacific Rim – a zone marked by intense earthquake and volcanic activity, the so-called "Ring of Fire.") However, the Atlantic Ocean did not open up exactly along the earlier "suture" - the line along which the earlier Iapetus Ocean had closed - between North America and Europe and Avalonia. Initially, it opened along a rift (now seen as the modern Mid-Atlantic Ridge) to the east of the original suture between the continental crustal blocks involved. This means that the rocks underlying much of New Hampshire, including those underlying most of the Monadnock Region, specifically those rocks to the east of the Bronson Hill Anticlinorium, probably originally were actually part of Avalonia, that Madagascar-sized, micro-continent associated with Africa!

An important portion of the Monadnock Region (for example, Mount Monadnock itself) is underlain by rocks of the Littleton Formation. The rocks of this formation actually extend southward into Massachusetts and points beyond and northward into the White Mountains (the Littleton Formation forms the major erosionally-resistant ridge in New Hampshire, Mount Washington and the Presidential Range), then swings eastward into Maine and beyond. The rocks of the Littleton Formation are metamorphic rocks, mostly schists and gneisses, the result of subjecting the originally mostly marine sedimentary rocks involved in the collision between North America, Europe, and Avalonia to the high temperatures and pressures that prevailed during the building of the Acadian Mountains. Specifically, these rocks contain assemblages of minerals that indicate the high temperatures and pressures that are found at least three to four miles down in the lithosphere. For these and a variety of other reasons, we feel that these rocks are the rocks of the root zone of the old Acadian Mountains. They now are exposed for us to see by virtue of the eons of subsequent erosion (mostly stream erosion) that have stripped away the overlying rocks and by virtue, most recently, of erosion by the Laurentide Ice Sheet, the effects of which we will examine below. Some zones within the Littleton Formation are composed of minerals that are more resistant to weathering and to erosion than are others, so that these areas within the formation stand up as resistant ridges, such as Mount Washington, mentioned above. The most prominent of these resistant ridges in our region, of course, is Mount Monadnock. The mountain lends its name to the geomorphic term "monadnock", meaning "a point of land rising conspicuously above the surrounding region".

On Top of the Bedrock: The Ice Age and Its Effects on the Monadnock Region

The last 2,000,000-year interval of Earth history, an interval characterized predominantly by "ice house" climatic conditions, is known as the Pleistocene, or "Ice Age." Geologic evidence demonstrates that there have been at least two other truly major ice ages in the last billion years, each apparently of a similar, few- to tens-of- millions-of years in duration. These ice ages have occurred at roughly 350,000,000-year intervals, back to about 700,000,000 years ago, but it is not known whether or not there is any real significance to this apparent "periodicity" in ice age occurrences - what we do know is that ours is only the most recent ice age, and probably, barring the effects of human-induced global warming, it will not be the last. Based on evidence from many localities across North America, the most recent Ice Age has seen at least four major advances and retreats of continental ice sheets (the ice sheet directly affecting our region is called the Laurentide Ice Sheet). However, some localities, such as a subsurface core locality in Nebraska, have yielded evidence of up to seven major advances and retreats of the ice sheets - but four is the currently agreed-upon number of definite major ice sheet advances and retreats. During the Ice Age, the particularly cold climatic intervals were marked by glacial advances and are called, appropriately enough, "glacials," while the somewhat warmer climatic intervals following the glacials were marked by glacial retreats and are called "interglacials." The last major ice advance is known as the Wisconsin Glacial, which saw maximum southward advance of glacial ice occurring from about 21,000 to about 18,000 years ago - an ice advance in which all of New England was completely under ice, even the summits of our highest mountains. The southern extent of the ice margin was along a line marked by Long Island, Block Island, Martha's Vineyard, Nantucket, and Cape Cod. The reason that the ice front was able to move to such a southward position, over land the entire way, was because so much water was incorporated into the ice sheet that sea level had dropped some 400 feet below our present sea level by the

time of the glacial maximum - Long Island Sound was dry land overridden by ice! However, by about 18,000 years ago, the ice sheet began retreating, moving northward out of our Monadnock Region by about 15,000 to about 12,000 years ago, and essentially completely melting away by about 6,000 years ago. (However, it is unlikely the Ice Age truly is over - we simply are within the latest interglacial interval!) In New Hampshire, there is only the record of the last, Wisconsin advance and subsequent retreat of the Laurentide Ice Sheet, the record of earlier glacial episodes in our region apparently having been obliterated by its effects.

Although ultimately less significant in the sculpting of the Monadnock Region's landscape than the previous eons of "normal" erosion, mostly by streams, the Wisconsin Glacial nevertheless left its mark on our region's landscape. Most familiar to all who live here, and even to many who are just visiting or are only passing through, are the glacial "erratic" boulders littering the landscape, many of which now are incorporated into our numerous stone walls, and many of which were transported by the Laurentide Ice Sheet from far to our north in Canada. In addition, along the side of many of our highways are sand and gravel pits, many still being actively excavated, and all of which are excavations into the sediments left behind directly by the glacier or by meltwater from the glacier. The glacier also left its mark on the resistant bedrock ridges of the area, most noticeably seen in the way that north-facing slopes (up which the ice sheet ascended) are relatively shallow in gradient, while south-facing slopes (down which the ice sheet descended) are noticeably steeper in gradient. Hikers in the region are all well aware of this phenomenon, but anyone can see it for themselves - just look at, for example, Mount Monadnock, either from the east side or from the west side, and note the relatively shallow gradient of the north-facing slope (sloping up from Dublin Lake, and along which runs Pumpelly Ridge Trail) versus the steeper gradient of the south-facing slope (sloping downward toward Jaffrey and along which runs, for example, the White Dot Trail). These steeper south-facing slopes of the resistant ridges in our region are due to a process that occurs as continental glacial ice moves down a pre-existing slope, working on pre-existing fractures in the underlying bedrock over which it is moving, and removing blocks of rock as it goes, a process known as "glacial plucking."

An ice sheet advancing over an area acts largely as an agent of erosion, scouring the land surface over which it is moving. It often leaves behind a record of its movement in the form of, among a variety of other features, a series of parallel grooves indicating ice flow direction, called striations, etched into the rock. A retreating ice sheet, along with the glacial meltwaters derived from it, on the other hand, acts largely as an agent of deposition, the thickness of sedimentary material and the specific kind of deposit laid down (for example, as well as the erratic boulders mentioned above, moraines, kames, eskers, drumlins, etc.) being controlled by the rate of ice recession and other aspects of the local dynamics within the moving ice sheet. In particular, a stagnant or slowly-receding ice sheet can leave behind thick sequences of glacial- and glacial meltwater-derived sedimentary deposits, while a rapidly-retreating ice sheet will leave behind only a relatively thin veneer of such deposits, such that the effects on the landscape of the earlier advance of the ice sheet are more apparent. It has been suggested (Weir, 1999, personal communication) that the southern half of our Monadnock Region, roughly south of the latitude of Mount Monadnock, largely was an area of deposition, indicating relatively slow recession of the ice sheet that had been covering the area, and was left covered with a relatively thick blanket of glacial sediments. Much of this sediment is incorporated into small, knobby hills called drumlins. The hilly terrain and the slow drainage created by the cover of glacial sediments results in the many shallow lakes, ponds, and wetlands of the southern half of our region, for example, Pearly Pond and its associated wetlands in the town of Rindge. The northern half of our region, on the other hand, is more an area of relatively thin glacial sediment cover, indicating a relatively more rapid retreat of the ice sheet out of this portion of our region, and is characterized by depressions scoured into the underlying bedrock that were created by, or at least enhanced by, the erosive action of moving ice. These bedrock depressions typically are filled with water and form deep lakes, such as Dublin Lake, north of Mount Monadnock, in the town of Dublin. (These deep-water lakes present us with beautiful scenery and with abundant recreational

opportunities, but also present us with particular environmental problems. By virtue of their low surface area to volume ratios, accompanied by slow turnovers of the volumes of water that they contain, they are particularly at risk of long-term pollution problems.) In the future, an interesting line of research would be to test this hypothesis regarding the thicknesses and kinds of glacial deposits and their control on aspects of geomorphology in the southern portion of the Monadnock Region versus the northern portion of the region.

The Bedrock Geology of Pisgah State Park

As an area within the Monadnock Region, Pisgah State Park retains the geologic signature, especially, of two of the major geologic events affecting the larger region: the Acadian Orogeny and the Ice Age. Pisgah State Park is underlain almost in its entirety by one kind of rock, granodiorite. This particular granodiorite is known as the Kinsman Granodiorite, formerly known as the Kinsman Quartz Monzanite. In addition to the Kinsman Granodiorite underlying most of the park, its extreme eastern margin is underlain by a member of the metamorphic Rangeley Formation Schist, and the extreme western portion by another member of the metamorphic Rangeley Formation Schist and an igneous granite.

Granodiorites are granite-like in appearance. In terms of texture, they are coarse-grained rocks. [Coarse-grained means that the mineral crystals that make up the rock are visible to the naked eye, anywhere from 1 mm to 10mm (1cm) in diameter, or larger; this kind of coarse-grained texture is called "phaneritic".] In terms of composition, granodiorites contain, as their essential minerals, an array of geologically-important silicate minerals - quartz, plagioclase feldspar, potassium feldspar, the amphibole mineral hornblende, and biotite mica, and they also may contain a number of minor accessory minerals, as well, including another important silicate mineral, garnet. The coarse-grained textures of granodiorites tell us that they are formed by the slow cooling and crystallization of magma deep below the surface of the Earth, and so they are examples of intrusive igeneous rocks. The particular kinds and proportions of minerals that make up granodiorites are referred to as "intermediate" in composition, as the term implies a composition lying between a "felsic" composition (among other compositional differences, felsic igneous rocks contain more quartz) and a "mafic" composition (among other compositional differences, mafic igneous rocks typically contain no quartz). Such an intermediate composition, in turn, suggests formation from an intermediate composition, relatively water-rich magma derived from partial melting of a subducting slab of ancient seafloor along an ocean-continent convergent boundary.

The Kinsman Granodiorite underlying Pisgah State Park is distinctive for its particularly conspicuous, large phenocrysts (called megacrysts) of potassium feldspar and for its local concentrations of garnets. Phenocrysts are mineral crystals in an igneous rock that are conspicuously larger than the surrounding mineral crystals (called the "matrix" or "groundmass" minerals). Such a bimodal distribution of mineral grain sizes in an igneous rock results in a texture that we refer to as porphyritic - in the case of an igneous rock such as the Kinsman Granodiorite, in which the phenocrysts are imbedded in a coarse-grained matrix, we call the texture porphyritic-phaneritic. Such a texture suggests a two-stage cooling history of the parent magma. In the first, slow-cooling stage, the phenocrysts of potassium feldspar grew slowly and to a large size within the magma. In the second , more-rapid cooling stage, a stage probably due to a relatively rapid upward migration of the now potassium-feldspar-phenocryst-rich magma into a shallower, less well-insulated level of the lithosphere, the smaller mineral grains making up the matrix crystallized relatively rapidly around the earlier formed phenocrysts of potassium feldspar.

Putting the Kinsman Granodiorite into the larger, regional tectonic setting of the time, it formed from a magma derived from the partial melting of a water-rich, subducting slab of Iapetus seafloor. Because this magma was hotter and, therefore, less dense than the surrounding rock that insulated it, it rose buoyantly upward from the slab into the miles-thick stack of intensely folded, thrust-faulted, and metamorphosed older rocks (examples of which are the outliers of Rangeley Formation Schist at the eastern and western

margins of Pisgah State Park) overlying it. (Magmas rise through overlying rocks by a variety of mechanisms, sometimes making it all the way to the surface, but often remaining trapped underground.) Unable to rise all the way to the surface to erupt there as a lava, the magma slowly cooled and crystallized at depth (probably in the two-step process outlined above) to form the coarse-grained, intermediate composition, intrusive igneous rock called granodiorite, one of many igneous plutons emplaced throughout the region during the course of the Acadian Orogeny, in this case, a pluton called the "Ashuelot Pluton". The ensuing eons of erosion then removed the miles of rock once covering the pluton, and the geologically-recent advance and retreat of the Laurentide Ice Sheet applied the "finishing touches" to the landscape by directly sculpting the bedrock surface during its advance and leaving behind a veneer of glacier-derived deposits during its retreat. Where not covered by these glacial deposits, soils, and vegetation, the granodiorite pluton is exposed as outcrop for us to see as the bedrock underlying most of Pisgah State Park.

An as yet unpublished study of the age of the Kinsman Granodiorite, a study using uranium – lead (U – Pb) radio-isotopic dating techniques, puts the crystallization age of the rock at 403,000,000 plus or minus 3,000,000 years (Robinson, personal communication, 2008), an age corresponding to the "heart" of the Acadian Orogeny in our region. It is not yet known whether or not the parent magma from which the Kinsman Granodiorite crystallized was emplaced along a thrust fault already existing within the stack of older metamorphic rocks it intruded, or whether the existence of the original magma body actually facilitated later thrust faulting in the area (Thompson, personal communication, 2008). This intriguing question remains one for future research to answer.

Conclusions

In summary, then, the landscape of the Monadnock Region, in general, and Pisgah State Park, in particular, largely is the product of the ancient tectonic forces that shaped this eastern margin of our continent hundreds of millions of years ago, and, after eons of "normal," largely stream-dominated erosion wearing down and further sculpting this once truly mountainous landscape, a product also of the effects of the advances and retreats of the ice sheets of the last 2,000,000 years. This combination of geologic forces has resulted in the area's picturesque landscapes of hills, streams, lakes, ponds, wetlands, and forests.

Management Recommendations and Objectives

Even if the watershed that has been protected as Pisgah State Park was not so protected, the geologic materials of the park, both bedrock and glacial deposits, do not have sufficient economic potential such that they would be likely to be actively quarried. Rather, the value of the geologic materials within the park boundaries overwhelmingly is of an educational nature. We recommend developing educational signage illustrating the geologic history of the park, with said signage being posted at all park entrances. In addition, we also recommend developing a series of self-guided walks along the trails already extant in Pisgah State Park, with numbered stops along the way illustrating particular aspects of the geology of the park. (This latter recommendation also should be applied to, for example, the plant communities and the historic sites within the park.)

In addition, we also recommend allowing legitimate geologic research (and other scientific research) to be carried out within the park boundaries. For example, the question of the nature of the emplacement of the original magma body that cooled and crystallized to become the Kinsman Granodiorite (mentioned above) and other technical issues relating to the geologic, structural, and tectonic history of the bedrock of the park should continue to be explored, and the relationship between the bedrock of the park and the

nature of the overlying glacial deposits, soils, plant communities, ground water, and surface water all are fertile ground for scientific investigation.

Key Finding and Key Recommendation

Because there are a number of valid research questions with regard to both the bedrock geology and glacial geology of Pisgah State Park, geologic field work and appropriate sampling (for laboratory analysis) of the Kinsman Granodiorite (forming, by far, the greatest portion of the bedrock underlying the park) and the various glacial materials overlying the Kinsman Granodiorite should be encouraged within the park boundaries.

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Water Resources[3]

Water, as a resource critical for life, is included in this management plan, with the goal that management should work to maintain or enhance the quality and quantity of these resources on the property and throughout the region. Water resources covered in this section include watersheds, groundwater, surface water, floodplains and flood control, and wetlands. More detail on lake, stream and wetlands as wildlife habitat is found in the wildlife section and in the natural communities section.

The condition of the land plays a very large role in determining the condition of water resources, both locally and regionally. The entire hydrologic cycle is affected by land use; compared to areas altered for agriculture, development or other uses, forested areas will have different rates of infiltration (percolation of water into the ground), groundwater recharge (addition of water to the underground aquifers), groundwater discharge (outflow of groundwater from underground aquifers), transpiration (water loss through the leaves of plants), evaporation, and surface runoff. The timing of flows, temperature and chemistry of a cold-water trout stream, for example, can be negatively affected by inappropriate forestry, recreation or construction. Wetlands, groundwater supplies, stream flows and lake levels in Pisgah depend on a substantial forest cover, and the flora and fauna of these areas are adapted to the resulting water levels and water chemistry. Since Pisgah is located at the top of the watershed, activities there will affect all water supplies downstream.

In Pisgah, Park boundaries were designed to encompass most of the Broad Brook watershed. The headwater streams and small tributaries of Kilburn Brook, Hog Tongue Brook and Broad Brook were identified as conservation targets in the Ashuelot Watershed Conservation Plan (Zankel 2004) as were several of the wetland communities and complexes (black gum swamps, Broad Brook valley - see Natural Communities Chapter).

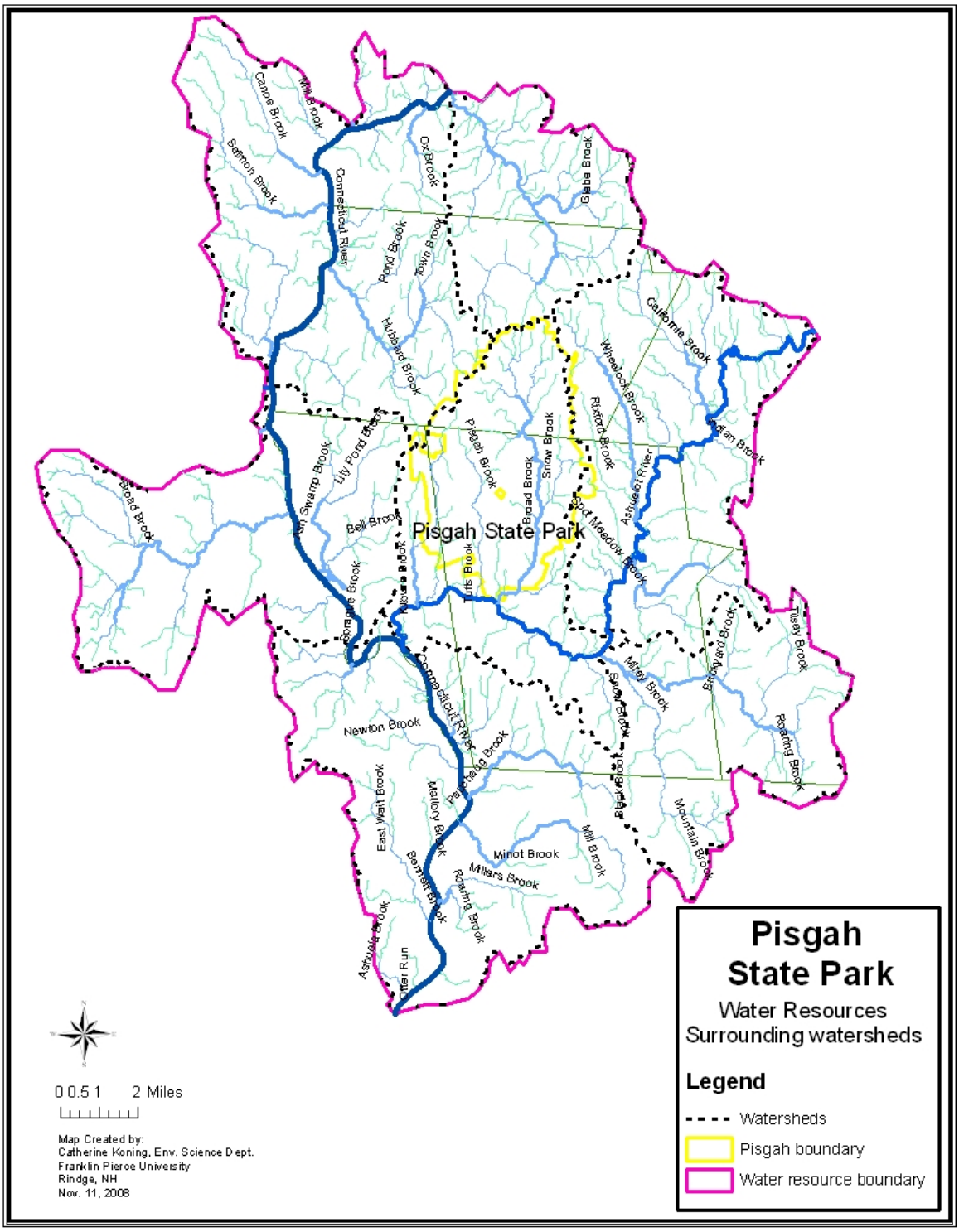
Watersheds and Water Quality

Almost all of Pisgah State Park falls into one 37.2 square-mile sub-watershed of the Ashuelot River, which then drains into the lower Connecticut River basin. Most of this watershed is drained by Broad Brook, which is a third-order stream, and Pisgah Brook/Tufts Brook, which are second-order streams. The Connecticut River is only about 4 miles (7 km) downstream along the Ashuelot River from Broad Brook and Tufts Brook. Hog Tongue Brook and Kilburn Brook also drain a small section of the southwest corner of the park directly into the Ashuelot.

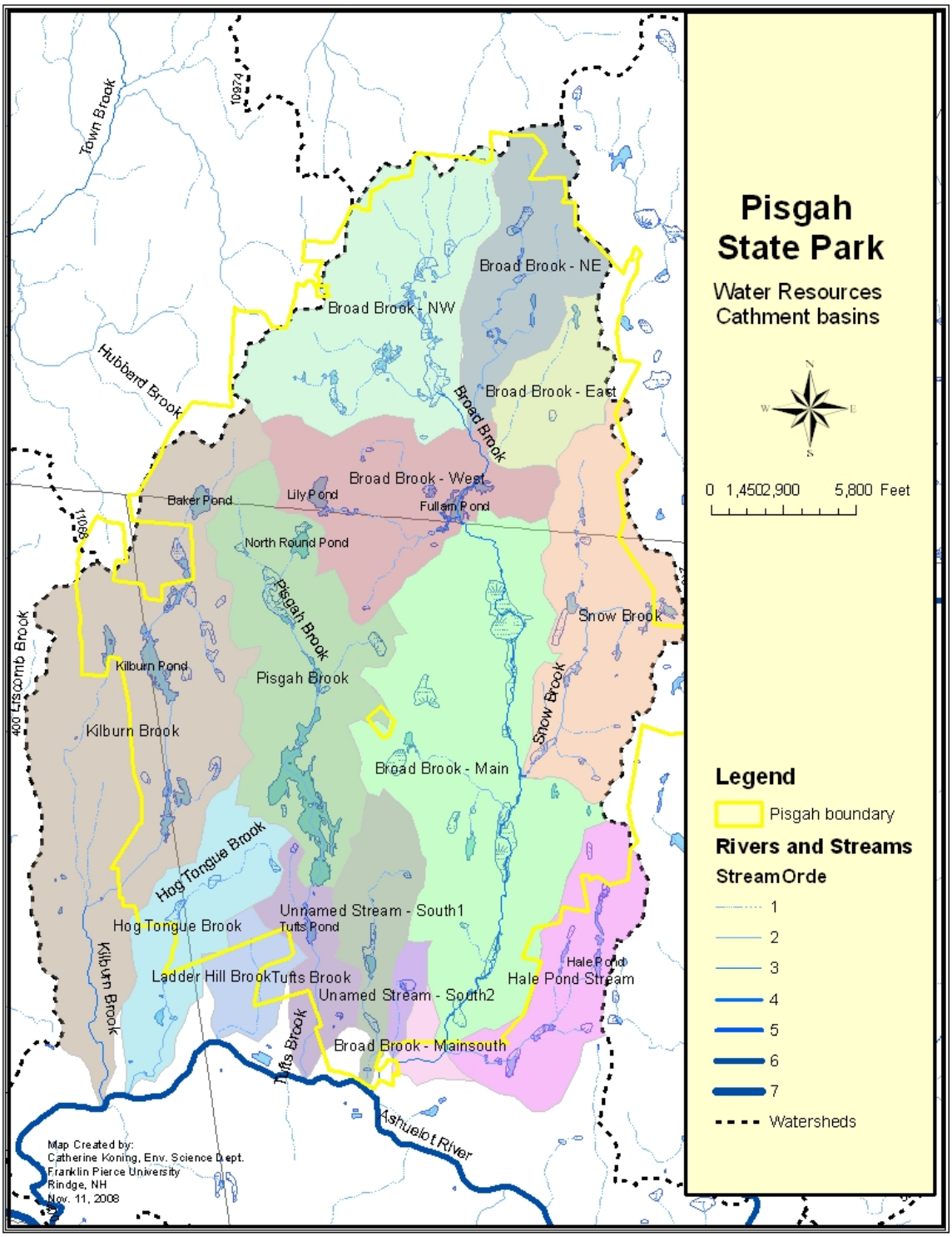
Broad Brook and its tributaries, including Snow Brook, drain 8,383 acres of the park, or roughly 63% of the park. Kilburn Brook drains 3,163 acres or 24% of the park, while Pisgah/Tufts brook drains 2,029 acres or 15% of the park.

[3]Catherine Owen Koning, Franklin Pierce College

Watersheds of the Pisgah State Park area.



Catchment basins within Pisgah State Park.



Catchment basin areas, Pisgah State Park.

Catchment Basin	Area (Acres)
Broad Brook, NW branch	1640.14
Broad Brook, NE branch	876.11
Broad Brook, E branch	479.94
Snow Brook	1354.27
Broad Brook, W branch	1181.06
Pisgah Brook	1610.42
Kilburn Brook	3163.15
Broad Brook Main central	2725.31
Unnamed South Stream,	525.35
Unnamed South Stream, 2	105.25
Broad Brook, Main South	126.34
Hog Tongue Brook	804.94
Ladder Hill Brook	307.27
Tufts Brook	418.88

Water quality data from Pisgah is sparse, although some data is available for Broad Brook where it meets Rte. 119. Elevated levels of sodium, organic carbon and potassium were found. Sodium most likely finds its way into the brook from road de-icing materials (road salt). Organic carbon and potassium may be the result of local erosion. The data show no indications of nutrient enrichment in the brook, such as nitrogen or phosphorus, which can cause cultural eutrophication, including algae blooms and low levels of dissolved oxygen.

Groundwater resources

Groundwater resources in the lower Connecticut River basin are generally not substantial, but groundwater quality meets USEPA standards for drinking water in all but a few cases (Moore et al., 1994). Groundwater chemistry in the Pisgah area tends to show low concentrations of all natural minerals and total dissolved solids (Moore et al., 1994), indicating a low-nutrient, acidic tendencies. No contaminants were discovered in any of the wells tested near Pisgah (Moore et al., 1994). Groundwater resources in Pisgah are limited to shallow surface aquifers in glacial till, and bedrock aquifers (Moore et al., 1994). Shallow (10-40 ft. deep) layers of till, sand and gravel or clay overlay the bedrock.. Figure 3 shows that there are no stratified drift aquifers within the park; stratified drift is the layered sand and gravel left by the glaciers, which yields significant groundwater (GRANIT 2000, Moore et al., 1994). There are only three wells dug within the park boundaries; two draw from surficial deposits and one is in bedrock (Figure 3) (GRANIT 2000). The prevailing regional groundwater flow is northeast-southwest, towards the Ashuelot River. The municipal water supply for the Town of Hinsdale comes from wells that are down hill from Pisgah.

Water quality sampling results from Broad Brook, at junction with Rte. 119. Samples taken in 1999 were part of the NHDES Ambient Water Quality Monitoring Program; Samples in 2004-05 were taken as part of the UNH Stream Classification Project. NHDES 2008.

DATE OF SAMPLE	ALKALINITY, CARBONATE AS CACO3 mg/l	ALKALINITY, TOTAL MG/L	ESCHERICHIA COLI #per 10ml	ALUMINUM mg/l	CALCIUM mg/l (RDL=0.1)	CARBON, ORGANIC mg/l (RDL=0.05)	CHLORIDE mg/l	COPPER mg/l	DISSOLVED OXYGEN mg/l	DISSOLVED OXYGEN SATURATION %	HARDNESS, CA + MG RESULTS	LEAD RESULTS	MAGNESIUM mg/l
06/29/1999	7.3		325	0.057				<0.001	8	91.5	9.18	<0.001	
07/16/1999	5.7		30	0.104				<0.001	8.2	92	8.8	<0.001	
07/30/1999	7.4		130	0.072				<0.001	7.7	86.4	10.5	<0.001	
08/11/2004					2.19	6.84	1.09						0.67
08/22/2005		16											

DATE OF SAMPLE	NITROGEN, AMMONIA AS N mg/l	NITROGEN, AMMONIUM (NH4) AS NH4 ug/l	NITROGEN, DISSOLVED mg/l	NITROGEN, KJELDAHL mg/l (total N)	NITROGEN, NITRATE (NO3) mg/l	PH	PHOSPHORUS AS P mg/l	PHOSPHORUS, ORTHOPHOSPHATE AS P ug/l (RDL=5)	POTASSIUM mg/l (RDL=0.05)	SILICA AS SiO2 mg/l (RDL=0.01)	SODIUM mg/l (RDL=0.1)	SPECIFIC CONDUCTANCE	SULFATE RESULTS mg/l (RDL=0.04)	TURBIDITY National Turbidity Units	ZINC mg/l
06/29/1999	<0.1			0.3	0.33	6.02	0.012					38			0.006
07/16/1999	<0.1			0.3	0.05		0.015					19		0.7	<0.005
07/30/1999	<0.1			0.3	0.5	6.9	0.01					30		0.6	0.006
08/11/2004		2	0.38		0.07	6.48		2	0.25	1.67	2.06	23.5	0.5		
08/22/2005															

Groundwater quality may be affected by any of the management activities under consideration within Pisgah by of motorized recreation, and mechanized harvesting equipment. Oil, anti-freeze, gasoline and its additives can infiltrate into aquifers, even bedrock aquifers, causing down-gradient contamination. However, it is reasonable to assume that there is sufficient distance between the park and most of the wells that the chances of contamination are relatively small. Groundwater supplies within Pisgah may be critical for groundwater supplies down gradient, particularly for residents to the southwest of the park and the Town of Hinsdale.

Surface water

All of the surface water bodies are part of the Ashuelot River Basin. The major surface water streams are listed below. All have high water quality, although they are naturally acidic because of the nature of the bedrock, which does not yield the elements needed to buffer acids, such as calcium and magnesium.
There are five major streams in Pisgah: Broad Brook: (48 km); Pisgah Brook: 2.97 km; Tufts Brook: 2.42 km; Hog Tongue Brook: 4.71 km; and Snow Brook: 4.08 km. Tributaries to these streams add another substantial amount of surface water; maps show 12 tributaries to Broad Brook, for example, covering 23.04 km.

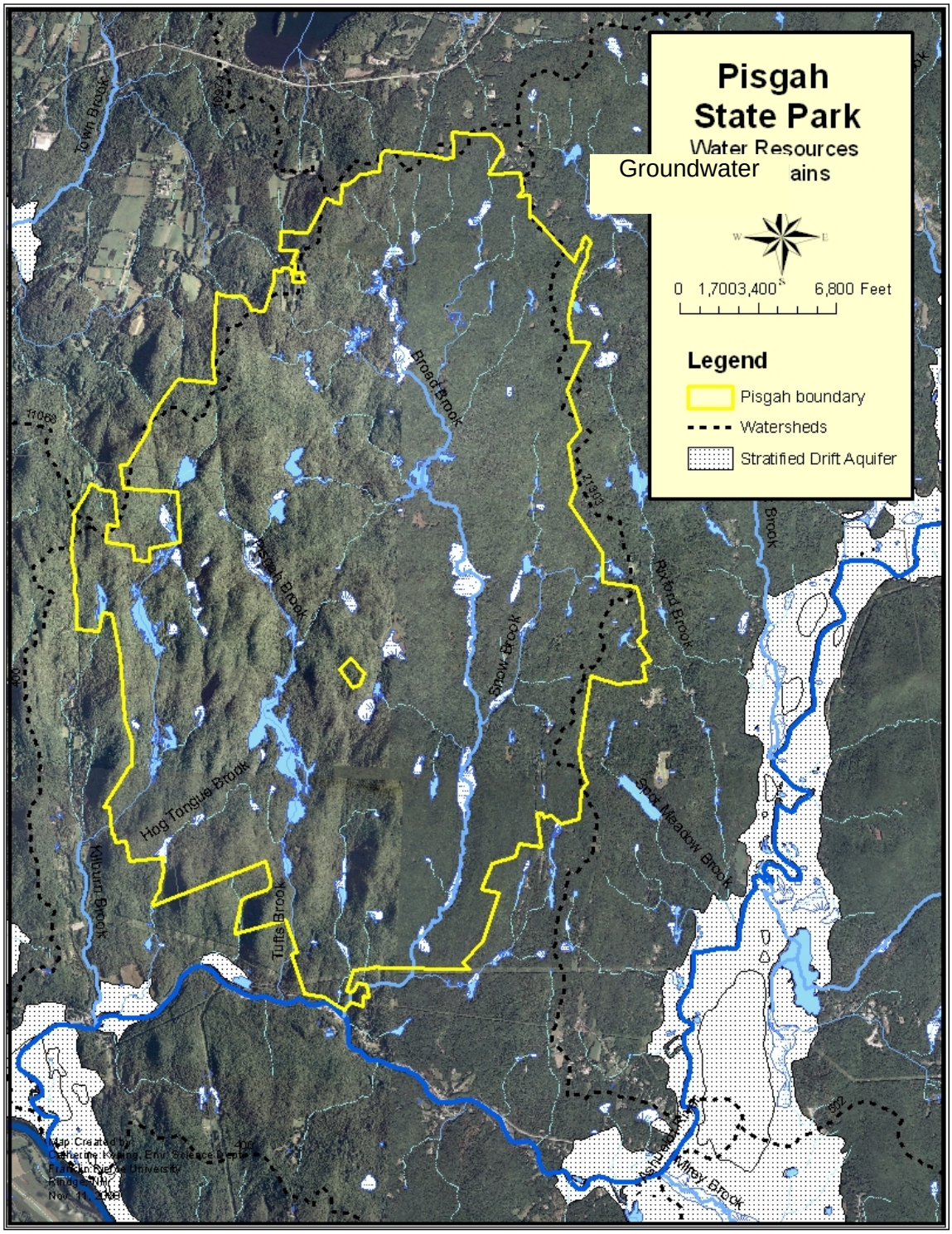
Pisgah State Park contains seven named ponds: Pisgah Reservoir (115 acres), Kilburn Pond (35 acres), Fullam Pond (21 acres), Baker Pond (16 acres), Lily Pond (16 acres), North Round Pond (12 acres), and Tufts Pond (7.5 acres). Eight ponds of similar size (5.8 – 13.5 acres) are currently unnamed. Consistent with the groundwater quality, all of the ponds are acidic and relatively low nutrient, according to the Department of Environmental Services (DES). Based on an ecological assessment conducted by The Nature Conservancy, four lakes and ponds in Pisgah SP are among the top ten in their class statewide.

Floodplains and Flood Control

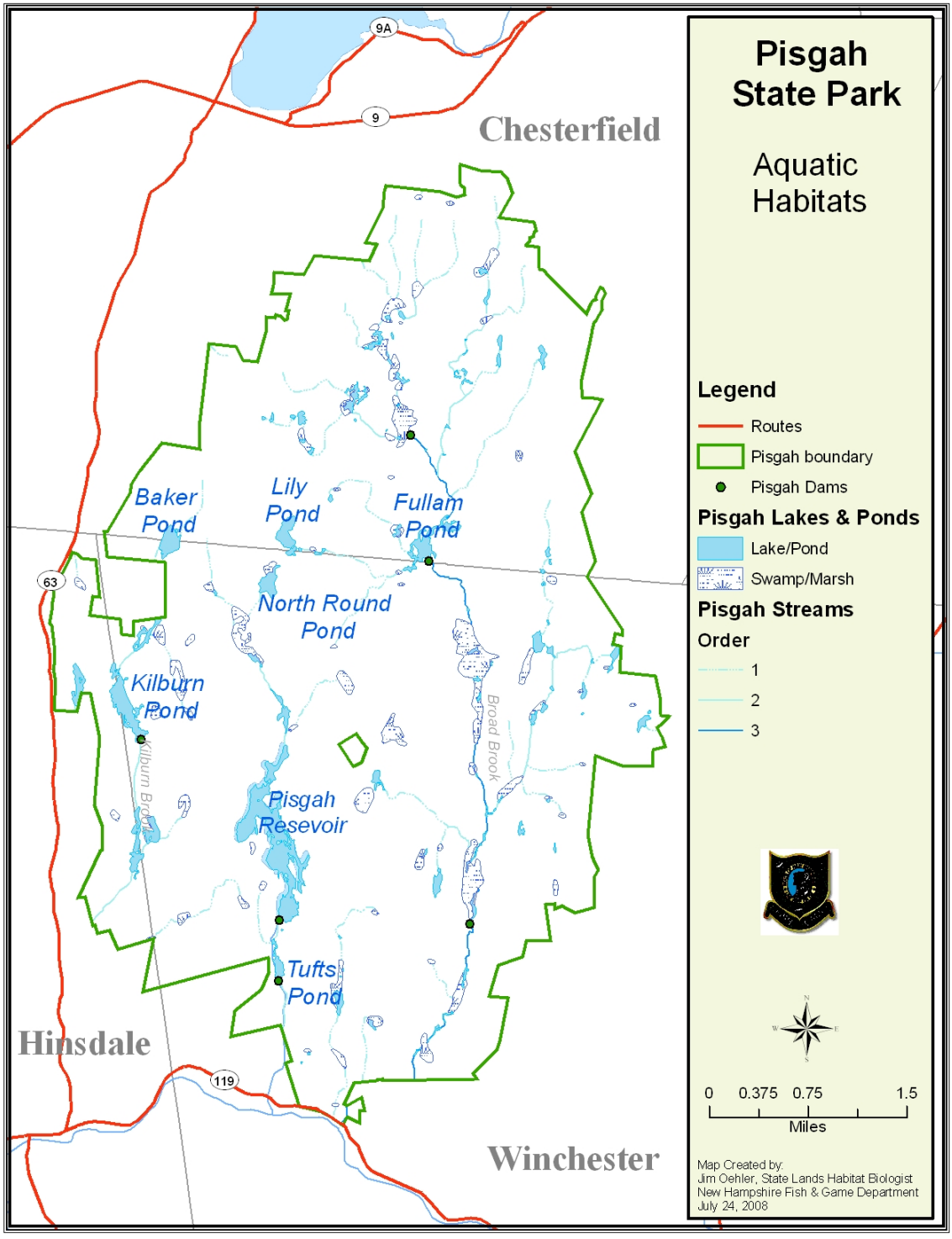
There are four small areas that fall within the 100-year floodplain (Figure 6): the upper reaches of Broad Brook, below Kilburn pond, along a tributary of Kilburn Brook, and a small area along Hog's Tongue Brook. The largest is along Broad Brook, but since there is no development in this area, and the flow downstream is controlled by a dam at Fullam Pond, there is little flooding danger. The other three floodplain areas might bear more study, since they are on the edges of the park and upstream from residential areas.

There are six dams in Pisgah State Park, the largest dams are at the outlet to Pisgah Reservoir, and at Fullam Pond. Most of these dams were constructed for power for sawmills or gristmills. A recent study found that both dams were severe barriers to fish passage (Bechtel, 2007). Park staff, under the guidance of the NHDRED Design, Development and Maintenance Office (2008 contact: Seth Prescott) maintain the dams. DES inspects the dams yearly and makes sure there is an operation and maintenance plan, as well as Emergency Action Plans; the contact at the NHDES Dam Bureau is Steve Doyon. In addition to the human-built dams, beaver dams are also a concern; they can breach and cause downstream flooding. Therefore there is a need to manage any beaver dams that have roads downstream.

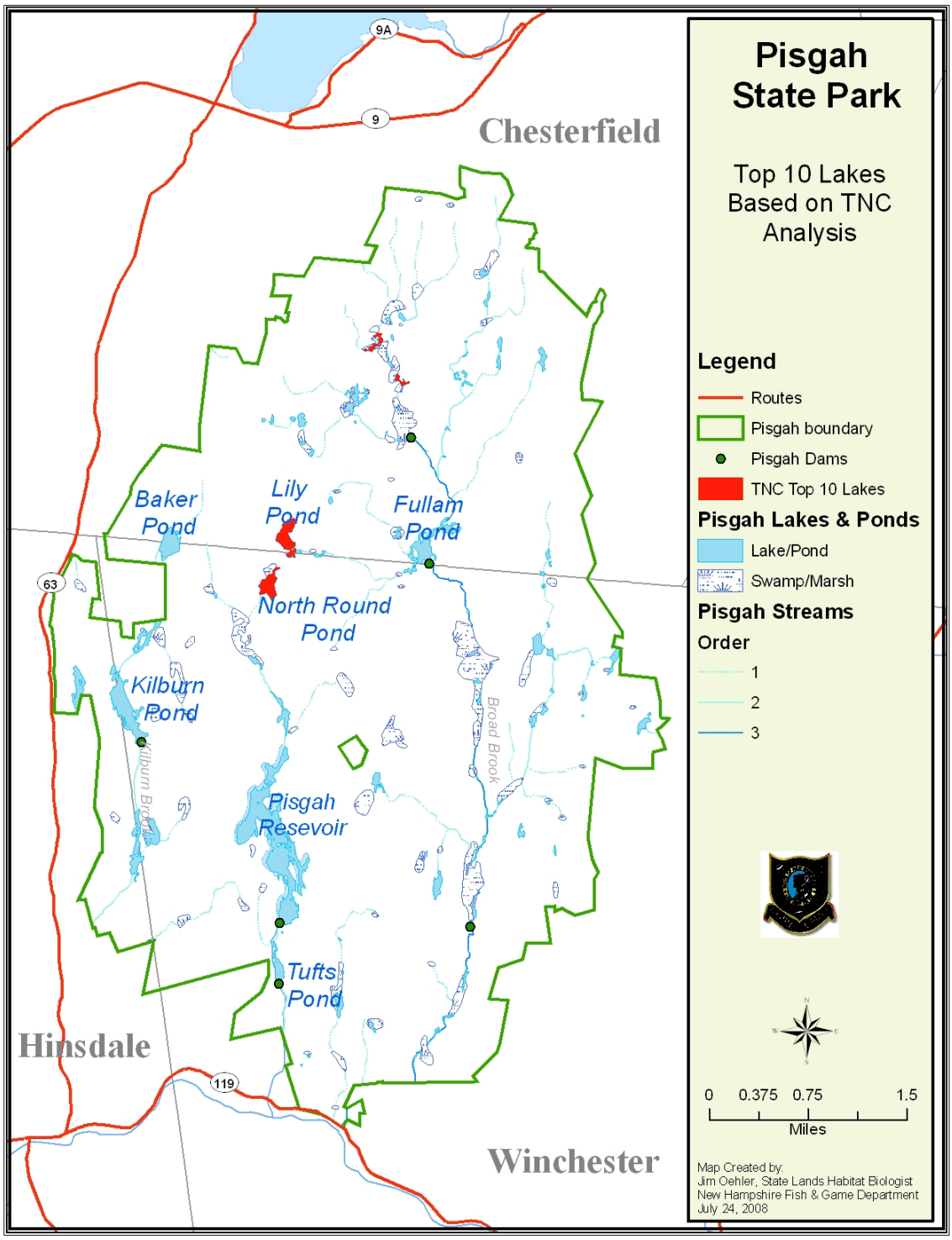
Groundwater Resources of Pisgah State Park.



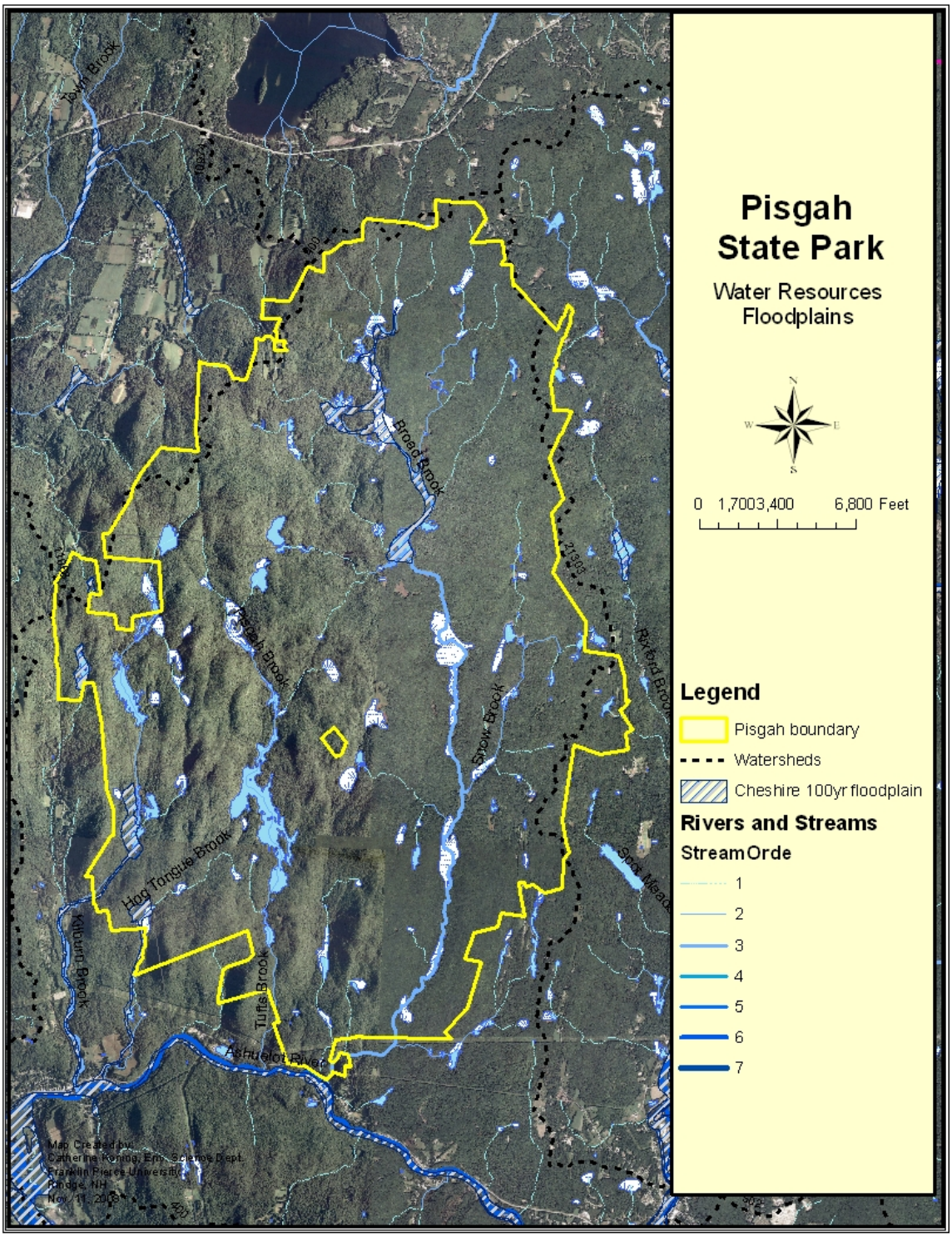
Aquatic habitats (lakes/ponds, streams/rivers, and marshes) at Pisgah State Park.



Location of "Top 10 Lakes" in Pisgah State Park based on a statewide GIS assessment conducted The Nature Conservancy.



Floodplains of Pisgah State Park



Dams in Pisgah State Park

Name	River	Dam Type	Use	Hazard Class A=low, B=significant C=high	Status	Impounded Area	Height
Broad Brook Lake Dam	Broad Brook	Earth	Recreation		Not Built	313.00	8.0
Fullam Pond Dam	Broad Brook	Stone/ Earth/ Concrete	Recreation	A	Active	31.40	18.0
Kilburn Pond Dam	Kilburn Brook	Concrete	Recreation	A	Active	37.0	15.0
Pisgah Reservoir Dam	Tufts Brook	Earth	Recreation	C	Active	110.0	33.0
Broad Brook Dam	Broad Brook		Recreation		Ruins	0.0	0.0
Tufts Ponds Dam	Tufts Brook	Stone/ Earth	Conservation		Breached	5.0	6.0

The dam at Pisgah Reservoir (dam #255.11) has an Emergency Action Plan (EAP), which was developed by NHDES-Water Division administrative rules, Part Env-Wr 505. The EAP is designed to notify local emergency response personnel in case of the development of a potentially hazardous situation at the dam (NHDES 2004a). DRED is the owner and operator of both dams, and is responsible for safety. Two condition levels are outlined in the EAP. First is Condition Yellow, which includes serious seepage, movement, cracking, erosion or other major deterioration of the dam. In this condition, the dam will be closely monitored. Condition Red occurs when water overtops the dam. This code system has been changed but the EAP for Pisgah has not yet been updated. The dam monitor calls 911 and then the notification procedures are followed; actions to prevent or mitigate overtopping may then be taken, and evacuation of specific areas downstream may be required. The notification flow chart is updated every 2 years. The Park manager starts notification in case of imminent flooding, notifies Regional park mgr, state police Emergency Operations Center and DOT.

The Pisgah Reservoir Dam was built in 1870 and reconstructed in 1984. It is a gravity stone-masonry dam with earth fill behind, and a service road runs over it. The dam is 33 feet high, 90 feet long, with a 20-foot top-width. A 60' side-channel overflow spillway dike is located approximately 100 feet east of the dam. A 130 foot long dike blocks a saddle just west of the dam. The dike runs perpendicular to the dam, and its faces are made of masonry block (NHDES 2004a). The dam drains an area of 2.4 square-miles. The pond area at normal height, is 110 acres, and stores 660 acre-feet of water. At maximum height (top of the dam) the pond is 190 acres and stores 950 acre-feet of water. During a 100-year storm, the reservoir is expected to discharge 425 cubic feet of water per second (cf/s); the discharge capacity of the dam, assuming water level is one foot below the top of the dam, is 690 cf/s with the gate closed and 825 cf/s with the gate open (NHDES 2004a). The dam is capable of passing 960 cf/s with no operations and 1 foot freeboard at the main dam/dike and 461 cf/s with 1 foot of freeboard at the west dike and 2 feet of freeboard at the main dam (NHDES 2004a). Therefore, the analysis shows that the dam is capable of handling 100-year storms, as long as the dam remains intact.

After passing over the dam, Pisgah Brook flows south to Tufts Pond, ¼ mile downstream. The stream discharging from Tufts Pond is Tufts Brook, which flows southerly about 1.2 miles before emptying into

the Ashuelot River, approximately 3.5 miles upstream of the Ashuelot's confluence with the Connecticut River.

The water levels in the Pisgah Reservoir are controlled by a crank, which is accessed via a manhole set in the concrete spillway. Access to this manhole during a flood is difficult and dangerous. During the floods of 2005, DRED required Pisgah park staff to place sand bags around the dam, although no water was going over the dam and 8-10" of water was going over the spillway.

According to the EAP (NHDES 2004a), the effects of dam failure in the Pisgah reservoir were analyzed using the National Weather Service Dam-Break Flood Forecasting Computer Model, assuming a worst-case scenario, that the dam failed during storm conditions, when the Ashuelot River would already be at flood stages. An increase in water depth from 2.5-12.0 feet could result, depending on the location. See Inundation map Dam #255.11.

Several areas downstream could be affected, including:

- A residential area at Route 119, approximately 1.2 miles downstream of the dam. The road would be overtopped, and the failure of the embankment is likely. Homes could experience flooding at depths of approximately 5' above their sills.
- The mill adjacent to the Dam on the Ashuelot River could be damaged. The stone retaining wall adjacent to the river could be seriously damaged. The maximum flood depth would be approximately 2 feet above the top of the wall.
- Some homes near the McGoldrick Mill in Hinsdale (on the north bank of the river) could receive flooding above their sills.
- A ball park immediately downstream of Route 63, in Hinsdale, could be inundated by approximately 3 feet of water.

Maximum depths and flows at critical areas downstream of the dam (NHDES 2004a).

Summary of Dam Failure Analysis
100 Year Storm Conditions in Ashuelot River

Downstream Distance from Pisgah Reservoir Dam (miles)	**Peak Failure Discharge (cf/s)**	**Pre-Failure Storm Flow (cf/s)**	**Depth after Dam Failure**		**Location Description**
			Maximum river depth (ft)	**Increase in depth over flood conditions**	
1.2	11,250	500	12.0	12.0	Route 119
1.4	20,160	9200	14.0	7.0	Ashuelot River, Winchester 0.2 miles below confluence with Tufts Brook
1.7	19,850	9270	8.5	2.5	Hinsdale, Just upstream of Depot Road
2.35	19,680	9270	10.5	3.0	Route 63
3.0	19,420	9270	9.5	3.0	River Rd., Wastewater Treatment Plant

Fullam Pond was reconstructed in 1987, and it actually has two dams. According to the operation and management plan (DRED 1998), there is an 18' high section of the dam with a spillway, which is watched with no specific operations made. The other 32' dam is 3'2" above the top of the base slab and is concrete for the entire length. The height of the water over the dam at the spillway is maintained so the water just runs over the top of the concrete spillway (DRED 1998). Dams are inspected yearly by personnel from the Dam Bureau, and inspected for cracks, spauling, movement, etc.

The park manager indicated that the spillway dam is made of wooden blocks or backboards. 1-2 boards are removed from the dam at Fullam if the water gets to 5-6" over the spillway. Repucci keeps an eye on the weather, and every fall goes and takes two sets of boards out, and puts them back in spring when the ground is dry (after mud season, approximately May 23). In 2007, Reppucci replaced the rotting boards with a new set. In 2008, NH DOT personnel working on a bridge repair on Highway 119 were allowed to drain the pond down for several weeks.

The maintenance plan (DRED 1998) states that the dams should be checked weekly, and floating debris is removed; beavers are active in the area. Any erosion of embankments or abutments is supposed to be repaired and re-seeded semi-annually. Both dams have to be kept clear of brush and debris, which is done on an annual basis. Flashboards in the dam are inspected annually, as are the bridge gate and framework over the dam, and replaced as necessary. According to park manager Norma Reppucci, water levels in the dams are maintained so that there is only about 2-3" of water running over the dam at Fullam or the spillway at Pisgah (Reppucci, pers. comm., 2007). Reppucci's biggest concern about managing the dams is that there are few specific guidelines for maintenance and operations, and it takes a while for a manager to come up to speed. She keeps a close eye on the weather and visits the dams frequently during wet periods.

The dam at Kilburn Pond, built in 1935, is owned and operated by the Town of Hinsdale; it used to serve as a water supply but is not used as such anymore, and is currently only a recreational water body. It drains 0.46 square miles. According to the 2004 inspection report, (NHDES 2004b), it has a maximum capacity of 2,329 cf/s, which is well below the 100-year storm prediction of 51 cf/s outflow. A recent analysis of the effects of a dam breach in 2002 showed that there is no predicted flooding of downstream residences. Minor damage to Route 63 and downstream dam #117.09 would occur. The dam was re-classified from hazard level B (moderate hazard) to level A (low hazard) in 2004 because of this information. There is no operation and maintenance plan on file. The 2004 NHDES inspection report recommended that the Town of Hinsdale repair the concrete deterioration along the interfaces of the spillway and abutment walls and the central concrete pier, and that they complete and submit an operation and maintenance plan.

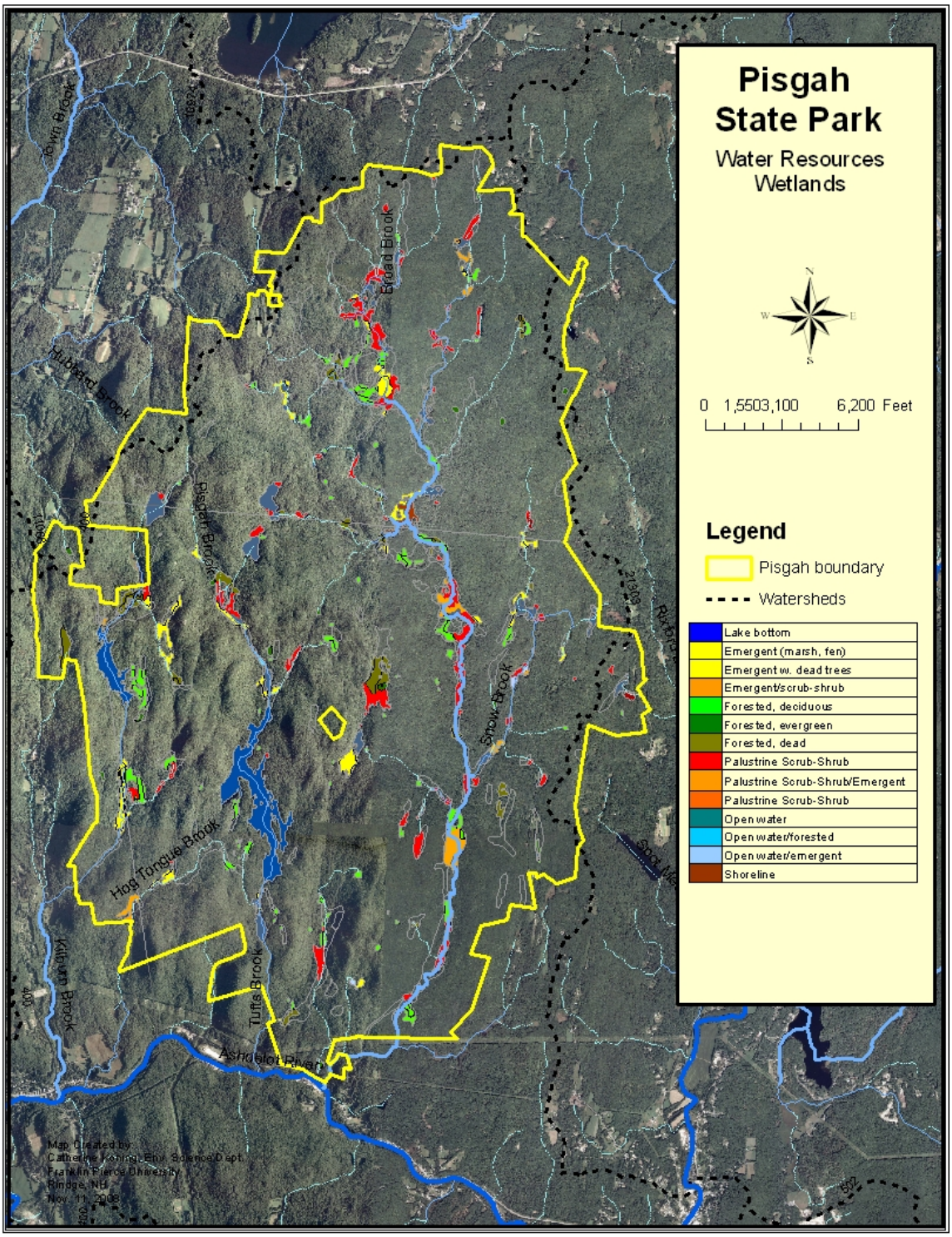
Wetlands

Wetland areas are important not only as habitat for biodiversity, for chemical uptake, transformation and release into the soil, water and atmosphere, but also for flood control, groundwater recharge and discharge, pollutant removal, stream-flow maintenance, erosion control, and other critical processes related to water resources. They also may perform many social functions, including educational and recreational opportunities, and aesthetic enhancement, as well as others (Amman and Stone 1991).

There are approximately 688 acres of wetlands in Pisgah State Park. This number has not been confirmed by actual measurement on the ground, but was estimated from GRANIT map data on hydric soils (A and B) and National Wetland Inventory (NWI) map data. These two data layers were combined in ArcGIS

9.2 and their areas measured. Because hydric soils are likely to be wetland areas that were not detected from aerial photos used for the NWI maps, the "wetland type" assigned to them was determined from the

Wetlands of Pisgah State Park



nearest NWI wetland, and may be inaccurate. Inspection of the resulting wetland map, with the topographic map and the aerial photos, does show some areas of inconsistency, particularly in the Broad Brook NW catchment basin, where Hydric A soils are not in locations that would seem likely for wetlands to form. Therefore, the data in Table 1 should be considered estimates until field verifications are made. See the Natural Communities and the Wildlife section for more detailed descriptions of wetland types.

Wetland types and acreage at Pisgah State Park.

NWI Code	Wetland Type	Acres	Percentage of Park
PUB1/EM1	Open water/emergent	3.47	0.03
PEM1/SS1Eb	Emergent/Scrub/ shrub	4.63	0.03
PSS5	Palustrine Scrub/Shrub	4.96	0.04
PUB/FO	Open water/forested	5.21	004
PUS	Shoreline	13.27	0.10
PFO4	Forested, evergreen	18.48	0.14
PEM1/FO5Eb	Emergent w/dead trees	21.66	0.16
PSS1/EM1E	Palustrine Scrub/Shrub/ Emergent	48.40	.35
PFO5	Forested, dead	90.72	.66
PEM1	Emergent (marsh, fen)	107.00	.78
PUB	Open water	142.89	1.05
L1UBHh	Lake bottom	159.71	1.17
PFO1	Forested, deciduous	162.13	1.19
PSS1	Palustrine, Scrub/Shrub	208.36	1.52
U	Upland	12,677.30	92.75
	Total	13,668.16	100.00
	Total Wetland Area	688.29	

Flood control is an important function, and large wetlands with small watersheds are valuable for flood control, as well as wetlands with restricted outlets, which will hold water longer, and prevent downstream floods (Amman and Stone 1991). The wetlands in Pisgah are generally small with relatively large sub-watersheds, and many have restricted outlets due to beaver dams. Most of them are located along the main streams, and as a result, they may play a significant role in flood control, particularly in the Pisgah Reservoir watershed, since downstream flooding is a concern there.

Wetlands may also serve as groundwater seepage areas (groundwater discharge) or areas where water percolates downward into the groundwater aquifer (groundwater recharge), although the latter is relatively rare. Figure 2 shows that there are no stratified drift aquifers in Pisgah, but there are some stratified drift aquifers in the Hinsdale area, downstream; they are far enough away that it is unlikely that groundwater exchange from the Pisgah wetlands plays a large role in their water quality (Amman and Stone 1991).

Related to flood control and groundwater discharge, wetlands also modulate stream-flow, since groundwater and surface water flows into the wetland, and the wetland soil and vegetation controls the temperature, chemistry and outflow rates. Many of Pisgah's wetlands are located along streams, so they are likely to have a large impact on water flows and water quality in the streams.

Flooded or ponded wetlands can be important for trapping sediments, and reducing pollutants such as nutrients which can cause algae blooms and eutrophication in downstream water bodies. Since Pisgah

State Park is so undeveloped, there are little or no sources of these pollutants. However, if such pollutants were produced due to poorly managed construction or forestry operations, then those wetlands with deep open water and emergent or floating vegetation would be important for sediment trapping and nutrient removal (Amman and Stone 1991), and wetlands with seasonal variation in water levels would be useful for pollutant transformation (Mitsch and Gosselink 2000). Many of the wetlands in Pisgah have bog-like vegetation indicative of low-nutrient conditions, which would not be able to remove excess nutrients without major changes in plant species composition. These wetlands are particularly vulnerable to erosion and sedimentation.

The table shown above illustrates the approximate areas of different wetland types within Pisgah State Park and includes both areas mapped as wetlands by the National Wetlands Inventory and hydric soils. Open water areas and lake-bottom areas were not considered wetlands in the total acres of wetlands. The total wetland area shown here is less than the total reported in the Forest Resource section, presumably because the Div. of Forests and Lands includes upland inclusions in their map of wetland polygons.

Key Findings

- Limited surface water quality data are available. Data from Broad Brook at the crossing with Rte. 119 show no indications of nutrient enrichment such as nitrogen or phosphorus. Calcium, potassium, silica, sodium and sulfate are above the recommended daily limits.
- The actual extent and type of wetlands in Pisgah is not clear because of inconsistencies in mapping and lack of map verification.
- Surface water and wetlands are particularly vulnerable to changes in land use. Many of the wetlands in Pisgah have bog-like vegetation indicative of low-nutrient conditions, which would not be able to remove excess nutrients without major changes in plant species composition. These wetlands are particularly vulnerable to erosion and sedimentation. Most of the wetlands are located along the main streams, and as a result, they may play a significant role in flood control, and water quality in the streams.
- Groundwater resources are limited in this area. Groundwater quality is good. Groundwater supplies within Pisgah may be critical for groundwater supplies down gradient, particularly for residents to the southwest of the park and the Town of Hinsdale.
- Because Pisgah is at the top of its watershed, its groundwater is unlikely to be affected by contaminants up-gradient (to the north and east), although bedrock wells may have complex and undetected connections deep underground. As long as groundwater is not pumped out of Pisgah, these kinds of problems are not anticipated. Groundwater quality may be affected by any of the management activities under consideration within Pisgah that uses motorized vehicles; contamination of other areas from gasoline additives such as MTBE (no longer used) illustrate the potential problem. Although there are very few wells within Pisgah that would be affected, there are several to the southwest of the park, which presumably would be in the flow path of any oil or chemical spill in the park. This does include the Hinsdale municipal water supply. However, it is reasonable to assume that there is sufficient distance between the park and most of the wells that the chances of contamination are relatively small.
- There is only a small area of land in the 100-year floodplain, and most of it is along Broad Brook which has no development, so flooding issues are not likely there. The other three small 100-year floodplain areas might bear more study, since they are on the edges of the park and upstream from residential areas.
- There are six dams in Pisgah State Park. A recent study found that two of the dams were severe barriers to fish passage.
- NHDES analysis of the effects of dam failure in the Pisgah reservoir showed potentially severe impacts. Failure of the dam could lead to flooding downstream, resulting in an increase in water

depth from 2.5-12.0 feet, depending on the location. Other dams have maintenance issues and similar concerns.

Recommendations

- Hazards at the Pisgah Reservoir are so high that management should consider dropping the water level in the reservoir 1-2' to reduce the risk of flooding. Any forestry operations should be aware of potential impacts to the Pisgah reservoir, as it is a high-hazard dam. Beaver dams that are upstream from roads need to be monitored and managed.
- Other issues of concern would be the obstacles to fish passage presented by all the dams;
- Dam removal might be worth consideration for some of the smaller dams.
- If additional wells are installed in Pisgah for public water use, more information will be needed on potential contaminants and flow paths.
- Additional mapping of groundwater flows is needed, to determine the connection of groundwater within Pisgah with groundwater resources located down hill.
- If best forestry management practices are employed, and large areas of uplands are not subject to timber harvest over too short a time period, then long-term negative impacts to wetlands and surface water probably can be avoided. Good Forestry in the Granite State (DRED 2011) presents recommended management (limited harvest) and no-harvest zones around surface water and wetlands; strict adherence to these guidelines and other best management practices for erosion control should provide adequate protection for these resources.
- A baseline study would allow future monitoring of any large-scale land management activities to detect changes in water quality and quantity. A study of the wetlands and streams at the outflow of the catchment basins, comparing areas that are not likely to be harvested with those that will be logged, would be useful for a before-after-control-impact study.
- Wetland maps should be field-verified.

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Natural Communities[4]

Natural communities, as defined by the New Hampshire Natural Heritage Bureau, are combinations of distinct plant assemblages, their physical environments, and the ecological processes that affect them (Sperduto 2004). Essentially, they are ecological units that are repeated on the landscape. Natural communities include both uplands and wetlands such as forests and woodlands, shorelines, marshes, forested swamps, peatlands, floodplains, and aquatic systems. These communities provide scientists and resource managers with an ecological understanding of the land and its inhabitants to make informed decisions regarding land management options. Therefore, natural community classifications provide a powerful tool to guide strategic land use planning. Equally as important, they provide a basis from which inventory and monitoring programs can be developed, and a means to document and track rare species and exemplary natural communities.

The NHNHB, a bureau within DRED's Division of Forest and Lands, is responsible for locating, tracking, and facilitating the protection of rare and imperiled plants and exemplary natural communities. They have developed an extensive classification system for natural communities in New Hampshire (Sperduto 2004). This classification system was the basis from which the various forest and wetland communities of Pisgah State Park were identified.

During 2007 and 2008, Peter J. Bowman of the New Hampshire Natural Heritage Bureau conducted field visits to 635 observation points within Pisgah State Park for the purposes of gathering data on the floristic and ecological diversity to help inform management considerations for the property (Bowman 2009). Data collected at each point included the following:

- Natural community system type (Sperduto 2005)
- Natural community type (Sperduto and Nichols 2004)
- Identification of all native and non-native plant species
- Percent cover estimates for all plant species
- Other descriptive notes including information on soils and other physical site
- characteristics, evidence of human disturbance, size of the community, and
- wildlife.

These data, as well as the New Hampshire Wildlife Action Plan (2005) and other anecdotal information gathered by Tom Wessels (2008) and Jeffry Littleton (2006-2009), were incorporated into the findings and recommendations of this chapter.

[4] Pete Bowman, New Hampshire Natural Heritage Bureau, and Jeffrey Littleton, Moosewood Ecological

Natural communities of Pisgah State Park.

- Wooded Uplands
  - Spruce-Fir Zone
    - Lowland Spruce-Fir Forest
  - Northern and Transition Hardwood – Conifer Zone
    - Sugar Maple- Beech – Yellow Birch Forest
    - Hemlock-Beech-Oak-Pine Forest
    - Hemlock-Oak-Northern Hardwood Forest
    - Hemlock Forest
    - Beech Forest
    - Semi-rich Mesic Sugar Maple Forest
    - Rich Mesic Forest
- Wooded Wetlands
  - Boggy Nutrient Poor Swamps
    - Red Maple-*Sphagnum* Basin Swamp
    - Black Gum-Red Maple Swamp
  - Minerotrophic Swamps
    - Seasonally Flooded Red Maple Swamp
    - Hemlock – Cinnamon Fern Forest
    - Red Maple-Black Ash-Swamp Saxifrage Swamp
  - Forest Seeps
    - Acidic Sphagnum Forest Seep
    - Subacid Forest Seep
- Open Wetlands and Riparian Communities
  - Open Emergent Marshes and Aquatic Beds
    - Shallow Emergent Marsh
    - Medium-depth Emergent Marsh
    - Deep Emergent Marsh – Aquatic Bed
    - Tall Graminoid Emergent Marsh
    - Aquatic Bed
  - Riverbanks
    - Alder-Dogwood-Arrowwood Alluvial
  - Open Peatlands
    - Highbush Blueberry – Winterberry Shrub Thicket
    - Fenny Marsh

Vegetation

Forest covers 11,000 acres (85 percent) of Pisgah State Park. The vast majority of this forest corresponds to the ***hemlock - hardwood - pine forest system***, with the dominant natural community in this system the ***hemlock - beech - oak - pine forest***. This matrix forest community is highly variable, but is dominated by a mix of hemlock (*Tsuga canadensis*), American beech (*Fagus grandifolia*), red oak (*Quercus rubra*), and white pine (*Pinus strobus*). The relative abundances of these species vary depending on the age of a given stand, topographic position, soil conditions, and history of disturbance. Hemlock is the dominant or co-dominant tree across large portions of the landscape at Pisgah, and where it occurs to the exclusion of other tree species patches constitute a separate community type, the ***hemlock forest***.

The ***sugar maple - beech - yellow birch forest*** community, often referred to as northern hardwood forest, is the dominant matrix forest type at higher elevations of central and northern New Hampshire. The community is relatively uncommon in the southern portion of the state. Large patches of this community are located on mesic sites at higher elevations in the northern half of Pisgah State Park. As the community name indicates, the dominant tree species in this forest are sugar maple (*Acer saccharum*), American beech, and yellow birch (*Betula alleghaniensis*), with white ash (*Fraxinus americana*) often a common associate. As in northern hardwood forests elsewhere in the state, the tall shrub hobblebush (*Viburnum lantanoides*) is common at Pisgah. However, other herbaceous species characteristic of this community, such as northern wood sorrel (*Oxalis montana*), blue-bead lily (*Clintonia borealis*), and bunchberry (*Cornus canadensis*), are absent or sparse in the park.

While the ***hemlock - beech - oak - pine forest*** and the ***sugar maple - beech - yellow birch forest*** are relatively well-defined forest types, there are also areas where the dominant species of these communities overlap. Northern hardwoods such as yellow birch and sugar maple are co-dominant with red oak or hemlock in ***Hemlock – oak – northern hardwood forest.*** Often viewed as a transition zone between the two forest types, this community often occurs along a gradient, although it can be more extensive in some settings.

The bedrock geology of Pisgah State Park is not conducive to the development of enriched soil conditions. However, limited areas with rich site plant species occur within the park. These rich conditions are the result of some combination of increased mineral nutrient concentrations (typically calcium), increased organic matter accumulation, and moist to wet soils. In some areas, these conditions are the result of topography and occur at the base of steep slopes, often in concave cove settings. Organic matter collects at the base of the slope and decomposes, a process called colluviation, in essence forming a natural compost bin. The resulting soil has higher concentrations of organic matter and mineral nutrients than soils of the surrounding landscape, and is usually very moist. These moist conditions may be enhanced by fine textured soils, which hold water more effectively than coarse-grained soils. Enriched conditions are often a result of groundwater seepage, which can carry mineral nutrients to the surface. At Pisgah, the groundwater may be passing through till soils with elevated concentrations of minerals, or through fractured bedrock, where minerals are leached from the rock over very long periods of time.

Small patch communities occur in areas where enriched conditions are present, contrasting with the surrounding matrix forest. These patch communities are typically ***semi-rich mesic sugar maple forests***. The canopy of this forest type is dominated by sugar maple, often with white ash and occasionally basswood (*Tilia americana*). Herbaceous cover is often quite lush; characteristic species include Christmas fern (*Polystichum acrostichoides*), sessile-leaved bellwort (*Uvularia sessilifolia*), wakerobin (*Trillium erectum*), Jack-in-the-pulpit (*Arisaema triphyllum*). Blue cohosh (*Caulophyllum thalictroides*), a species normally associated with the ***rich mesic forest*** community, occurs in some locations.

Wetland communities are diverse and extensive at Pisgah State Park. They are associated with three major settings: riparian corridors, isolated basins, and areas of groundwater seepage. Riparian wetlands are located along every significant stream in the park, and virtually all have been impacted by beaver activity. Beavers build dams and flood forested areas, killing the trees and creating areas of open water in which they build their lodges. Eventually, the beaver abandon the pond and the dam fails, draining most of the water from the pond. Herbaceous marsh species then colonize the drained basin. Over time, shrubs displace the herb species and form shrub thickets. If conditions are suitable, these shrub thickets are themselves replaced by trees, creating a forested swamp.

The variety of herbaceous and shrub communities that develop in this successional process collectively form the ***emergent marsh - shrub swamp system***. The system communities range from the ***deep emergent marsh - aquatic bed*** in areas of permanent standing water, to dense shrublands such as the ***alder - dogwood - arrowwood alluvial thicket***. ***Medium-depth emergent marsh*** and ***tall graminoid emergent marsh*** are other common communities in these wetlands. *Sphagnum*-dominated organic soils can develop, producing peatland communities in areas where the seasonal fluctuation of the water level is reduced. The ***fenny marsh*** is a transitional community, which typically has a thin layer of peat over mineral soils, and has a mix of marsh and peatland species. Where the organic layer is deeper and seasonal water level fluctuations are less pronounced, communities that are characteristic of a ***medium level fen system*** can occur.

Isolated basin wetlands differ from riparian wetlands in both function and composition. Typically, they occur as flat or slightly concave basins without any significant streams flowing through them, although they often have a small outlet that releases water when water levels are high. Almost all isolated basin wetlands are seasonally flooded, i.e., inundated in the winter and spring and drawn down in the summer in most years.

In larger isolated wetlands, the most common community type is the ***red maple - Sphagnum basin swamp***. Red maple (*Acer rubrum*) is the dominant tree in a sparse canopy and a robust tall shrub layer is characterized by highbush blueberry (*Vaccinium corymbosum*) and winterberry (*Ilex verticillata*). Cinnamon fern (*Osmunda cinnamomea*) is usually abundant, with other herbs present including follicled sedge (*Carex folliculata*), common water horehound (*Lycopus uniflorus*), and three-seeded sedge (*Carex trisperma* var. *trisperma*). *Sphagnum* mosses are dominant, often forming a carpet across the basin. In a few Pisgah State Park red maple swamps, black gum (*Nyssa sylvatica*) is a frequent or co-dominant tree. In these instances, the community is a ***black gum - red maple basin swamp***. With the exception of the black gum, the composition is essentially the same as the ***red maple - Sphagnum basin swamp***. Swamps with black gum are uncommon, and the black gum trees in these communities can be 400 years old. Black gums in swamps elsewhere in New Hampshire are the oldest documented hardwood trees in eastern North America, and represent a unique ecological legacy.

In contrast, the surrounding forest shades smaller isolated basin wetlands and vascular plants are often absent. These small wetlands are vernal pools, and they perform a critical function in the landscape. The seasonal flood regime excludes fish predators, creating significant breeding areas for a variety of amphibian and invertebrate species.

Other wetlands at Pisgah State Park are associated with groundwater seepage. These include forest seeps and seepage swamps, which occupy tiny areas compared to riparian and isolated wetlands within the park. Forest seeps occur at the headwaters of many stream systems, are often less than ¼ acre in size, and have soft, saturated soils because of the near constant flow of groundwater. They are commonly found at slope breaks, where the slope angle changes from steep to relatively flat. Forest seeps have a higher concentration of mineral nutrients than the surrounding forest soils because of the movement of groundwater through the bedrock and soil. In some instances, the seep is large enough to be considered a

subacid forest seep community. Characteristic plants include foamflower (*Tiarella cordifolia*), northeastern mannagrass (*Glyceria melicaria*), golden saxifrage (*Chrysosplenium americanum*), and small enchanter's nightshade (*Circaea alpina*). The topography at Pisgah State Park is conducive to the development of these seeps, and they are frequent.

Red maple - black ash - swamp saxifrage swamps are larger than forest seeps, but much less common. There are three noteworthy occurrences of these swamps in Pisgah State Park, where mineral-rich water from seepage sources collects in a flat basin along a small stream. Red maple and black ash are the dominant trees, along with yellow birch. The herb layer is lush and diverse, with abundant species including swamp saxifrage (*Saxifraga pensylvanica*), Robbins' ragwort (*Packera schweinitziana*), northeastern mannagrass, dwarf raspberry (*Rubus pubescens*), sensitive fern (*Onoclea sensibilis*), and water pennywort (*Hydrocotyle americana*), among many others. The ***red maple - black ash - swamp saxifrage swamp*** community is uncommon in New Hampshire.

Exemplary Natural Community Systems

Hemlock - hardwood - pine forest system

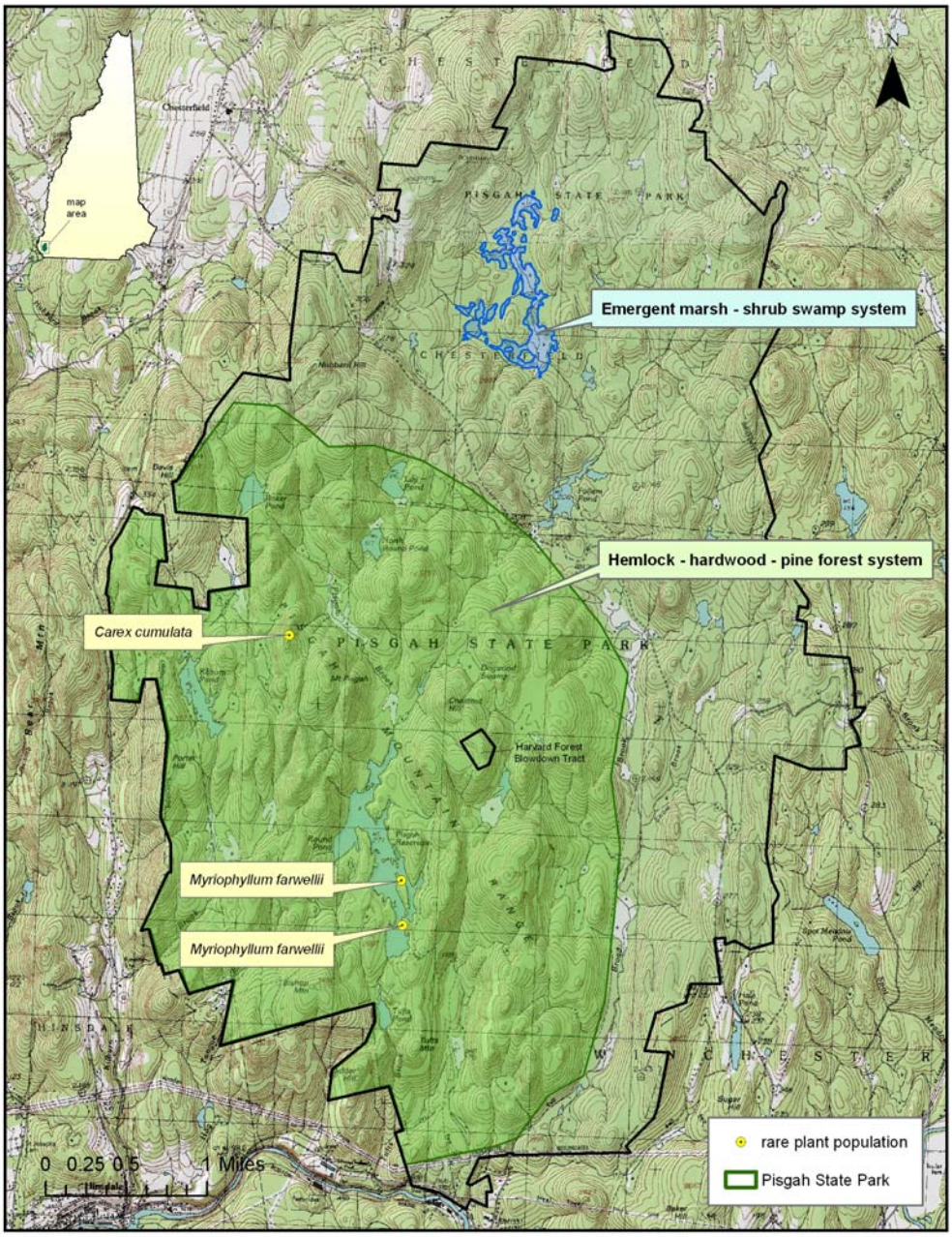
This exemplary forest system covers about 6,400 acres of the central and southern portions of Pisgah State Park. It represents an unusually large, non-fragmented example of the matrix forest of southwestern New Hampshire. The system's land use history distinguishes it from other forestlands in the region. Although it has been used for timber production for over 200 years, it was never cleared for agricultural uses, and its soil has never been tilled. In addition, old-growth forest patches have been observed within the exemplary forest ecosystem (Brant 2006; Wessels 2008).

The hemlock-hardwood-pine forest system is comprised of several natural communities. The primary matrix forest type of this system is the ***hemlock - beech - oak - pine forest***, which covers the majority of the acreage. Hemlock is the most abundant tree species, with substantial amounts of red oak and beech,

and lesser numbers of white pine and black birch (*Betula lenta*). Areas where hemlock dominates to the essential exclusion of other species are classified as ***hemlock forest***. Most of the forest has a mid to late successional condition, with a few small patches that have been identified as old growth in other studies (Jones 2006). Although coring of sample trees in these patches did not confirm the presence of unusually old trees, NHB observed other characteristics of old growth forests including unusually high volumes of coarse woody material (e.g., large logs). Evidence of past cutting history can be found throughout the forest in the form of old stumps.

Small (10 to 20 acre) inclusions of ***sugar maple - beech - yellow birch forest*** occur within the hemlock - beech - oak - pine forest. Typified by sugar maple, yellow birch, and beech, the forests usually occur on rocky slopes. The herb layer in Pisgah State Park is characterized by rock polypody (*Polypodium virginianum*), hay-scented fern (*Dennstaedtia punctilobula*), sessile-leaved bellwort, and Christmas fern, but lacks the lush cover found in more northerly examples of this community. In addition, there are areas of the transitional community ***hemlock - oak - northern hardwood forest***, where the northern hardwood species sugar maple and yellow birch mix with hemlock, red oak, and beech.

Rare plant and exemplary natural community system locations at Pisgah State Park.



Appalachian species, which have a more southern distribution, are generally absent in these forest communities, with two notable exceptions. Mountain laurel (*Kalmia latifolia*) is patchily distributed and is particularly frequent on slopes along the western boundary of the park and on scattered slopes just west of Pisgah Reservoir. Chestnut oak (*Quercus montana*) is also present, although its only significant concentrations are on Bishop Mountain in the southwest corner of the property.

Various wetland types and open water bodies also occur within the hemlock - hardwood - pine forest system. The areas occupy about 12 percent of the exemplary system's 6400 acres.

Emergent marsh - shrub swamp system

An extensive complex of open wetland communities occurs at the headwaters of Broad Brook in the northern end of Pisgah State Park. The watershed of these headwaters is located almost entirely within Pisgah, and is essentially completely forested. These wetlands have been heavily influenced by beaver activity, and there are currently at least two active beaver dams and lodges. Beaver influenced natural community systems of this type are common at Pisgah, but this example is the largest group of connected wetland openings in the park, and the only one that meets NHB's size and ecological integrity criteria for exemplary status.

The dominant communities in the system are emergent marshes, particularly the ***tall graminoid emergent marsh***. This community is typically dominated by bluejoint grass (*Calamagrostis canadensis*), often in association with tussock sedge (*Carex stricta*). Peat mats can develop in areas with restricted flow and little influence by active stream channels, resulting in the ***fenny marsh*** community. This community typically has a mixture of marsh species, such as bluejoint and common cattail (*Typha latifolia*), and fen sedges such as bottle-shaped sedge (*Carex utriculata*) and hairy-fruited sedge (*Carex lasiocarpa*).

Rare Plant Species

*Carex cumulata (*piled-up sedge*)*

This small sedge is associated with dry, rocky habitats that often have a history of fire. In the park, the plant occurs at one site, the Pisgah Mountain Vista on Mt. Pisgah, a maintained opening that affords views of Mt. Monadnock and the surrounding landscape (Figure 3). Approximately 50 flowering stems occur in a very small, moist depression immediately adjacent to the Pisgah Ridge Trail. The proximity to the trail makes the plants vulnerable to trampling from hikers, although NHB did not observe trampling impacts. Under a natural disturbance regime, the habitat for this species would be maintained by wildfires, and the presence of pitch pine (*Pinus rigida*) nearby indicates that this ridge has a past fire history. Currently, the opening is being maintained for the view, which should keep these plants from being shaded out, but the exclusion of fire will preclude new habitat from being created.

Myriophyllum farwellii (Farwell's water milfoil)

Farwell's water milfoil is an aquatic plant observed at two locations in Pisgah Reservoir (Figure 3). Both locations are in shallow water (1-3 feet deep) near the southeastern shore of the lake. This species was first observed in the reservoir in 2004 during surveys for the invasive plant water chestnut (*Trapa natans*) (Callahan 2004). The 2004 survey also identified Farwell's water milfoil in Fullam Pond within the park, although that water body was not visited during this survey.

*Panax quinquefolius (*ginseng*)*

This woodland herb occurs in areas of enriched soils at three separate locations within Pisgah. The largest population consists of roughly 50 plants scattered in a semi-rich ravine. The second population has two fruiting plants associated with an enriched seep. The last occurrence has only a single observed stem in a semi-rich ravine. NHB does not release the specific locations of ginseng populations to prevent illegal removal by commercial collectors.

Features of Local Significance

Locally significant communities are too small or lack sufficient ecological significance at a statewide scale to be exemplary natural communities. However, locally significant communities have good ecological condition and integrity, encompass community types of limited extent in the state, contribute to biological diversity, and are significant at the local scale. Locally significant communities warrant consideration when planning management activities. NHB determined that two Pisgah State Park communities were locally significant features.

Red maple - black ash - swamp saxifrage swamp

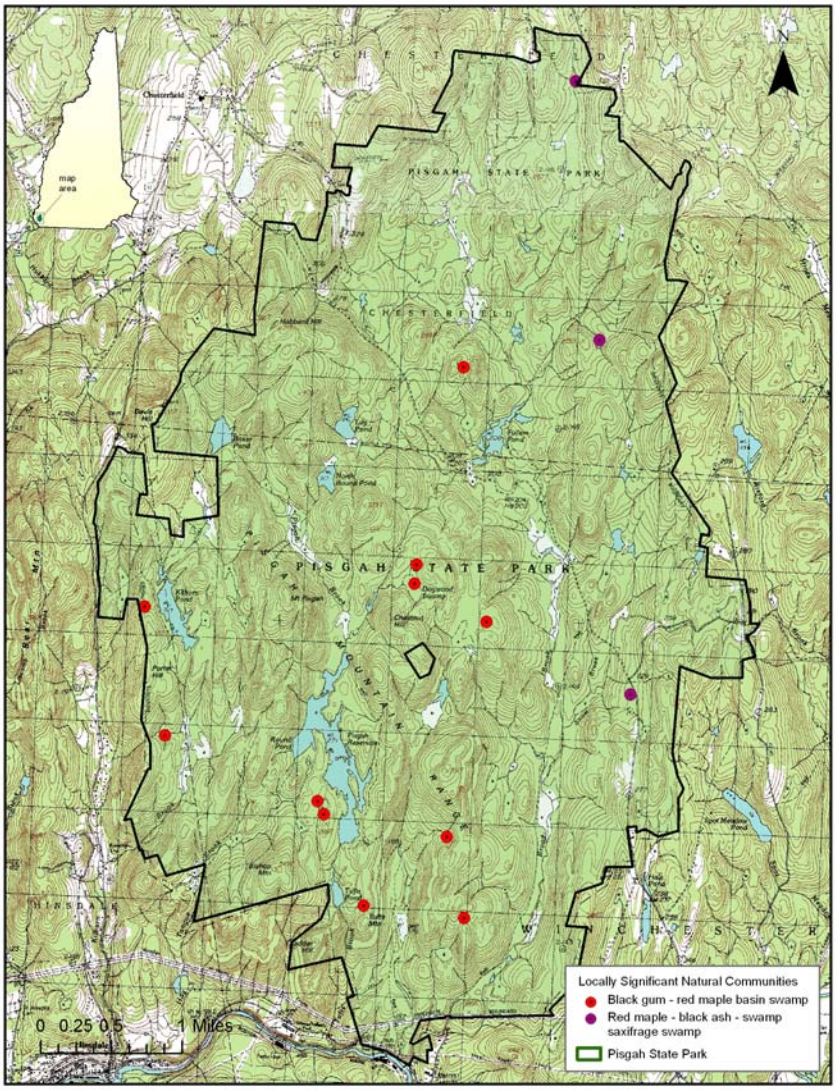
This wetland type is associated with seepage of mineral-enriched groundwater, and is uncommon at Pisgah State Park. NHB identified three occurrences of this wetland community during the survey, each too small to be considered exemplary at a statewide scale. However, the ***red maple - black ash - swamp saxifrage swamps*** are noteworthy for their contribution to the vascular plant diversity of the park. A number of plant species found in this community occur nowhere else at Pisgah State Park, such as swamp saxifrage (*Saxifraga pensylvanica*), Robbins' ragwort (*Packera schweinitziana*), and great angelica (*Angelica atropurpurea*).

Black gum - red maple basin swamp

This wetland type is very similar to the ***red maple - Sphagnum basin swamp*** community common across the landscape of Pisgah State Park. What differentiates the ***black gum - red maple basin swamp*** from ***red maple - Sphagnum basin swamp*** is the presence of black gum, a tree species that reaches the northern limit of its range in New Hampshire. Black gum is notable primarily for being an extraordinarily long-lived tree. An earlier NHB study of black gum swamps (Sperduto et al. 2000), mainly in the southeastern part of the state, found trees at a number of sites in excess of 300 years old, with extreme examples near 700 years old.

At Pisgah, there are roughly a dozen basins that contain ***black gum - red maple basin swamp*** communities, although none of them are large enough to be considered exemplary at a statewide scale. However, tree cores taken at three basins identified several trees over 300 years old, with the oldest tree over 400 years of age. It is likely that additional coring would reveal even older trees in some of these basins.

Locations of locally significant natural communities at Pisgah State Park.



Key Findings

- Pisgah State Park is embedded within a 28,000 acre block of contiguous forest.
- Pisgah State Park encompasses three natural community systems: 1) ***hemlock – hardwood -pine forest***, 2) ***emergent marsh - shrub swamp***, and 3) ***medium level fen***.
- Natural Heritage designated an estimated 6,640 acres of ***hemlock – hardwood –pine forest*** as an exemplary natural community system.
- Several distinct old-growth patches occur within the ***hemlock – hardwood - pine forest*** system.
- Natural Heritage designated an estimated 100 acres of ***emergent marsh – shrub – shrub swamp*** as an exemplary natural community system.
- Pisgah State Park encompasses 24 known natural communities, including 8 upland forest community types and 16 wetland community types.
- Natural Heritage designated ***red maple-black ash-swamp saxifrage swamps*** and ***black gum-red maple swamps*** as features of local significance.
- Protected plants at Pisgah State Park include the state endangered *Carex cumulata* (piledup sedge), state endangered *Myriophyllum farwellii* (Farwell's water milfoil), and state threatened *Panax quinquefolius* (ginseng).

Recommendations

- Exclude 4,723 acres of exemplary ***hemlock – hardwood - pine forest*** in Criteria 1 from routine commercial timber management, and apply Natural Preserve Area zoning. An estimated 1,500 acres of inoperable or inaccessible exemplary ***hemlock – hardwood - pine forest*** in Criteria 2, adjacent to the Natural Preserve Area, will also be exempt from routine commercial timber management.
- The Natural Heritage and Forest Management Bureaus will partner in multidisciplinary research with a goal to enhance ecological processes within an estimated 300 acres of operable and accessible exemplary ***hemlock – hardwood - pine forest*** in Criteria 2.
- Apply Natural Preserve Area zoning to an estimated 100 acres of exemplary ***emergent marsh – shrub – shrub swamp***.
- Natural Heritage will evaluate opportunities for managing *Carex cumulata*, including fire management.
- The Trails Bureau, or its designee, will maintain trails to avoid or minimize impacts to natural communities.
- The Trails Bureau will, to the best of its ability, enforce trail rules, and coordinate with Fish & Game and local law enforcement agencies on trail law enforcement matters.
- DRED and/or other stakeholders will conduct additional surveys of non-native invasive plants, and develop a plan to control existing invasive plants and prevent establishment of new populations as needed.
- The Forest Management Bureau will continue to seek Natural Heritage input prior to initiation of a timber harvest.
- Natural Heritage will encourage ecological research throughout Pisgah. DRED must approve any research in advance and in writing. A Special Use Permit may be required.

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Invasive Plants in Pisgah State Park[5]

Given their propensity for out-competing and displacing native species, invasive plants pose a significant threat to natural communities (NHDAMF & NHISC 2005). To document current conditions, two surveys independently conducted by New Hampshire Natural Heritage Bureau (NHNHB) and Ashuelot Valley Environmental Observatory (AVEO) explored the extent of invasive plant establishment in Pisgah State Park (Pisgah) in Cheshire County, NH. Six invasive species - common reed (*Phragmites australis*), Japanese barberry (*Berberis thunbergii*), garlic mustard (*Allaria petiolata*), glossy buckthorn (*Frangula alnus*), purple loosestrife (*Lythrum salicaria*), and wall-lettuce (*Lactuca muralis*) - were noted during an ecological inventory conducted by NHNHB (Bowman 2009). In response to the need for further study, AVEO Citizen Scientists carried out a second survey covering all trails and roads in Pisgah. AVEO documented five invasive species, including Japanese barberry, glossy buckthorn, multiflora rose (*Rosa multiflora*), Oriental bittersweet (*Celastrus orbiculatus*), and purple loosestrife at 29 trailside locations, and non-native bush honeysuckle (*Lonicera* spp.) and winged burning bush (*Euonymus alatus*) at several areas off-trail (Moon et al. 2009). Other invasive plants known to occur in the region, including Japanese knotweed (*Polygonum cuspidatum*), autumn olive (*Elaeagnus umbellata*) and common (European) buckthorn (*Rhamnus cathartica*), were not documented at Pisgah. Both NHNHB and AVEO found invasive plants to be sparsely distributed throughout Pisgah, documenting their presence primarily at John Hill Road, Old Chesterfield Road, and trails near the Habitat Trail/Horseshoe Road trailhead. The majority of occurrences were noted within 0.5 miles of the park's boundary and generally corresponded with past or present anthropogenic disturbance. Management of existing occurrences, prevention of additional establishment, and implementation of a monitoring protocol in areas of increasing land use are necessary to gauge and curtail the presence and spread of invasive plant species throughout Pisgah.

In southern New England, "large areas of protected forestland are uncommon, conserved forests are largely disconnected, important natural and cultural resources (including many plant and animal species) are vulnerable to loss" (Foster et al. 2005; pg. 2). As New Hampshire's largest state park, Pisgah State Park's 13,421 acre mosaic of rugged topography, mature- and old-growth forests, wetlands, mid-succession habitat, and rich cultural history affords an unparalleled setting for conservation, recreation and education, while providing a vast array of ecosystem services. Considering myriad ecological, social, aesthetic, and economic benefits of large tracts of conserved land (Foster et al. 2005), Pisgah requires nothing less than best management practices. This includes monitoring and management of ecological threats, not the least of which is the establishment of invasive plants.

Invasive plants are non-native species that have several characteristics allowing them to out-compete native plants and negatively impact natural areas. These species reproduce rapidly, grow quickly and often earlier in the season than native plants, and adapt to various environmental conditions (NHDAMF & NHISC 2005). Given these advantages, it is crucial to determine where, and to what extent, invasive plants occur on lands where conservation of natural communities is a priority. Pisgah currently "has relatively few invasive plant species for a property of its size," primarily because conditions throughout the majority of Pisgah are not conducive to supporting invasive species (Bowman 2009; pg. 21). Several species, however, are present in southwest New Hampshire and have the potential to achieve a greater foothold in the region at large and in Pisgah in particular. Among these are: Japanese barberry, Oriental bittersweet, autumn olive, winged burning bush, non-native bush honeysuckles, purple loosestrife, glossy buckthorn, European buckthorn, Japanese knotweed, common reed and multiflora rose (NHDAMF &

[5] D. Moon and B. A. Thelen, Ashuelot Valley Environmental Observatory, and K. A. Yard, Ashuelot Valley Environmental Observatory and Antioch University New England

NHISC 2005). To date, management of invasive plants in Pisgah has occurred in the John Hill Road area; techniques included herbicide treatments and mowing.

Current Conditions

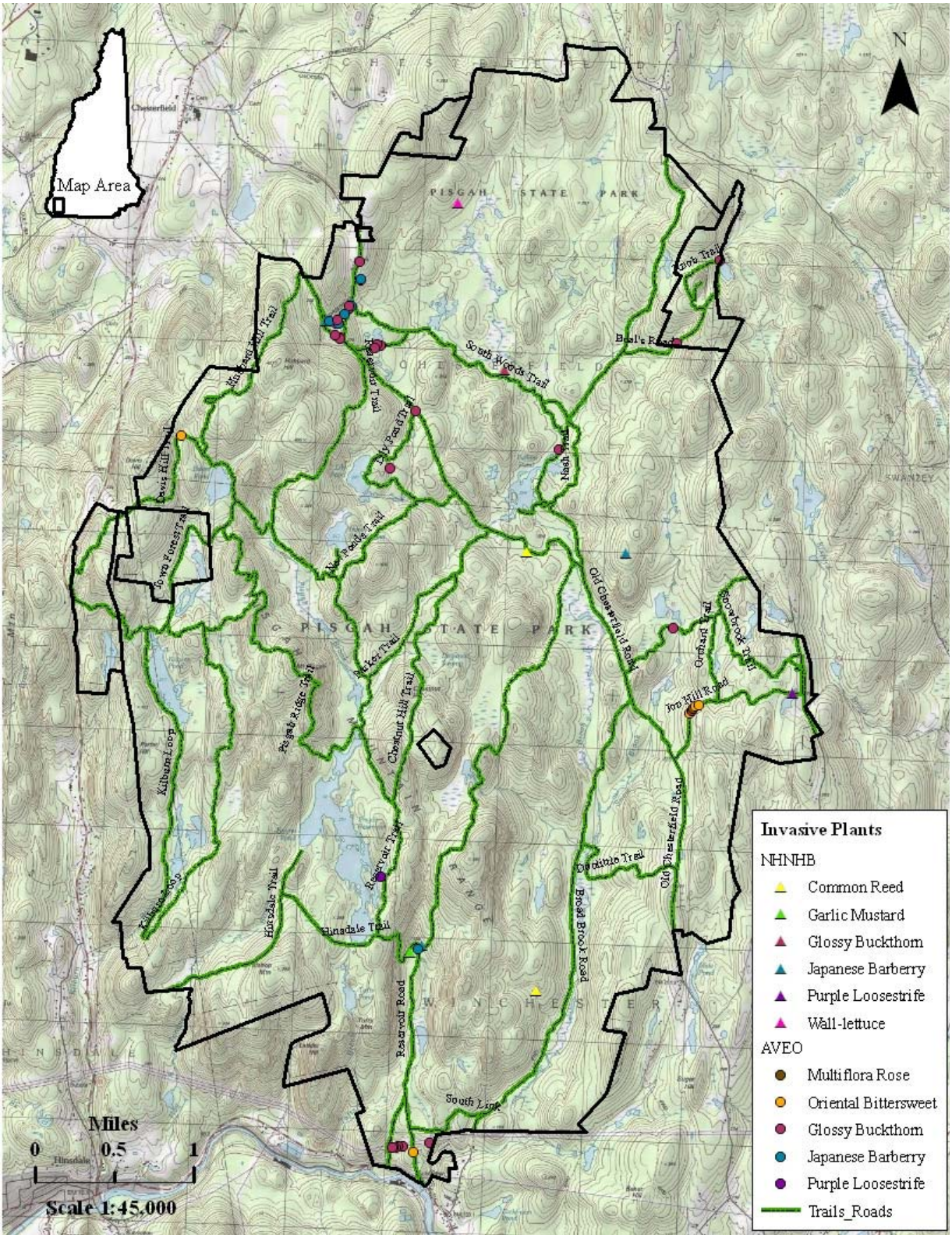
In 2008 and 2009, AVEO trained Citizen Scientists to document the location and extent of invasive plant occurrences in Pisgah. Volunteers visually searched for focal species along all trails and roads throughout the park. The detailed methodology, as adapted from the Rutgers University Invasive Plant Monitoring Project (Rutgers 2009), is available from Moon et al. (2009). Findings of this project paralleled NHNHB's observations of invasive plants during a park-wide ecological inventory (Bowman 2009).

Invasive species occurrences

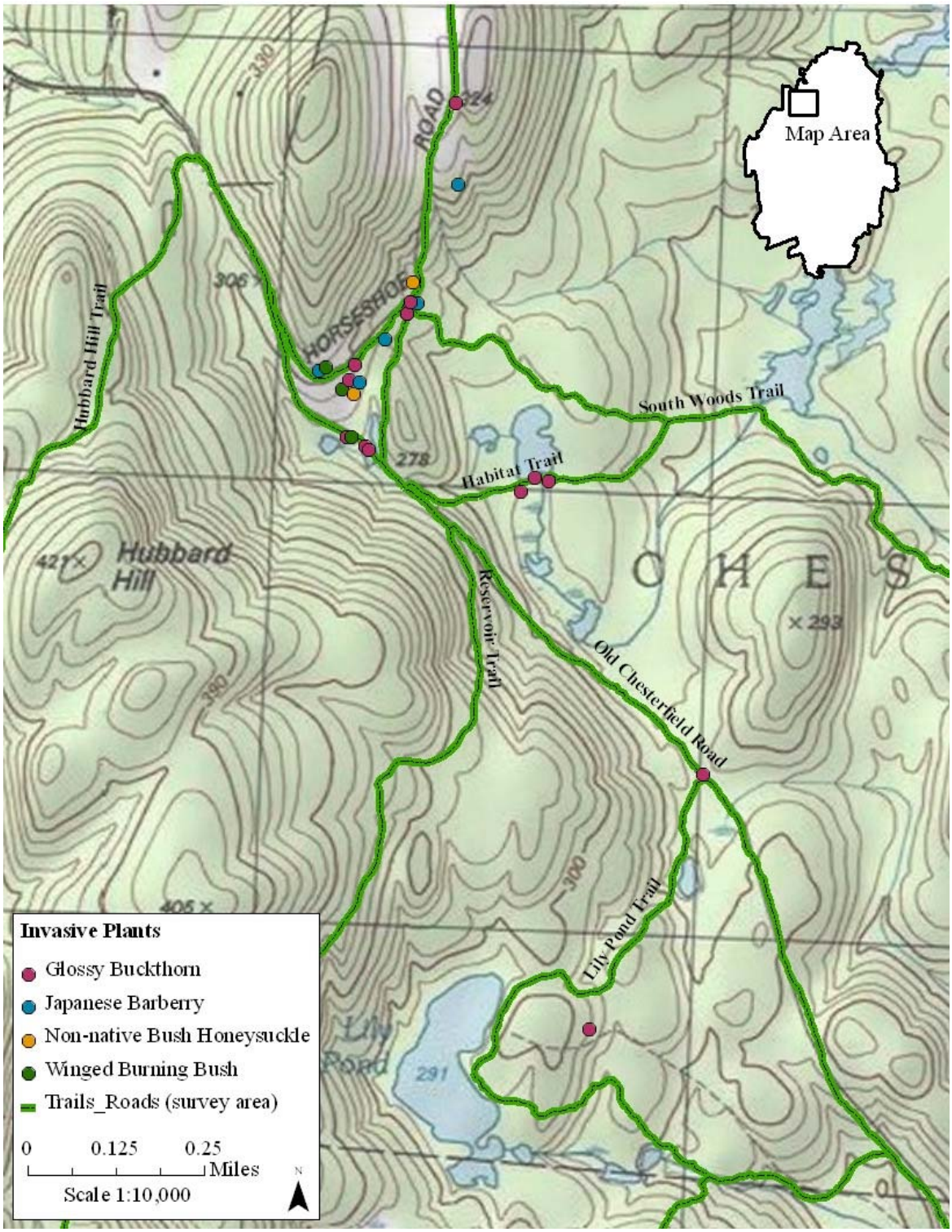
Along 87.5 km (54.4 mi) of trails and roads, volunteers documented 29 occurrences of one or more invasive species. Five species, Japanese barberry, glossy buckthorn, multiflora rose, Oriental bittersweet and purple loosestrife, were observed at least once. Glossy buckthorn was most frequently encountered, followed by Oriental bittersweet and Japanese barberry; the remaining species each were observed at only one location. Generally, abundance was relatively low; the majority (41%) of occurrences were less than three stems, 38% were greater than three stems, while only 10% of occurrences were substantial enough that the ground was covered (Moon et al. 2009).

In AVEO's survey, invasive plants were observed on only ten trails in Pisgah. With few exceptions, these occurrences fell within 0.5 miles of the park's boundary. The majority of invasives were noted in two areas: John Hill Road and unnamed trails near the Habitat Trail/Horseshoe Road trailhead (Figure 1). The greatest number of invasives was noted along trails in the latter area; volunteers documented ten occurrences of glossy buckthorn and two of Japanese barberry. In the old orchard on John Hill Road there were three occurrences of Oriental bittersweet, one of multiflora rose, and one of glossy buckthorn. Other locations included Beal's Road (two buckthorn occurrences), Davis Hill (one bittersweet occurrence), Lily Pond Trail (two buckthorn occurrences), Nash Trail (one buckthorn occurrence), Reservoir Road (one occurrence each of bittersweet and barberry), the south end of Reservoir Trail (one loosestrife occurrence), Snowbrook Trail (one buckthorn occurrence), and South Woods Trail (one occurrence each of barberry and buckthorn).

Invasive plant occurrences in Pisgah State Park, NH as documented by both NHNHB and AVEO, including those on the powerline right-of-way at the south edge of the Park.



Location of invasive plants near the Horseshoe Road trailhead in Pisgah State Park, NH, as documented by AVEO in fall 2008. Map includes off-trail observations.



In addition to the formal trailside surveys, volunteers explored two areas suspected to have invasives. First, volunteers observed winged burning bush, Japanese barberry, bittersweet, non-native honeysuckles, and glossy buckthorn in the Horseshoe Road trailhead/Habitat Trail area (Figure 2). Second, volunteers documented six occurrences of glossy buckthorn along the 0.5 mile stretch of ROW at Pisgah's southwestern boundary; most were of moderate abundance (Moon et al. 2009).

Similarly, NHNHB determined that the greatest number of invasives occurred along Old Chesterfield Road and John Hill Road. Throughout Pisgah, NHNHB observed species including Japanese barberry, Oriental bittersweet, shrub honeysuckles, glossy buckthorn, and purple loosestrife, as well as garlic mustard, common reed and wall-lettuce (Bowman 2009). Most observations of invasive plants corresponded with areas of past or present human land use. Despite the number of occurrences reported, invasive species were not detected throughout the majority of the park; large areas including Pisgah Ridge, the Kilburn Loop trail, Broad Brook Road, and backcountry trails such as the Dogwood Swamp Trail were free of invasive plants.

Location of invasive plant occurrences in Pisgah State Park, NH as observed during AVEO's survey in 2008-2009.

Trail Segment	Species	Number of Occurrences	Date
Baker Pond Trail	none	0	8/31/2009
Beal's Road/Knob Trail	buckthorn	2	8/18/2009
Broad Brook Road	none	0	7/23/2009
Chestnut Hill	none	0	8/13/2009
Davis Hill	bittersweet	1	5/21/2009
Dogwood Swamp Trail	none	0	10/18/2008
Dolittle Trail	none	0	10/10/2008
Fullam Pond Trail	none	0	8/18/2009
Hinsdale Trail	none	0	8/20/2009
Hubbard Hill	none	0	5/21/2009
John Hill Road	bittersweet	3	10/10/2008
	buckthorn	1	10/10/2008
	multiflora rose	1	10/10/2008
Kilburn Loop - East	none	0	8/6/2009
Kilburn Loop - West	none	0	8/6/2009
Kilburn Road	none	0	10/20/2008
Lily Pond Trail	buckthorn	2	10/2/2009
Nash Trail (West)	buckthorn	1	8/18/2009
North Ponds Trail	none	0	9/18/2009
Old Chesterfield Road - Mid	none	0	7/24/2009
Old Chesterfield Road - North	none	0	10/5/2008
Old Chesterfield Road - South	none	0	7/23/2009
Orchard Trail	none	0	10/2/2009
Parker Trail	none	0	8/13/2009
Pisgah Ridge Trail	none	0	10/2/2008
Reservoir Road	barberry	1	7/22/2009
	bittersweet	1	7/22/2009
Reservoir Trail - North	none	0	7/12/2009
Reservoir Trail - South	loosestrife	1	6/9/2009
Snowbrook Trail	buckthorn	1	10/2/2009
South Link	none	0	10/14/2008
South Woods Trail	barberry	1	10/24/2009
	buckthorn	1	10/24/2009
Unnamed trail between John Hill Rd. & Snowbrook Trail	none	0	10/19/2008
Unnamed trail from 119 Parking to Reservoir Rd.	none	0	10/12/2008
Horseshoe Road & Habitat/Wildlife Trail area	barberry	2	10/19/2008
	buckthorn	10	10/19/2008

Key Findings

- Currently, Pisgah State Park is predominantly clear of invasive plants (Bowman 2009).
- Seven invasive species have been documented in Pisgah, including common reed, Japanese barberry, garlic mustard, glossy buckthorn, multiflora rose, Oriental bittersweet, and purple loosestrife, as well as wall-lettuce (Bowman 2009; Moon et al. 2009).
- Most invasive plant occurrences are of relatively low abundance (Moon et al. 2009).
- Areas with the greatest number of invasive species generally correspond to those areas with past or present land use (e.g. abandoned homesteads, areas managed for early succession habitat, utility rights-of-way).

Recommendations

- DRED, AVEO, and/or other stakeholders will conduct additional surveys of non-native invasive plants
- DRED will develop a plan to control existing invasive plants and prevent establishment of new populations as needed.
- DRED will apply best management practices to its forestry activities in accordance with *Good Forestry in the Granite State* (New Hampshire Division of Forests and Lands 2010).

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Forest Health Protection[6]

Insects, diseases, and abiotic events like ice storms and tornado's all play a healthy roll in sustaining the forest ecosystem. It's only when exotic pests are introduced, epidemic native pest outbreaks occur, or abiotic damage occurs which causes damage beyond what is tolerable by managers and the environment that actions need to be taken to protect forest health. Balancing the mitigation of epidemic pest populations with timber management, wildlife habitat management, recreational opportunities and wilderness preservation while maintaining ecological integrity takes skill and forethought. To accomplish this goal there are three broad tenants that forest health efforts could be grouped in. First is "maintaining a healthy forest". Actions to maintain healthy forests strengthen the resiliency of the forest ecosystem and allow it to resist and defend itself against pest attack without having to "assist" with intrusive pesticides, herbicides, salvages, or quarantines. The second tenant would be "keep invasive pests and plants out of the forest". Actions to impede the spread of non-native insects, diseases and plants allow native flora and fauna to maintain balanced and rich species diversity. Exotic invasive organisms lack ecological control measures and often cause catastrophic economic and biological damage to the forest. The third tenant would be to "have a control or mitigation strategy developed" in advance of epidemic damage causing agents entering the forest. Knowing how you plan to control exotic insects as they are found will allow for quick response and reduce total costs of the outbreak. Likewise, having a plan for when an ice storm or tornado strikes will reduce the initial panic and ultimately target mitigation where it needs to take place rather than over a broader area that may absorb the damage as part of a healthy forest process.

Key findings

Management Criteria 1, Undisturbed Landscape Component

- There are many natural damage causing processes that create severe economic and environmental losses. Tornado's, hurricanes and ice storms all have the ability to destroy large tracts of forest. These events are naturally occurring in New Hampshire and if the events occur in management criteria #1 the remnants should be left undisturbed by salvage operations unless the removal is necessitated by a need to control unacceptable fire risk or pest outbreaks threatening the surrounding forests.

- There are several exotic forest pests listed under the jurisdiction of the U.S.D.A and the management of these pests, regardless of local zoning, will be implemented and managed by Federal Agencies. Specific examples would be the Asian Long-horned beetle and the Emerald Ash Borer. Both of these pests have continental implications and there are nationally developed strategies for controls that would mandate tree removal in Criteria #1.

- There are several invasive forest pests under the State jurisdiction, 227:K, for control regardless of ownership or zoning. Hemlock woolly adelgid (HWA) is an example. New Hampshire has an exterior quarantine, an interior quarantine, and a statewide management plan approved through the Federal NEPA process. If an infestation of HWA were found at Pisgah, regardless of zoning, there may be control actions taken to protect the vast hemlock resource on that property and in the region. Options include cutting infested trees, insecticide treatments, and releases of predator beetles.

[6] Kyle Lombard, New Hampshire Forest Protection Bureau

Management Criteria 2&3, Actively Managed Forestlands

- Reduce undesired mortality and growth loss from native pests, limit pathways for introductions of exotic pests, and eradicate any new introductions as they occur.
- Target stands for vegetation management based on risk of incurring growth loss and mortality from insects, diseases and weather. Target the overstocked stands and forest types not well suited to the soils or environment they occupy.

- Strive to maintain maximum diversity of forest structure. A diversity of height classes, age classes, and species in combination with horizontal landscape diversity will be the best defense against insect and disease outbreaks. The scale at which to apply this tenant is important. It is impractical and unproductive to create this mix on each acre but you loose effectiveness if contiguous monocultures or blocks of uniform structure are large enough to maintain independent pest outbreaks.

- Follow the below recommendations when considering a harvest in forests managed for multiple uses. These recommendations mitigate a variety of different types of damage causing agents including insects, diseases, logging damage, wind and ice storms.

Recommendations

Management Criteria 1, Undisturbed Landscape Component

- Monitor criteria #1 for exotic pest outbreaks. High risk sites should be identified using the latest knowledge of regional exotic pest populations and sites should be surveyed on a schedule appropriate to the pest and its major vectors.

- Contact the NH Division of Forests and Lands, Forest Health office for a list of current exotic pest threats in the Pisgah area prior to starting any inventories or surveys where the survey staff may be able to incorporate some level of pest detection.

- If an infestation is suspected contact the Forest Health office at 464-3016. The Forest Health office in concurrence with the State Forest Pest Advisory Group (FPAG) will provide an action plan for mitigation as needed. The FPAG is council to the State Forester and is made up of representatives from most major private and public Forestry and Environmental Agencies in NH.

Management Criteria 2&3, Actively Managed Forestlands

Defoliators

"Defoliators" are insects that feed on leaves and needles during the growing season. Common examples include spruce budworm and large aspen tortrix in northern NH, saddled prominent and forest tent caterpillar in central NH, and gypsy moth and hemlock looper in southern NH.

- *Limit the losses from defoliators by keeping a well diversified forest both in age structure and species composition*. Most insects are host specific and prefer one or two species of a particular age group. A large contiguous block of mature fir is highly susceptible to spruce budworm and a

large uniform block of sugar maple is begging to be attacked by forest tent caterpillar. Large contiguous blocks would be uniform stand conditions over several thousand acres in size. Insects do not notice political boundaries as they spread so managers should consider the forest structure as an ecosystem region rather than focus on a single property ownership.

- *Do not enter a stand for partial harvest until at least three years after the last major year of defoliation*. After three years the weakest trees will be dead or evident and you can thin those stems from the stand. Until three years has passed, the defoliated stand is highly susceptible to residual logging damage. Defoliators reduce the amount of carbohydrates stored in the root system during the dormant season. Root damage and basal wounding from logging equipment compound the stress to residual trees and may cause serious growth reductions and branch dieback.
- *Partial harvests during the outbreak will divert the epidemic insect population to fewer and more exposed trees*. Defoliation and subsequent stress and tree decline is likely to be exacerbated.
- *The need for aerial pesticide applications are rare but appropriate options under the right circumstances*. A special pesticide application through the NH Division of Pesticide Control is required. Any forester considering the aerial application of insecticides should contact the Division of Forests and Lands, Forest Health Office for guidance and support.

Piercing-sucking insects

"Piercing sucking insects" are those insects that have mouth parts called stylets and penetrate the tree to search for particular nutrients. The most common forest pest examples in NH are hemlock woolly adelgid, balsam woolly adelgid, and elongate hemlock scale. These insects are more chronic than defoliators that are absent and then in outbreaks within a few years. Once infested, a stand remains infested for a long time. This condition affects our long-term forest management.

- There is little true control of these pests that a forester can perform using silvicultural practices. However, silvicultural practices will help immensely in reducing stand susceptibility to attack and vulnerability to damage.
- Improving tree and stand vigor by proper stocking is important. Trees fighting for growing space and nutrients are far more likely to succumb to constant yearly attacks by adelgids and/or scales.
- Cut stands infested with balsam woolly adelgid in the winter because nymphs attached to tree tops can't survive. If cut in the summer, they are mobile enough to spread to uncut trees.
- In most areas of NH if you find a small infestation of hemlock woolly adelgid cutting and burning the foliage will eradicate the problem before you harvest the timber. If the infestation is larger than a quarter acre, it's likely the infestation cannot be eradicated before harvesting. In this case, the infested products must not be shipped outside the quarantine area. There are several mills and burn facilities inside the regulated area. Contact the DFL for further information.
- Insecticides work well for these insects, however access and tree size is a limiting factor. Adelgid populations are successfully treated with soil injections or drenches of imidacloprid. Contact the DFL forest health office for specific information on products, dosages and application methods.
- Cut beech heavily infested with beech bark disease early in the growing season but after full leaf out when carbohydrate levels in the roots are lowest. Cut only the heaviest infected trees, preferably on frozen ground to avoid beech sprouts from dominating the regeneration. If you find signs of resistance in a group of trees encourage sprouting by harvesting in the late summer months.

Wood borers and bark beetles

"Wood borers and bark beetles" are the group of insects that spend one or two years as a grub-like larvae boring tunnels under the bark or through the cambium of the tree. Common examples in NH are sugar maple borer, oak borer, white pine weevil, Ips beetles and Dendroctonus beetles. While in NH the native

wood borers and bark beetles tend not to grow past endemic levels and only attack dead and dying trees there are a growing number of invasive wood boring insects spreading in North America. Have the pest identified before proceeding with any recommendations.

- Trees showing signs of active wood boring activity such as large exit holes and frass piles should be marked and cut.
- Trees showing signs of bark beetle activity such as multiple small exit holes and frass littering the bark should be removed along with the slash and burned.
- Bark beetles generally attack severely stressed, dying and dead trees. The best practice to avoid beetle attack is to keep the forest in a diversified species composition, properly stocked, and minimize logging stress like soil compaction and mechanical damage to residual trees.
- Heavily infested monocultures like pine plantations should be cut completely and slash removed if pine is the desired future condition of that stand.
- To avoid excessive white pine weevil injury in the regeneration, maintain partial overstory shade and cull seedlings with the thickest leaders.

Root Diseases

"Root Diseases" are a broad group of fungi that cause decay, stress, reduced growth and mortality of plants. Common examples in NH forests include Armillaria, *and Heterobasidion* annosum (formerly "fomes annosus"). Root diseases like armillaria are present in almost all forest soils in NH. For the fungi to become a problem it requires favorable environmental conditions of moisture and oxygen, a point of entry into the host tree, and low tree vigor that makes it difficult for the tree to defend itself.

- Re-entry periods longer than 10 years should be considered to avoid exacerbating root rot infections from previous timber harvests. Armillaria will travel from cut stumps to stressed trees through the maze of root grafts in the soil.
- Limit damage to the roots and boles of residual trees, reducing the opportunity to colonize residual trees.
- Fumigations and stump/root removal works well in other regions, however this practice is expensive and not a practical option in our forests.

Stem Canker Diseases

"Stem canker diseases" are those fungi that attack the stem, shoots and branches of a tree and cause lesions or dead areas on the stem. Common examples in NH include Nectria canker, caliciopsis, blister rust, chestnut blight, and Eutypella cankers.

- Remove any trees that show signs of stem cankers. Spores are produced from the margins of these infected areas and can infect surrounding trees.
- For rust diseases that require an alternate host, eliminating the non-timber alternate host is the best control. Gooseberries and currents should be absent within several miles of a young white pine stand.
- Caliciopsis canker on white pine is not well understood but seems to be an annual canker that appears like a black mold on the upper stems of the tree. Often the lesions weep pitch in streaks. Control is not well understood but preliminary work has shown that thinning infested stands to allow more sunlight and warmer air conditions will not only improve the vigor of the residual trees but reduce the favorable moisture conditions needed by the fungi. Remove the trees with heaviest infections.

Foliage Diseases

"Foliage diseases" are those organisms that attack the needles and leaves. Common examples in NH are anthracnose, needlecast, tar spot and sooty mold.

- Hardwood foliage diseases are generally less serious than softwood foliage diseases because hardwoods can drop the infected leaves and re-foliate in subsequent years. The specific conditions of moisture, temperature, and host susceptibility in sporadic and heaviest infections in hardwood forests last just one year. No control is usually needed
- Spores over-winter on fallen leaves. In an urban setting you can reduce the annual inoculum by raking and removing infected leaves.
- Softwood foliage diseases most often affect older needles and lower needles on the live crown. Thinning stands to reduce the amount of spores can help. Thinning will help reduce high moisture conditions around the base of the trees.
- Remove the most infected trees in the stand.

Heart Rots

Heart rots are the decay fungi that penetrate to the center of a tree and rot the core from the inside out. There are "white rots" that feed on lignin and cellulose and "red rots" that feed just on cellulose. The red rots leave a brown or red brittle material while the white rots leave a white coloring where lignin has been removed. Fruiting structures of these diseases are shelf like conks attached to the sides of the tree.

- Remove trees with conks during harvesting.
- Avoid logging damage, specifically broken branches in the residual stand, to minimize the entry points for wind blown spores.

Wind Damage

- Consider the rooting depth, butt flair, crown size and soil profile when proposing a partial harvest of large contiguous blocks of dense or overstocked forests. Trees growing for long periods in tight conditions or on shallow or wet soils are going to be at risk of wind throw during moderate to severe wind conditions.
- When possible position thin strip cuts so that prevailing wind skips across the narrow width rather than down the full length of the strip. Position larger openings so that prevailing winds cross at the narrowest point.
- Eliminate high risk trees that have stem cankers, forking tops and signs of internal decay.
- Consider even-aged management where there is evidence of repeated occurrences of wind damage. Stands naturally growing in mosaics of even-aged gaps or groups because of localized wet or shallow soils or exposure to high winds should be candidates to continue that pattern to take full advantage of a unified unbroken overstory.

Post wind storm actions

- Quickly determine the footprint of the storm damage.
- Determine what percentage of trees were blown over with roots intact versus tree breaking above the stump.
- Trees broken off should be salvaged first.
- A healthy forest blown over with roots intact will remain alive and insect free for many months. There is no need to expedite the removal process just to avoid infestations of pathogens.

Ice Damage

- In NH it seems ice storms cause most forest damage at elevations between 1000' and 3000' and within hardwood stands. This is the case because most softwood branching patterns are naturally

pointing down thus under extreme weight they sag down and in rather than bend and break like hardwoods.

- In forests with previous sign of branch breakage and top dieback, remove trees with weak or hazardous branch structure. A good example is the tree with a fork that creates a "V" shape crotch rather than the stronger "U" shape.

Post ice storm actions

- Quickly determine the footprint of storm damage
- Inventory the damaged areas to determine the percentage of trees damaged and the average amount of branch breakage BY SPECIES.
- Trees with less than 50% branch breakage are likely to recover. The notable exception would be paper birch.
- Breakage in the main stem is more severe than breakage of the secondary branches. Decay fungi and rot will affect the product quality and strength of the tree.
- Trees with greater than 75% branch breakage are a risk to keep as a future high quality tree.
- Trees with ANY bole breakage below the live crown are a high risk to keep.
- There is no need to rush the decision to salvage standing, living ice storm damaged trees. It takes many years for previously healthy trees to succumb to a single severe ice storm event. Discoloration and decay travel from the damaged branches into the stem of the tree only a few inches to a few feet per year.

Soil compaction

- Match the harvesting equipment to the soil conditions and timber type. Northern hardwoods and their associated fine textured, rich organic soils tend to compact easily and show subsequent tree stress in the form of branch dieback more readily than coarse soils with pine forest types.
- Root damage from soil compaction can be reduced by harvesting after the soil has frozen**.** The key is to remove the equipment from the site in a timely manner. It's easy to destroy a winters worth of conscientious logging by trying to get a few days of timber out after the ground has thawed.
- Discuss and set limits with the logger as to the amount of acceptable soil disturbance before the sale starts. Heavy compaction should be limited to less than 20% of the total harvested area.
- Design a skid trail system before the harvest begins and re-use existing trail systems whenever possible.

Cultural Resources[7]

This paper provides an overview of the land-use history of the area now incorporated into Pisgah State Park, by enumerating the kinds of archaeologically and historically significant features that are currently identified in the park. It also suggests strategies that will preserve these known sites of archaeological and historical significance as well as strategies to help protect sites that have yet to be identified.

The information in this paper draws upon many sources; but, it relies most heavily on the work of a few organizations and individuals who have been caring for the historical records and documenting the remains that pertain to Pisgah. Future treatments of this subject will undoubtedly draw from a larger pool of resources, but several deserve special acknowledgment here: Friends of Pisgah, an organization that seeks out and preserves records of historical value; Fred and Janet Doolittle, former owners of a family farm now part of the park who provide documents and valuable oral history; Cliff Struthers, a Winchester native who has been surveying and mapping the park for many years; SCRAP, New Hampshire's State Conservation and Rescue Archaeology Program, which conducted an archaeological survey of the Broad Brook portion of Pisgah during the summer of 2008; and the Division of Forests and Lands which conducts detailed resource inventories throughout the property, noting and mapping cultural resources as they are discovered.

Before the 13,361-acre park was formed from 90 parcels in 1972 (Getchell 2006) the region surrounding 1,303-foot "Mt. Pisgah" had been settled very sparsely. The low, wooded hills, small ponds, and year-round streams that comprise the local topography were deemed largely unsuitable for agriculture and, as a consequence, when settlement did take place it was concentrated in places where the timber industry briefly flourished, between the 1850s and 1910s (Schach 2006). Once the park was formed, however, the state removed the structures that housed and served the people who had lived in the Pisgah area, permitting the land to return to forest and meadow. It now requires a careful reading of the landscape to discern evidence of habitation, milling, farming, and transportation.

To most members of the public the term "archaeology" tends to have a connotation relating to matters of ancient or even pre-historic time. However, archaeology is an investigatory discipline that ranges from the pre-historic, through periods of historic record-keeping, to the present. The features that can be identified as archaeologically and historically significant are those human-made structures that have been constructed and embedded into the landscape. We can thus differentiate "features" from "artifacts" in that the features are generally immovable and the artifacts are potentially removable from their physical context. With this distinction in mind, we should be sensitive to the fact that archaeological and historical features in Pisgah State Park must be preserved in-place; they cannot be preserved by putting them in a museum.

The most readily discerned archaeological features on the Pisgah landscape are cellar holes and foundations, where dwellings, outbuildings, mills, and schools once stood. They may occur over extensive areas in concentrated clusters of heavy settlement or as discrete sites of individual or small groups of settlements dispersed over the landscape. Information of this kind is helpful to economic and social historians.

[7] Sarah Bockus, Antioch University New England

Extensive Areas of Habitation, Farming, and Milling

Pisgah contains several areas of concentrated features, some many acres in size. So far researchers have identified six "hot spots" that contain evidence of habitation, farming, and milling. They can be inventoried counterclockwise from the Winchester Visitor's Center, from the southeast, through the north, and finally to the southwest.

Broad Brook Mill and Farm Community

Running approximately 3 miles southwest along Old Broad Brook Road (from its intersection with Old Chesterfield Road to the southern park boundary near Route 119), there are foundations and structural remnants that field surveys and historical records show to be associated with mills and the people who lived nearby to work the mills. In this area:

- The Friends of Pisgah, and volunteers and archaeologists from SCRAP and Antioch University New England have identified at least two mill sites immediately adjacent to Broad Brook, at least 10 apparently domestic foundation sites, and a roughly 1,700 foot long canal running parallel to Broad Book that was surveyed and mapped by Cliff Struthers.
- The 1858 Map of Cheshire County identifies six dwellings and two mills (the map is well annotated with names of owners).
- The 1898 Map of Cheshire County shows four likely dwellings, and three likely mills.

Old Chesterfield Farm Community

Running approximately 2.5 miles north along Old Chesterfield Road (from the Visitor's Center north to Fullam Pond), and along Jon Hill Road (from its junction with Old Chesterfield Road to its intersection with Old Spofford Road), there are foundations and old agricultural fields that field surveys and historical records clearly show to be sites of small-scale farming. In this area:

- The Friends of Pisgah and SCRAP have inventoried 18 foundation sites and 1 school.

- The 1858 Map of Cheshire County identifies 13 dwellings, and three schools (#7, #8, and #9).
- The 1898 Map of Cheshire County shows 14 likely dwellings and one likely school.

Hardscrabble/Nash City

In the northeast end of the park the remains of a crescent shaped settlement stretch around the north, east and south of Fullam Pond for approximately 1.5 miles. The area has been called both Hardscrabble and Nash City. In this area:

- The Friends of Pisgah and SCRAP have identified at least 11 apparently domestic foundation sites, one mill site, and two former "camps" (lacking foundations).
- The 1858 Map of Cheshire County identifies 10 dwellings, and 1 mill.
- The1898 Map of Cheshire County shows just two likely dwellings and no mill (a mill pond is absent from this map).

Horseshoe Road Cluster

An as of yet un-inventoried, historically significant settlement that runs approximately 1.5 miles along the northwest boundary of the park (north on Horseshoe Road, from its southern intersection with Old Chesterfield Road to the northernmost boundary of the park). In this area:

- The 1858 Map of Cheshire County identifies 10 likely dwellings and one school (#6).
- The 1898 Map of Cheshire County shows just two likely dwellings.

Hubbard Hill Settlement

At the northwest end of the park, running approximately 1.5 miles south-southwest along the Hubbard Hill Trail (from its intersection with Winchester Road/Old Chesterfield Road to a point midway between Baker Pond and Lilly Pond), there is another settlement. In this area:

- The Friends of Pisgah have identified at least 6 foundations that lie on the undulating top of Hubbard Hill.
- Neither The 1858 Map nor the 1898 Map of Cheshire County shows any structures in this area.

Round Pond/Pisgah Reservoir Mills and Camps

There are building remains distributed across an arc approximately 1.5 miles long (from the southwest end of the old Round Pond down to the south end of the present Pisgah Reservoir and back up to the southeast end of the old Round Pond). In this area:

- The Friends of Pisgah have identified the remains of 2 mills, and 15 dwellings (7 former "camps" lacking foundations and 8 foundations including 2 boarding houses).

- The 1858 Map of Cheshire County identifies 1 boarding house and 1 mill.
- The 1898 Map of Cheshire County shows no structures.

Discrete Areas of Habitation, Farming, and Milling

Researchers have identified several discrete sites that contain evidence of dispersed habitation, farming, and milling. In addition to the foundations that alerts researchers to the fact that people once lived and worked in these locations there is also an area of interest that extends out from each feature that may contain outbuildings, gardens, and fields that can also be of interest to researchers. The following sites and their surroundings have been identified and are only a fraction of what may exist within Pisgah.

The Baker Pond/Parks Pond Mill Site

At the south end of Baker Pond (called Parks Pond in 1858) the Friends of Pisgah have identified a mill site. Given the propensity for mill sites to have dwellings in close proximity, future surveys may discover evidence of additional associated dwellings and other features.

The Dickenson/Doolittle Farm Site

On Old Chesterfield Road, the Erastus Dickenson/Fred Doolittle farm comprised 148 acres during the first-half of the 20th century. That place sustained a family of nine (seven sisters and brothers, plus two parents), orchards containing 700 apple trees, fields yielding more than 100 bushels of potatoes annually, and pastures that fed 10-12 cows, and some horses and pigs and oxen. This site has been protected from development since 1972, and could serve as an archaeological and ecological "time capsule" that may help archeologists assess effects of reforestation, and interactions among native and cultivated plants.

The Dickenson Mill Site

The Dickenson Mill site on Broad Brook was surveyed extensively and carefully mapped by Cliff Struthers in 2008, yielding carefully plotted locations of a bridge, a mill house cellar hole, two mill sites, two dam walls, a millpond, five unidentified cellar holes, a water canal, a boarding house with cellar hole, three wells, and a barn. A similar complex of associated features may exist at other mill sites.

Longitudinal Features - Roads, Stone Walls, and Canals

Archaeological and historically significant features that run for relatively long distances are described as "longitudinal features." Much like the extensive and discrete areas of habitation contained within Pisgah, the historic roads, stone walls, and canals have not been comprehensively inventoried. These features can often be easy to overlook as they are seemingly everywhere. These features are also subject to disturbance as present day activities may require crossing walls and canals or reuse of old roads.

Broad Brook Road and Walls

During the summer of 2008, Cliff Struthers, assisted by Alex Coombs, and Peter Davenport, surveyed and mapped the Broad Brook Road and its adjacent stone walls for a distance of approximately 6,000 feet (from the "parking lot" at the south end of the road and to the intersection with Old Chesterfield Road at the north end of the road). The southern half of the road is flanked on both sides by approximately 1,000 feet of stone walls; and the northern half of the road is paralleled on the east side by approximately 2,400 feet of stone walls.

Dickenson Mill Canal and Dams

The same survey conducted by Cliff Struthers, Alex Coombs, and Peter Davenport also mapped a canal that is approximately 1,700 feet long (running roughly parallel to the southern portion of Broad Brook Road). In addition, the survey mapped approximately 400 feet of dams that are associated with two millpond sites.

Prehistoric and Unidentified Native American Sites

In an area as extensive as Pisgah State Park, it is very likely that undiscovered prehistoric and Native American sites exist. During the last 12,000 years, after the last glacier receded, much of western Cheshire County was submerged under Glacial Lake Ashuelot–a body of water that filled the basin now coursed by the Ashuelot River. At the same time, Cheshire County was bounded to the west by Glacial Lake Hitchcock–an immensely long body of water that filled the Connecticut River basin from northern New Hampshire down to central Connecticut. The high ground now contained in Pisgah State Park comprised a long peninsula (resembling the Scandinavian peninsula, with its many deeply cut inlets) extending south from present-day Walpole and Surry to Hinsdale. The Pisgah highlands, thus, lay between two routes that migratory herds would have traveled—one along the Connecticut rift and the other along the Ashuelot. Early European colonists in New England noted that there was a place of indigenous habitation at "Fort Hill" in present-day Hinsdale. It is remarkable because it was established by Native American people on ground that is, by modern standards, very high above the adjacent river basin, on a large "peninsula" that is formed by the Ashuelot and the Connecticut Rivers.

Key Findings

- Pisgah State Park contains several extensive areas of concentrated features of archaeological and historical significance including early settlements and mill sites.
- Pisgah State Park contains several discrete sites with individual features of archaeological and historical significance including farms and mills.
- Pisgah State Park contains several longitudinal features of archaeological and historical significance including a unique canal system and an extensive network of stonewalls.
- Pisgah State Park undoubtedly contains additional areas and individual sites of archaeological and historical significance that have yet to be discovered or explored including prehistoric and Native American sites.

Recommendations

- Extensive areas of concentrated features of archaeological and historical significance should be zoned historic and protected with a buffer that encompasses an adequate perimeter around the site as recommended by the Department of Historic Resources (DHR).
- Discrete sites with individual features of archaeological and historical significance should be protected with a buffer that encompasses an adequate perimeter around the site as recommended by the DHR.
- Prior to the implementation of any project that results in significant ground disturbance within the park, the project area should be assessed by DHR for the presence or the likely hood of the presence of features of archaeological or historical significance.
- When implementing a project in or near areas with identified features of archaeological or historical significance, observe existing buffers as well as any additional set backs or seasonal restrictions recommended by DHR.
- When crossing a stone wall during the course of a project use existing openings whenever possible and practical. In the event that a new opening is necessary, review the proposed breach with DHR. Consider impacts to the surrounding environment including other cultural resources and choose a location that makes the most sense for future use. DHR does not recommend rebuilding stonewalls. Maintaining permanent openings will help preserve stone wall integrity over time by preventing multiple breaches and reconstructions at different locations along the same wall over the course of future projects.

References

Getchell, Elizabeth. "Eminent Domain: Evicted to Create Pisgah Park." In Howard Mansfield, ed., 2006. *Where the Mountain Stands Alone: Stories of Place in the Monadnock Region,* Lebanon, NH: University Press of New England, page 234.

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Wildlife and Habitats[8]

The New Hampshire Fish & Game Department (NHFG) is the guardian of the state's fish, wildlife and marine resources. NHFG works in partnership with the public along with state and federal agencies, and conservation organizations to conserve, manage and protect these resources and their habitats. DRED and NHFG have a long history of cooperatively managing wildlife on state lands including meeting monthly to discuss resource management plans and projects, and sharing staff and other resources to complete habitat and forest improvement projects on state lands.

At nearly 15,000 acres, Pisgah State Park has tremendous value to wildlife, common and rare; game and non-game. To ensure that the park continues to provide high quality habitat for a variety of species, the current condition of the park's wildlife and habitat resources was analyzed. Based on that assessment along with a review of the state's two primary wildlife plans (NH Wildlife Action Plan and Big Game Plan), a list of target species was developed for the park. The park's resource management staff should incorporate the habitat needs of these species during project planning and implementation. Management recommendations were also generated to assist staff in doing so.

Key Findings

Aquatic Habitats

- There are seven named ponds ranging in size from 7.5-acre Tufts Pond to the 115-acre Pisgah Reservoir in addition to eight unnamed ponds of similar size (5.8 – 13.5 acres).
- Four of the lakes and ponds were ranked among the top ten in their class statewide based on a conditions assessment by The Nature Conservancy. These include Lily Pond and North Round Pond and two unnamed ponds in the northern tier of the property.
- Pisgah SP hosts 50 miles of streams comprised mostly of 1st and 2nd order streams.
- Broad Brook is the longest of the named streams, covering 9 miles.
- Tufts Brook, Broad Brook, Kilburn Brook, and Hog Tongue Brook were ranked as important stream reaches in an assessment conducted by The Nature Conservancy because of their excellent condition and landscape setting.
- The NH Wildlife Action Plan habitat land cover predicts the occurrence of 39 marsh and shrub swamp systems totaling 691 acres. Eleven of the 39 marsh systems ranked highly in the state primarily because of their excellent landscape condition (e.g,. few roads and other fragmenting features).
- A 2007 survey documented the existence of 45 vernal pools. The vernal pool survey only took place in the portion of the park located in the town of Chesterfield.

Terrestrial Habitats

- Pisgah State Park contains one grassland complex of nearly 40 acres in the northwestern corner of the Park that consists of 6 fields separated by tree lines and hedgerows.
- A few shrublands in the form of old fields and orchards exist in the southeastern corner of the Park totaling approximately 15 acres. Many were reclaimed using a Brontosaurus mower in 2004.

[8] Jim Oehler, New Hampshire Fish and Game Department

- Although the NH Wildlife Action Plan habitat land cover predicts the occurrence of hemlock-hardwood-pine, Appalachian oak-pine, and lowland spruce-fir within Pisgah State Park, these predictions are based on analysis of statewide datasets and are not good substitutes for finer scale analyses at the property level (e.g., on-the-ground forest resource inventories and property wide field surveys of soils). Based on analyses of these finer scale data, the forests at Pisgah State Park would likely become dominated by hemlock-hardwood-pine and northern hardwood-conifer absence natural or man-made disturbance (see Forest Management chapter).
- Currently, the forests of Pisgah State Park are dominated by sawtimber sized forest stands with little structural diversity at either the patch or stand level (see Forest Management chapter).
- In addition to the habitats described above, Pisgah State Park contains over 4,500 acres in deer yards as mapped by the Fish and Game Department staff.

Wildlife

- Limited data exists for invertebrates across the state and none specifically for Pisgah State Park.
- Of the three species of mussels that are species of conservation concern, only the dwarf wedge mussel has any potential of occurring in Pisgah State Park. However, numerous dams between the park and known populations would make their existence unlikely.
- Typical warm water fish live in many of the lakes/ponds and rivers/streams in the park including largemouth bass, eastern chain pickerel, black crappie, common sunfish, and golden shiner.
- Limited surveys have not documented the existence of any fish species of conservation concern such as brook trout, northern red bellied dace, slimy sculpin, or tessellated darter.
- The park likely has the usual complex of turtles (e.g., painted and snapping) and provides suitable habitat for spotted turtles.
- Wood turtles have been documented nearby.
- Pisgah State Park likely contains the usual compliment of snakes including common garter, milk, and northern water snake and provides suitable habitat for smooth green snakes[SGCN] and black racers[ST].
- Timber rattlesnake[SE] historically occurred in the area but has not been documented since the 1980s.
- Nine of 10 frog and toad species in NH have been documented in or around the park including northern leopard frog[SGCN] and Fowler's toad[SGCN].
- Twelve salamander species have been documented in New Hampshire. Many likely occur in the park including eastern newt, Jefferson's salamander[SGCN], blue-spotted salamander[SGCN], northern dusky salamander, and spotted salamander.
- Eighty-three species of birds were documented in the park during a 2004 breeding bird atlas effort led by the Audubon Society of New Hampshire.
- Species that reached the highest abundances in the park were those typical of mixed or hardwood forests through New Hampshire: red-eyed vireo, blue jay, black-capped chickadee, veery, hermit thrush, and ovenbird.
- Also abundant were three species more typical of edge or brushy habitats: American robin, song sparrow, and American goldfinch.
- Raptor surveys in 2008 indicated the presence of sharp-shinned, red-shouldered, cooper's and broad-winged hawks, and barred owl.
- Game birds including ruffed grouse, American woodcock, and turkey are known to occur in the park, but likely at low densities.
- Several rare or species of greatest conservation need have been documented in the park including American black duck[SGCN], common loon[ST], ruffed grouse[SGCN], American bittern[SGCN], great blue heron[SGCN], northern goshawk[SGCN], red shouldered hawk[SGCN], wood thrush[SGCN], veery[SGCN], and

eastern towhee[SGCN]. Additional species that have potential of occurring include American woodcock[SGCN], canada warbler[SGCN], cerulean warbler[SGCN], osprey[SGCN], and purple finch[SGCN].

Although no site data exists specifically for the park, white-tailed deer, moose, and bear are all known to reside in the park and are commonly pursued by sportsmen. Pisgah State Park is located in Fish and Game wildlife management unit H2. According to the Department's Big Game Plan, the population objective over the next 10 years for each species is as follows:

- White-tailed deer: Increase the population 41% from current levels from 0.82 buck kill per square mile to 1.16. Habitat quality and human population density in this region indicate that this increase will be socially acceptable and within the habitat's capability.
- Moose: Increase the current population from .95 to 1.3 moose seen per 100 hunter hours. It's anticipated that this population increase will increase viewing and hunting opportunities without adversely impacting vehicle collision rates.
- Bear: Increase population by 35% over the current density. This objective reflects the expressed desire of the NH Fish & Game's Public Working Group who worked on the plan to have more bears in the region because of high quality habitat and strong public interest.
- Small Game: Snowshoe hare and gray squirrel are common in the park but not highly pursued by sportsman.
- Furbearers: Over the last five years, ten species of furbearers have been harvested in the towns of Chesterfield, Hinsdale, and Winchester. Significantly more beavers were harvested than other species (n=305) followed by muskrat (n=113) and coyote (n=75). Beaver is the only furbearer allowed to be trapped in the park.
- Bats: Bat surveys indicate that little brown myotis and big brown bats are relatively common. Northern myotis[SGCN] and eastern red bat were also documented.
- The park likely holds the typical assortment of other small mammals including long-tailed shrews, deer mouse, southern red-back vole, meadow vole, and others.
- Although no empirical data exists, bobcats[SGCN] almost certainly occur.

Other species of conservation concern that have the potential to occur in the park include eastern pippestrelle[SGCN], eastern small-footed bat[SE,] hoary bat[SGCN], and silver-haired bat[SGCN].

Target Species

A list of target (or focal) species was generated for the park based on the type and condition of habitats in the park, a review of the NH Wildlife Action Plan & Big Game Species Plan, the habitat requirements of the species cited in those plans, and where they are likely to occur in the state.

Primary target species meet one or more of the following criteria:

- High likelihood of occurring on property based on the park's location in the state, the park's habitats, and documentation of species presence/absence in or near the park
- Existing conservation plans call for increasing populations or existing populations highly threatened.
- Suitable habitat exists or could exist through active habitat management or restoration.

Secondary target species meet one or more of the following:

- Potential, but not necessarily highly likely to occur on property.
- Populations are not highly threatened or existing plans call for stabilizing populations.
- Populations not as threatened as primary target species.

- Ecological conditions on the property are such that required habitat to sustain species is feasible to attain and would not have a significant negative impact on other priority species.
- Species do not have highly specialized habitat requirements or would benefit sufficiently from habitat management or restoration completed for primary target species.

Land management decisions should be primarily based on the habitat needs of the primary target species. Secondary target species should be considered during land management planning or implementation, but not necessarily focused on.

Many secondary target species are categorized as such, because degree of potential for them to occur in the park is unknown. Some secondary target species could become primary target species if they become documented in the park.

Primary and Secondary Target Species

Primary Target	Secondary Target
Eastern brook trout[SGCN]	Northern redbelly dace[SGCN]
Blue-spotted salamander[SGCN]	Slimy sculpin[SGCN]
Jefferson salamander[SGCN]	Tessellated darter[SGCN]
Wood turtle[SGCN]	Marbled salamander[SE]
American bittern[SGCN]	Northern leopard frog[SGCN]
American black duck[SGCN]	Black racer[ST]
American woodcock[SGCN]	Ribbon snake[SGCN]
Canada warbler[SGCN]	Smooth green snake[SGCN]
Northern goshawk[SGCN]	Cerulean warbler[SGCN]
Red shouldered hawk[SGCN]	Cooper's hawk[SGCN]
Ruffed grouse[SGCN]	Eastern towhee[SGCN]
Veery[SGCN]	Great blue heron[SGCN]
Wood thrush[SGCN]	Purple finch[SGCN]
Whip-poor-will[SGCN]	Eastern pipistrelle[SGCN]
Bobcat[SGCN]	Eastern red bat [SGCN]
Bear	Eastern small-footed bat[SE]
Moose	Hoary bat[SGCN]
Beaver	Northern myotis
	Silver-haired bat[SGCN]
	White-tailed deer
	Wild turkey

SE = state endangered
ST = state threatened
SGCN = species of greatest conservation

Recommendations

The following management recommendations for the park are based on the habitat requirements of primary and secondary target species. Each section has a list of species that would benefit from the

recommended action. In addition, it is recommended that all management actions follow "*Good Forestry in the Granite State*" and other relevant Best Management Practices to maintain or enhance wildlife habitat quality.

Aquatic Habitats

- Use existing Best Management Practices to maintain water quality of lakes and ponds, especially the four ranked among the top ten in their class statewide based on a conditions assessment by The Nature Conservancy.
- Maintain no-cut buffers for at least 35 feet or as cited in "*Good Forestry in the Granite State,*" whichever is greater, adjacent to streams and rivers to maintain water temperatures, provide shading, a long term source of coarse woody material falling into the stream/river, potential nesting sites for raptors (e.g,. red-shouldered hawk), and roosting areas for bats.

Primary Target Species: Eastern brook trout

Secondary Target Species: Northern redbelly dace, slimy sculpin, tessellated darter, cerulean warbler, eastern red bat, hoary bat, northern myotis, silver-haired bat.

- Maintain a network of wetlands representing a variety of successional stages.
- Encourage hydrologic management and restoration prescriptions that promote a diversity of successional stages including open water, forested, emergent, and shrub wetland types to support a maximum diversity of wildlife. This goal can be partially accomplished by allowing the natural occupation and abandonment of beaver flowages.

Primary target species: Wood turtle, American bittern, American black duck, American woodcock, Canada warbler, red shouldered hawk.

Secondary target species: Northern leopard frog, black racer, ribbon snake, smooth green snake, great blue heron, eastern pipistrelle, eastern red bat, eastern small-footed bat, hoary bat, northern myotis, silver-haired bat.

- Complete a survey for vernal pools in un-surveyed areas of the park.
- Maintain all vernal pools and maintain, or increase their vegetative buffers.
- When conducting any work near vernal pools, avoid creating ruts and skid roads that collect or change the flow of water. Through runoff, these disturbances can influence the timing of wet/dry periods in a vernal pool, altering the species that can breed there.
- Avoid clear cuts in or around vernal pools. Removing the shade of the tree canopy can heat up the air, soil and water in the pool, change the period of time that water remains in the pool, and influence which species can survive there.
- Maintain a relatively closed canopy (70%) forest between pool clusters.
- Do not create recreational trails near vernal pool habitats.

Primary target species: Blue-spotted salamander, Jefferson salamander, wood turtle

Secondary target species: Marbled salamander, northern leopard frog, black racer, ribbon snake, eastern pipistrelle, eastern red bat, eastern small-footed bat, hoary bat, northern myotis, silver-haired bat

Terrestrial Habitats

- Evaluate existing grassland areas to determine if they should be maintained or converted to another habitat type.
- Maintain grasslands close to water. Many reptiles, amphibians, and birds that use wetland areas also rely on adjacent grassland areas for nesting and foraging.
- If mowing is used to maintain fields, mow after July 15 to avoid direct negative impacts to grasslands nesting birds and establish a rotational mowing program in which different parts of a field (or different fields) are mowed at different times. Ideally, the rotation would allow for some areas to be mowed late in the fall (September-October) to allow late-blooming wildflowers to form and provide nectar sources for migrating butterflies.
- Mowing in the fall will also minimize impacts to reptiles and amphibians. Other areas would be mowed mid to late growing season (late July – August) to provide some control of woody shrubs and trees that may attempt to colonize a field. This type of mowing regime would move from field to field over a course of many years so that all fields would be maintained in the long term while providing significant habitat benefit to a wide array of wildlife.
- Mower decks should be raised to maintain a residual cover of at least 6 inches in height. This will provide some cover for small mammals and will minimize direct mortality of small mammals, reptiles, and amphibians.
- In areas targeting grassland birds, remove tree and shrub lines growing in the middle of fields, as these decrease the useable acreage as perceived by grassland-nesting birds. However, allowing shrubs to colonize edges of fields (or alternatively planting shrubs along field edges) can provide excellent food and cover for many species of wildlife including many primary and secondary shrubland species.

Primary target species: Wood turtle, American bittern, American black duck, American woodcock, northern goshawk, red shouldered hawk, ruffed grouse, bobcat, bear.

Secondary target species: Northern leopard frog, black racer, ribbon snake, smooth green snake, cooper's hawk, white-tailed deer, wild turkey.

Wildlife openings are small, non-forested areas dominated by a mix of grasses, forbs, and shrubs typically created and maintained in largely forested settings to provide foraging areas for various wildlife.

- Create additional wildlife openings where feasible to provide important foraging opportunities (soft mast, herbaceous food, and insects) for wildlife including snakes, migratory songbirds (both forest and nonforest), raptors, bobcats, white-tailed deer, bear, and others. This recommendation would be best suited for Criteria 2 & 3 areas.
- Openings should range from 0.25-0.5 acres in size. Smaller openings would provide little habitat value. Larger openings may contribute to lower bird nesting success rates in adjacent forest.
- A mix of native grasses, forbs, shrubs, and trees benefit a greater diversity of wildlife than openings planted and maintained solely with non-native grasses and will be easier to maintain in the long term.
- Maintain openings via mowing after July 15 every 3-6 years, depending on the growth rate of woody plants on site. Other shrubland habitat maintenance techniques can also be used.

Primary target species: Wood turtle, American black duck, American woodcock, Canada warbler, northern goshawk, red shouldered hawk, ruffed grouse, veery, wood thrush, whip-poor-will, bobcat, bear, moose.

Secondary target species: Black racer, ribbon snake, smooth green snake, cerulean warbler, cooper's hawk, eastern towhee, purple finch, eastern pipistrelle, eastern red bat, eastern small-footed bat, hoary bat, northern myotis, silver-haired bat, white-tailed deer, wild turkey.

- Maintain and create additional old field and shrubland habitats, where appropriate, in a mosaic of grass/forb and shrub patches. This recommendation would be best suited for Criteria 2 & 3 areas.
- Old fields and shrublands adjacent to other early-successional habitats such as grasslands, wet meadows, shrub wetlands, utility rights-of-way, or forests with well developed understories have significantly higher value as habitat than small, disjunctive patches.
- Strive for shrub patches ranging from 5-10 acres in size and avoid irregular patch shapes and edges to provide breeding as well as foraging opportunities and to minimize edge effects.
- If trying to control invading tree species, mowing should take place during the growing season to minimize re-sprouting. A rotational mowing program similar to that described for grasslands that always leave some old field or shrubland cover is a good technique for long term habitat maintenance.
- Old fields and shrublands that are relatively stable (e.g., comprised of species such as dogwoods and viburnums) will require monitoring and occasional selective cutting, mowing, or herbiciding (e.g., cut stem, basal bark, or other targeted application techniques) of small trees that invade the area (e.g., every five years). Patches dominated by regenerating trees will require aggressive management for several years to aid in conversion to a more stable shrubland.
- Restoring natural hydrology in wetlands will also help to create and maintain shrublands including removing unneeded man-made dams and allowing colonization and abandonment of beaver ponds.

Primary target species: Wood turtle, American bittern, American black duck, American woodcock, Canada warbler, northern goshawk, red shouldered hawk, ruffed grouse, veery, wood thrush, whip-poor-will, bobcat, bear, moose, beaver.

Secondary target species: Northern leopard frog, black racer, ribbon snake, smooth green snake, cooper's hawk, eastern towhee, eastern pipistrelle, eastern red bat, eastern small-footed bat, hoary bat, northern myotis, silver-haired bat, white-tailed deer, wild turkey.

A diversity of forest types and conditions are required to maintain populations of the target species. The types and conditions that are needed can be attained via implementation of a forest management program that incorporates a range of techniques; from no management (i.e., no harvest, eventually producing old growth conditions) to intensive management (e.g., even-aged management such as clearcutting). Refer to the Forest Management chapter for more detailed information on how each management technique will be employed within the park. All forest management activities in the park should follow the guidelines in "*Good Forestry in the Granite State,*" especially those pertaining to mast, cavity trees and snags, dead and downed woody material, and woodland raptor nest sites.

Target species benefiting from no management include:

Primary target species: Blue-spotted salamander, Jefferson salamander, wood turtle, Canada warbler, northern goshawk, red shouldered hawk, wood thrush, bobcat, bear, moose, beaver.

Secondary target species: Marbled salamander, cooper's hawk, purple finch, eastern red bat, eastern small-footed bat, hoary bat, northern myotis, silver-haired bat, white-tailed deer.

Target species benefiting from uneven-aged management include:

Primary target species: Blue-spotted salamander, Jefferson salamander, wood turtle, American black duck, American woodcock, Canada warbler, northern goshawk, red shouldered hawk, ruffed grouse, veery, wood thrush, whip-poor-will, bobcat, bear, moose, beaver

Secondary target species: Marbled salamander, ribbon snake, cerulean warbler, cooper's hawk, eastern towhee, purple finch, eastern pipistrelle, eastern red bat, eastern small-footed bat, hoary bat, northern myotis, silver-haired bat, white-tailed deer, wild turkey.

For even-aged management areas:

- When clear cutting is used in areas slated for even-aged management, strive for patches ≥ 5 acres and avoid irregular patch shapes and edges to provide breeding as well as foraging opportunities and to minimize edge effects.
- Even-aged management adjacent to the existing utility right-of-way would substantially enhance the habitat value of this already existing shrubland.

Primary target species: Wood turtle, American black duck, American woodcock, northern goshawk, red shouldered hawk, ruffed grouse, veery, wood thrush, whip-poor-will, bobcat, bear, moose, beaver.

Secondary target species: Northern leopard frog, black racer, smooth green snake, ribbon snake, cooper's hawk, northern goshawk, red shouldered hawk, eastern towhee, purple Finch, eastern pipistrelle, eastern red bat, eastern small-footed bat, hoary bat, northern myotis, silver-haired bat, white-tailed deer, wild turkey.

Invasive Exotic Plants

- Control the few infestations of invasive exotic plant species in both wetland and upland habitats.
- Use mechanical treatments where feasible and effective (e.g., hand pulling or mowing). Mechanical treatments are most effective and feasible in areas with low density infestations, on tap rooted plants, and seedling/sapling sized trees and shrubs.
- In cases where mechanical treatments are not feasible (high densities, plants with large root systems, etc), chemical treatment may be warranted.
- If herbicides are used, utilize the least toxic herbicide that has also proven to be effective. Use targeted application techniques when feasible (e.g., cut-stem treatments) to reduce non-target impacts. If a surfactant is needed, take care to use one that is non-toxic to aquatic organisms if applying in or near wetlands.
- Conduct a comprehensive survey of invasive exotic plant species in the park. The park has relatively few invasive exotic plant species for a property of its size. Knowing where they occur will help with controlling them before they become a problem.
- Be cautious when undertaking other management activities so they won't exacerbate the spread of invasive exotic plants (e.g., tractors used in field mowing can transport seeds to invasive free areas).

Primary target species: Canada warbler, veery, wood thrush, whip-poor-will.

Secondary target species: Northern leopard frog, black racer, smooth green snake, cerulean warbler, eastern towhee, purple finch.

Public Use

- Manage human access points and trails to provide suitable recreational and educational opportunities in Pisgah State Park, while also avoiding and minimizing impacts to sensitive resources. Use Best Management Practices for trail building and maintenance (i.e., trails should avoid vernal pool habitats and important wintering habitats).
- Dogs and human presence can adversely impact wildlife through direct mortality and alterations in behavior that could result in lower productivity, fitness and mortality of wildlife.
- Fix/install proper drainage along all roads and trails to minimize amount of silt entering adjacent marshes.
- Maintain the dam at Pisgah Reservoir as long as feasible to maintain the very popular warm-water fishery.

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Forest Management[9]

The Importance of Local Timber

Harvesting local timber to meet regional demands for forest products helps to keep income in the local economy. Currently much of the lumber and other wood products used locally are imported from other regions of the United States and even other parts of the world. This export of local dollars to other areas is a loss of wealth for our region which could have been used to support local jobs, merchants and communities.

Much attention has been focused on the cost of transportation and energy. It makes a lot of sense for a region to utilize forest products from within the region than to transport it from thousands of miles away. Even if shipping container costs are low, the energy used to transport forest products long distances contribute to pollution of the atmosphere and consequently other resources as well.

Not only does transportation of forest products use energy but this relocation has also been responsible for the movement of deleterious insect and disease infestations. Using local timber helps reduce the transportation of invasive plants and animals from outside the state.

Local forest products are earth-friendlier, renewable resources. Management of the forests in New England has shown that the forest is resilient. Harvested acres regenerate into young and vigorous new forests. Careful harvesting allows for the capturing of wood products while maintaining water quality, soil productivity, wildlife habitat and safe local employment. Many of these harvest characteristics are lacking in respect to forest products from other areas especially third world countries.

The argument has also been made that when forest products are imported from other areas, consumers tend to be wasteful, partly because consumers do not see the effect of their consumption. The harvesting of forest products from local sources reminds consumers that consumption has an environmental cost and encourages conservation.

Economic Impact

Timber harvests from state reservations provides employment for timber buyers, loggers, truck drivers, equipment manufacturers, mill workers, mill equipment manufacturers, re-manufacturing facility workers such as carpenters, cabinet makers, firewood dealers, biomass plant workers and the state forestry and wildlife staff.

The forest products harvested are re-sold several times and end up in home centers and lumber retailers where they provide employment for sales help. The University of New Hampshire - Cooperative Extension has estimated that each dollar received from stumpage sales within the state results in approximately 27 dollars in revenue for the state's economy. Much of this is through employment, product sales and re-manufacturing value added products.

Timber harvests also provide direct benefits to local communities in the form of the timber yield tax. About 10% of the stumpage value of any timber product harvested is paid to the town by the landowner in the form of a yield tax. If a harvest at Pisgah yields $40,000 in stumpage, the local community will

[9] Ken Desmarais, Will Guinn, and Inge Seaboyer, New Hampshire Forest Management Bureau

receive about $4,000 in additional taxes from the sale. Using the UNH – Cooperative Extension model, a $40,000 timber sale would add about $1,080,000 to the regional economy.

Forest Products

Forest management activities on state reservations are designed to improve the quality of the growing timber resources so they may be sold to regional timber markets. The regional markets reflect those uses that are usually important to local communities. Some forest products have little value and are consequently difficult to find buyers for; while many others are desirable and buyers are plentiful, offering prices that make harvesting worthwhile. Primary forest products are described below.

Veneer

Veneer is a thin layer of high quality wood that is glued to lower quality wood to give a better appearance to the product being made. Veneer is often peeled or sliced from a log instead of being sawn out. This increases the yield of veneer from each log and eliminates waste such as sawdust. Veneer logs usually return the highest price of all timber products. In New England high quality hardwoods such as sugar maple, red oak, white ash and yellow birch are sought for veneer. In order to qualify for veneer, logs must be perfect with no knots or other defects and generally have a small heart. Unfortunately veneer usually makes up a very small portion of the timber grown in New England. At Pisgah the yield of veneer can be increased by growing well stocked, young stands to encourage straight trunks that shed branches quickly, followed by periodic release from competing trees to increase vigor and diameter growth.

Where did the wood from the first timber sale go?

In the early part of 2008 the first commercial state timber harvest was conducted at Pisgah. The harvest was purchased by Cutting Edge Timber Harvesters of Marlborough, NH. Sawtimber removed totaled 223,752 board feet and 3,173 tons of low grade products.

Harvested firewood came to 1,513 tons or the equivalent of about 582 cords. If the average home burns 5 cords of wood per year for home heating purposes, this volume would heat approximately 116 local homes. The firewood harvested at Pisgah is estimated to replace the burning of 83,808 gallons of heating oil using the conversion rate available through the NH Office of Energy and Planning. Firewood is a sustainable, carbon neutral fuel compared to heating oil which is not sustainable and produces carbon emissions that otherwise would be stored within the earth. The firewood harvested also keeps local dollars local instead of sending local dollars abroad.

The sawtimber products were shipped to 3 sawmills within the region. The mills sawed pine lumber, pallet stock and fine quality hardwood lumber.

The harvest yielded an income of $39,808.36. Using the UNH Cooperative Extension estimate of $27 of economic benefit for every dollar of stumpage value, the harvest contributed about $1,074,816 to the regional economy.

Sawtimber

Sawtimber refers to logs that are sawn for lumber products. Sawtimber values can range from very high (similar to veneer) to very low (similar to firewood or pulp) depending on tree species, quality and size. Hardwoods usually bring the highest prices, however softwoods are capable of growing far more board feet per acre. Hardwood markets have traditionally been somewhat volatile with consumer preferences shifting back and forth from the grainy woods like red oak and white ash to the "white woods" such as maple and birch. Typically red oak prices are about double the prices of white pine.

White pine generally has a more stable market and has been the backbone of the forest industry for several centuries. White pine stumpage prices may vary slightly over a time but traditionally do not see the type of fluctuations that hardwood prices do.

The best quality pine logs have fewer, smaller knots, long lengths (12-16 feet) and a moderate scaling diameter (about 14 inches). When branches are present, the market pays more for logs with red knots (from live branches) than black knots (from dead branches). This is because red knots are woven into the board and stay tight, where as black knots are held in place by the surrounding wood. When a black knot shrinks, it will often loosen and fall out.

Sawlogs should be grown in well stocked, young stands, followed by periodic releases to encourage vigorous diameter growth. Tight stocking at a young age encourages the death of the lower branches on the bole. Tending practices such as thinning and crop tree release encourages the shedding of the dead branches.

Pallet Logs

Lower quality logs are often referred to as pallet logs. Traditionally this term was used because pallet logs yielded low quality lumber only suitable for making pallets for shipping materials, or other low quality products that only required strength. Pallet logs are now used to designate low quality logs of both hardwoods and softwoods. Pallet logs are a bi-product of a good timber management program. Because of their abundance there is a surplus of pallet quality logs on the market.

Pallets have been connected with the spread of invasive insect pests. The low quality of the lumber is often due to insect infestations in the wood or the wood may attract insects. Pallets that are built in other countries from wood that was not kiln dried may continue to pose a threat to our local forests as a source on imported pests.

Hardwood pallet logs will have knots on three to four sides and softwood pallet logs will have large black knots (3 inches in diameter or larger. The first log in a tree often will be the highest quality log because it is larger in diameter and has few or no branches due to mechanical or self pruning. However logs located above the butt log in many trees have a greater number of larger knots and are considered pallet logs.

Pulp

Wood provides a cheap source of raw material for paper. The wood fibers are mechanically or chemically separated then formed into thin sheets as paper. There has been a fluctuating market for paper pulp for nearly a century. Hemlock pulp from Pisgah is generally shipped to New York or to concentration areas to the north. Hardwood pulpwood is generally shipped to concentration yards to the north and east. Pulpwood competes with firewood and biomass chips for markets, and prices may fluctuate accordingly.

Chips

Biomass chips are made from the tops and low grade parts of trees. When trees are cut during a timber harvesting operation the higher quality products are removed from the tree. The remaining parts of the tree are sometimes fed through a very large chipper. Biomass chips may appear to be a simple product but chip buyers usually require a chip that is consistent in size, with minimal bark. At the biomass power plant the chips are fed into a boiler for generating electrical power. Older plants are not very efficient but newer plants can be extremely efficient.

Biomass is considered a *"green"* fuel because it is a renewable resource. Biomass is grown locally, so local dollars stay in the regional community. Unlike petroleum, when trees are harvested and burned, the location from which they were harvested will begin to recapture carbon again. Eventually the site will store as much carbon as it did prior to cutting. On the other hand oil field sites, once drilled will not refill with carbon rich oil.

Biomass chips are easy to grow and should be considered a bi-product of a good timber management program. They are typically the tops and branches of trees that have grown sawlogs and veneer, or the trees that have been thinned from a stand early in the rotation to provide space and other resources to sawlog quality trees.

In the Northeast, several schools, hospitals and community centers are converting their infrastructure to enable the use of biomass chips for heating purposes. Careful harvesting at Pisgah, can provide energy resources to the local communities and the surrounding region.

Firewood

Trees in New Hampshire forests have always produced wood for burning. Whether fuel for native American campfires or firewood burned in a wood stove, locally produced firewood provides a good opportunity to heat local homes at an affordable price.

Most hardwood trees are suitable for firewood although some species are better than others. Often species with the densest wood also produce the highest amount of BTUs.

Firewood is generally harvested from the tops of sawtimber trees or from trees that have been thinned out of the forest. Like other low value products, firewood should be a bi-product of a well managed forest.

Forest Carbon

Carbon storage is a topic that has generated much interest in respect to forests and forest products. Wood contains much carbon, so wood products that are long lasting and not burned or that does not decompose, can store carbon for a long time. Veneer and high quality lumber are generally long term products that are maintained for a long period of time because of their high value. Bi-products of sawtimber such as sawdust, slabs and edgings are often re-processed as paper pulp or as biomass fuel. Biomass fuels are burned to produce energy, often in the form of steam for electrical production or municipal heating or both. The burning of biomass chips as a fuel does produce carbon products that are released into the atmosphere. However biomass chips are considered a "green" fuel or a carbon neutral fuel because the carbon produced is being re-cycled from the immediate environment. Biomass chips offset the use/burning of fossil fuels which would release in the atmosphere carbon products that otherwise have been stored and would continue to be stored for a very long time out of the atmosphere.

Important Tree Species for Forest Products

Several native tree species that grow at Pisgah are important sources of lumber and other forest products locally and across the globe. Some of the most important species and the products they are utilized for are described below.

Eastern White Pine

White pine has needles occurring in fascicles (bundles) of five. It can be a very fast growing tree. White pine can grow well on nearly any soil however it does very well on sandy soils where the competition from hardwoods is less severe.

White pine can grow to well over 100 feet in height, often with a straight stem producing a large number of logs per tree. It is also fast growing in diameter. A stand of white pine with a 75 to 90 year rotation period can obtain an average diameter of about 20 inches.

This tree species is probably the most important commercial tree in New Hampshire. It was first harvested for ship's masts because of its tall straight stems. Now it is sawn into lumber for furniture, trim boards, cabinets, and utility lumber. It also is pulped for paper and chipped for biomass fuel.

On a per acre basis white pine can produce more value than most other species of tree. This is based on the fact that pine stands can carry as much as 40,000 board feet per acre although a typical pine stand under management carries between 10,000 and 20,000 board feet per acre.

Northern Red Oak

Red Oak is often the most valuable tree species in New Hampshire. It is a long living tough tree that often fights its way up through a stand from an understory position to the crown canopy. Red oak produces an abundant nut crop approximately every 2-5 years (Sander 1995), which is relied upon by over 30 species of wildlife as a main source of food (Yamasaki 2010). Red oak grows well on a wide variety of soils including some very low quality sandy soils. It can also do well on the better soils but has difficulty competing with some of the faster growing hardwoods on high quality soils.

Red oak is often sawn into lumber for furniture and millwork; it is a good peeler for high quality veneer. Red oak does not make good paper pulp but is good for stove pellets, firewood and biomass chips. It is also highly valuable for wildlife habitat due to the acorns it produces. The rotation for red oak sawtimber often ranges from 100 to 120 years.

Sugar Maple

Sugar Maple typically grows on the better quality soils inside Pisgah State Park. The soils have finer textures and higher amounts of organic matter, so they often have a higher level of base nutrients available for tree growth. Sugar maple is well known for the sweet sap it produces in the Spring that is often boiled down to make maple syrup or maple sugar.

Sugar maple also produces very high quality forest products. It can be peeled for veneer, sawn into high quality lumber or used for pulp, biomass chips and firewood. The lumber is prized for furniture, cabinets and millwork. It is often called "rock maple" because the wood is extremely hard.

The price of sugar maple stumpage can fluctuate widely, often comparable to red oak prices, sugar maple stumpage can occasionally fetch the highest prices in the state for veneer and sawtimber logs. Sugar maple is a very long lived tree. Management rotations for sugar maple stands can exceed 120 years under certain conditions. On the right soils, it can be managed using selection silviculture.

Birches

In Pisgah State Park birches include our state tree, paper birch as well as yellow birch and black birch also known as sweet birch. Paper birch is a short lived tree that is usually grown for 60 to 80 years. Yellow and black birch can be grown for a much longer period of time.

Yellow and black birches have the distinction of having twigs that have a wintergreen taste when chewed. They were at one time used to make birch beer and distilled to yield oil of wintergreen.

Yellow birch and black birch often produce high quality logs. They are often peeled for veneer and sawn for lumber to make furniture, cabinets and millwork. Lower grade stems can also be sold as firewood as well as chipped or pulped.

Black birch is very common at Pisgah. Recent interest in black birch has shown the species to be very responsive to forest management. It is easy to regenerate and to grow. It responds well to thinning, growing quickly in diameter. Black birch can produce a high yield of quality logs in a relatively short rotation.

The structure of regenerating birch stands can provide valuable early successional wildlife habitat.

Other valuable species

White ash, red maple and black cherry are also present at Pisgah. When good quality crop trees of these species are encountered it is profitable to grow them to mature sawtimber size.

Not all trees are grown for their timber value. Aspen and American beech, which are seldom worth more than pulp, are valuable species to grow for wildlife habitat purposes. The same is true for eastern hemlock, which is often grown to provide deer wintering areas.

Harvesting Systems

A timber harvesting system is one of several combinations of equipment used for extracting forest products from the forest. Harvests at Pisgah are typically conducted with the same equipment used on timber sales on private lands. The general configuration of harvesting equipment falls into the three following categories.

Traditional chainsaw and skidder

This is a labor intensive system in which trees are felled with a chainsaw and dragged to the log yard with a skidder to be processed into sawlogs, pulp, or firewood. Once the most common method of logging, it has rapidly been replaced by the two mechanized approaches below.

Mechanized Harvesting

In this system trees are cut with a feller-buncher and laid down in bundles or “hitches”. A grapple skidder then collects the hitches and drags them to the log yard for processing. This is currently the most common logging method used in New Hampshire. Although the first harvest at Pisgah utilized a cut-to-length harvesting system, future management at the park will undoubtedly include mechanized harvests as well.

Cut to Length

This method of harvesting involves cutting trees with a mechanical harvester that not only severs the tree from the stump, but also removes the branches and bucks the trees into logs. The logs and other segmented parts of the tree are carried to the log yard with a machine called a forwarder. Cut-to-length systems are considered easy on the land because they transport shorter lengths of trees from the forest, the wheels of harvesting equipment are designed to have a low psi rating on the ground and they do not drag the trees, but instead transport them in the back of the forwarder on bunks. Still, the weight on the wheels of forwarders can be quite heavy.

Figure 1 *A forwarder bringing pulp to the yard on a timber harvest on a New Hampshire state reservation.*

Intended Use and Management of State Reservations

When the General Court established laws for the acquisition and maintenance of state reservations, they stated in legislation the reasons for the purchase of tracts of land. The state laws that guide the ownership and management of state reservations specifically mention timber harvesting. The RSAs are provided below.

RSA 227-G:1 Declaration of Purpose

It is hereby recognized and declared that the public welfare of this state requires the maintenance, protection, conservation, multiple use, and rehabilitation of forests for the social, economic, and environmental benefits that result from a diverse forest cover. Such benefits include forest products, a viable forest-based economy, recreation opportunities, scenic values, healthful surroundings, climate mitigation, clean water, and biologically diverse populations of plants and animals. It is further recognized that long-term sustainability of the state's forests will require: the prudent acquisition and management of state-owned forests; data collection, planning, and education; protection of critical resources; monitoring and protection of forest health; and control of woodland fires.

RSA 227-H:1 Declaration of Purpose

It is hereby recognized and declared that state-owned reservations contribute to the conservation of natural resources and distinctive quality of life in the state. The public welfare of this state is served by the prudent acquisition and management of reservations to provide forest benefits and for the purposes of demonstrating sound forestry principles, protecting habitat for plants, animals, and other organisms, conserving forested watersheds, preserving areas of rare and exemplary natural beauty and ecological value, and providing for perpetual public access and use.

Pisgah State Park is the State of New Hampshire's second largest "state reservation". A state reservation is any tract of land managed by the NH Department of Resources and Economic Development (DRED)[10].

[10] RSA 227-G:2 defines a state reservation as *"Reservation" means public land under the jurisdiction of the department including, but not limited to: state forest, state park, natural area, historic site, geological site, recreation trail, memorial area, fire tower, wayside area, heritage park, resource center, agricultural area, state forest nursery, fish pier, administrative facility, information center, demonstration forest, certain islands, and lands under lease to the department.*

State reservations are managed through a system of zoning. Originally state reservations had red zones and white zones, red zones being those lands primarily managed under the jurisdiction of the Division of Parks and Recreation and white zones being lands primarily under the jurisdiction of the Division of Forests and Lands. These zones have adapted over the years into Recreation Land Use acres (formerly red zones) and Forestry Land Use acres (formerly white zones). This is due to the fact that the legislative charge of the Division of Parks and Recreation is to provide and manage developed recreation areas such as campgrounds, waterfronts, picnic areas, wayside areas, historic sites and other types of developed facilities where people come to participate in supervised recreation.

The Division of Forests and Lands is legislatively charged with overseeing the management of those portions of state reservations that do not contain developed recreation areas. Regardless of whether a tract of land is a "state forest" or a "state park", jurisdiction of non-developed sites is assigned to the Division of Forests and Lands. At Pisgah State Park, there are no acres that are zoned as Recreation Land Use.

As a state reservation the intended use of Pisgah State Park is to provide public access for dispersed recreational purposes as well as forest management activities, and for the protection of other resources as specified in the RSAs above. DRED documents from the 1960's concerning the purchase of Pisgah specify that forest management activities including timber harvesting will take place on the tract.

Pisgah State Park was purchased primarily through funding from the Land and Water Conservation Fund (LWCF). The purpose of the LWCF is to purchase land for public recreation. According to the LWCF manual "Areas acquired may serve a wide variety of public outdoor recreation activities including but not limited to: walking …, fishing, picnicking, nature study, …hunting, …horseback riding, …, snowmobiling, skiing, and other outdoor sports and activities". Also according to the LWCF manual "…natural resource management practices such as timber management … may be carried out concurrently within the area if they are clearly described in the project proposal…". Timber management within the park provides forest products as well as providing or improving recreation opportunities.

Background

Land acquisition for the Park began in 1968. Most of the property was formerly in the hands of three major owners, Dickinson Lumber Company in the south, Cersosimo Lumber Company in the north and Mr. Wakefield Dort to the west. The latest addition to the Park was 181 acres off Route 63 purchased in 1992.

Unlike much of New Hampshire much of this land was never dominated by agricultural uses. The shallow soils and steep topography were a major deterrent to would-be farmers. Agricultural settlements did occur in the northern and eastern portions of the Park including areas around Fullam Pond, in the lower Broad Brook Valley, east of Fullam Pond in an area known as Nash City or Hardscrabble, and along Horseshoe Road and the northern portions of Old Chesterfield Road. Here cemeteries with headstones dating back to the 1790's, numerous cellar holes and stone walls are evidence of past communities. These indications of past dwelling, however, linger at the perimeter of the Park.

The primary use of Pisgah has traditionally been for forest products. The first sawmill was erected at Winchester in 1734, and lumbering gradually increased in importance until it reached its peak in the latter part of the nineteenth century. In 1885 there were eight sawmills and four box factories dependant upon the forests in the vicinity of the villages of Winchester and Ashuelot. The annual production of these mills was more than six million board feet of mainly white pine. Dickinson Lumber Company had mills set up along Broad Brook, at the dam on Pisgah Reservoir and along the Reservoir Road.

Due to Pisgah's remote location and rough terrain, some stands of virgin white pine and hemlock avoided the saw blade well into the 20th century. However, many of these remaining old-growth stands could not avoid the catastrophic hurricane of 1938, leaving only those remnants where topography mitigated the storm's impact. Harvard University owns a 20 acre in-holding where prior to 1938, studies on the composition of virgin New England forests were done. Now the study concentration is on forest growth in such areas following natural catastrophes. Signs of both hurricane damage and salvage of wood following the storm are evident throughout the Park.

The State has done very little timber harvesting since the property was purchased. In 1997 the first of several projects to restore and maintain old field and early successional wildlife habitat was initiated. The first commercially accomplished habitat project focused on the former Doolittle and John Hill farms at the southern end of the Park, and was funded by the Ruffed Grouse Society through the New Hampshire Fish and Game Department. This project complemented earlier volunteer efforts to restore adjacent apple orchards. In 1998 similar work was begun on the north end of the Park with funding provided by the New Hampshire Fish and Game Department and the USDA Natural Resource Conservation Service (NRCS) Wildlife Habitat Incentive Program (WHIP). Until the late 1990's several fields at the north end of the Park had been maintained under an Agricultural Lease, however, since that time these fields have been maintained for wildlife habitat utilizing a combination of Fish & Game Department equipment and mowing contracts. Additional work to restore and maintain various upland openings and shrub land habitat continues. In 2008 the first commercial timber sale was completed in Compartment 10. This project focused on the areas adjacent to the habitat restoration done at the old John Hill farm, south along old Chesterfield Road, with a primary intent of increasing the value of the earlier wildlife habitat projects by creating additional early successional habitat through a commercial timber sale.

The initial resource inventory of the property was completed in two parts, the southern end of the Park begun in 1981 and the northern end completed in 1985. This initial mapping was done on a six hundred (600) foot grid, and variable plot sampling of the timber resource was done using a 10 basal area factor (BAF) prism. The Society of American Foresters (SAF) cover type descriptions were used to determine stand types. Size class for stands was defined from seedling through large sawtimber. At this time only stands in excess of five acres were mapped. Acquisitions made since 1985, along the eastern and western edges of the Park have not yet been inventoried; however, cover type has been assessed from aerial photos. In 2006 re-inventory of Compartment 10 (on the southeastern edge on the Park) began as part of the timber sale preparation, and field work and mapping was completed in the summer of 2007. Re-inventory continued in Compartment 14 (directly to the west) during 2008-2009. This iteration of the resource inventory is being done on a two hundred (200) foot grid, with a system of variable plot 2 phase sampling utilizing a 20 and 80 BAF used to evaluate the forest overstory.

In addition to the SAF cover types, the re-inventory looked to a number of other cover types, defined by the New Hampshire Division of Forests & Lands, Forest Management Bureau staff to determine stand types. Size class definitions have been expanded to include an "un-even aged" classification for areas dominated by three or more different size classes. While efforts are still made to define manageable upland forest stands with areas of five acres or more, recent mapping also includes smaller sub-stands which are unique and easily identified. Both changes are especially helpful in better defining areas affected by the 1938 hurricane.

Current Resource Conditions

Soils, Site and Forest Vegetation Relationships

Soils are an important part of the planning process for managing natural resources on any piece of property. In the Northeast soils play a major role in determining which plants (including trees) will naturally grow on a particular site.

Parent Material

Current theory suggests New England soils were moved several miles by continental glaciation. The glacial drift that makes up the soils at Pisgah is believed to have come from the north with some striations indicating a slight splaying to the east and west (see Figure 2) around the Pisgah Reservoir (Goldwaitht and Goldthwait 1969). The soil movement is believed to have mixed the soil with soils from other areas further and closer to Pisgah.

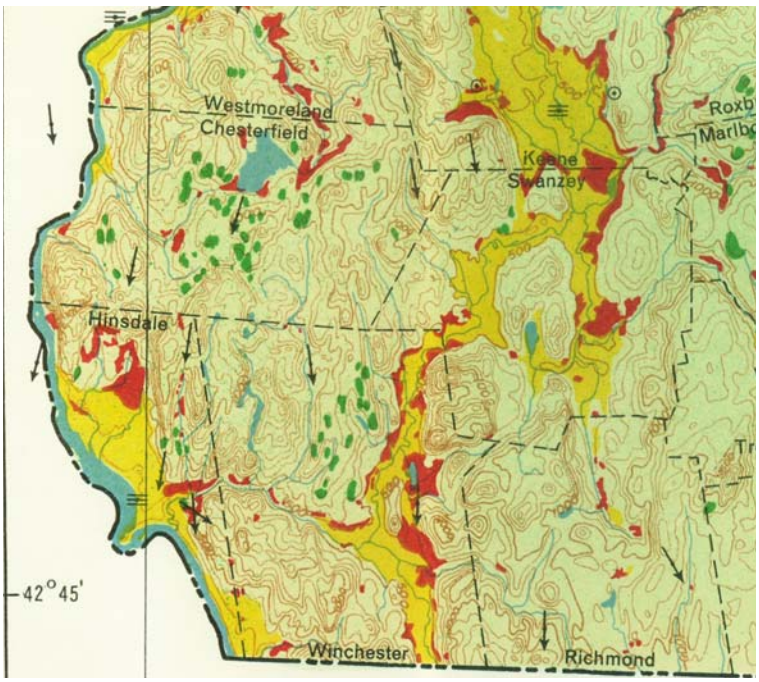


Figure 2 *Map of Surficial Geology of the general Pisgah area. Arrows designate the direction of striations in ledges and outcrops. From Goldthwait et al (1969).*

Most of the parent material that formed Pisgah's soil was probably felsic rock which contains much iron (Fe) and silica (Si). The silica is often found in minerals such as quartz and schist. Quartz is a crystalline matrix of silica and oxygen. These soils tend to have sandy textures because the quartz is chemically very stable and difficult to weather. Also, due to the nature of the silica and oxygen content, the secondary minerals that result from weathering tend to not form clay materials. Mica schist is also common in New Hampshire felsic formations. Mica schist contains a few more elements and in greater quantity than quartz.

When broken down these elements provide very few plant nutrients. However quartz will often contain minute amounts of other elements such as potassium. Potassium is found as a cation and contributes to plant growth. Potassium and other beneficial cations such as calcium and magnesium are not plentiful in soils derived from felsic rock and so soils derived from felsic bedrock tend to represent sites of average forest productivity.

Soils

The soils found at Pisgah State Park can be generally classified by the soil associations that they occur in. The Natural Resources Conservation Service (NRCS) identifies two soil associations that cover the entire park acreage. The associations are **Bernardston-Cardigan-Kearsarge-Dutchess** which generally occurs closest to the Connecticut River valley shown in blue in figure 3 and **Berkshire-Tunbridge-Lyman** which lies just to the east shown in orange. Black areas are general soils that are not specifically linked with either association. As with most things that occur in nature, not all soils in these associations fit these categories exactly, however the categories describe the dominant conditions.

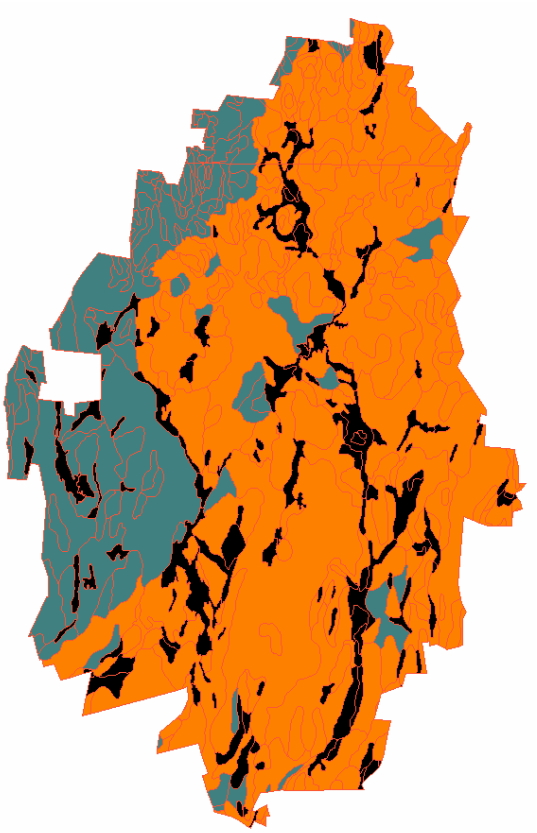


Figure 3 *Soil Associations at Pisgah State Park. Blue areas are Bernardston-Cardigan-Kearsarge-Dutchess association and orange areas are Berkshire-Tunbridge-Lyman association. Black soils are not linked with either association.*

Bernardston-Cardigan-Kearsarge-Dutchess soils tend to be classified as silt loams. They were formed from mica schist and phyllite which are formed (metamorphosed) from shale. These parent materials are very finely grained and tend to develop into fine textured soils relatively high in silt and clay content for New Hampshire soils. The NRCS considers these soils to be of silty textures. Some of the soils are firm, compact, platy tills and some are friable soils. Schist and phyllite contain more base cations and therefore can produce better quality soils than felsic stones, all other conditions being equal.

Soils classified as Berkshire, Tunbridge or Lyman tend to be classified as sandy loams. They usually are loose or firm tills of loamy textures. These soils are average to low quality soils in respect to forest productivity. White pine, red oak and red maple have an affinity for these soils as mid-successional species. When only minor disturbances occur over long periods of time, these soils tend to be dominated by shade tolerant species such as hemlock and beech with some black birch. In figure 3 these soils are represented by the orange areas and make up the majority of the Park.

Forest Cover Associations

The USDA Natural Resources Conservation Service has developed the Important Forest Soils Groups (IFSG) system to classify soils to predict what tree species will be found on-site under natural conditions. This system was initially applied to Pisgah to predict the property wide soil – vegetation relationships for the park. In applying the system it was determined that the system did not fit well with what was found on the ground. Many sites predicted to grow hardwood in late successional conditions were growing hemlock. It is felt that at Pisgah there are subtle conditions in the soil that do not allow the use of the IFSG.

Figure 4 shows the forest cover associations for the park. Soils in the orange areas comprise approximately 7.9% of the acreage at Pisgah and tend to grow northern hardwoods both in mid successional and late successional forest conditions. These soils are generally fine textured and often contain higher organic matter content and better moisture relationships. These soils tend to be located in the Bernardston-Cardigan-Kearsarge-Dutchess soil association. Most of the soils in this association however are colored green and are not expected to be vegetated with northern hardwood tree species due to other soil conditions such as:

- The presence of a compact pan layer that restricts water drainage enough to encourage hemlock as the late successional dominant species. Often the pan is subtle enough to not be featured in a soil profile description. Viewing many of these soils from an aerial photo shows them to currently be growing hemlock.

- The presence of shallow bedrock or rock outcrop. This can lessen the site quality enough to make it less favorable for northern hardwoods and more favorable for hemlock.

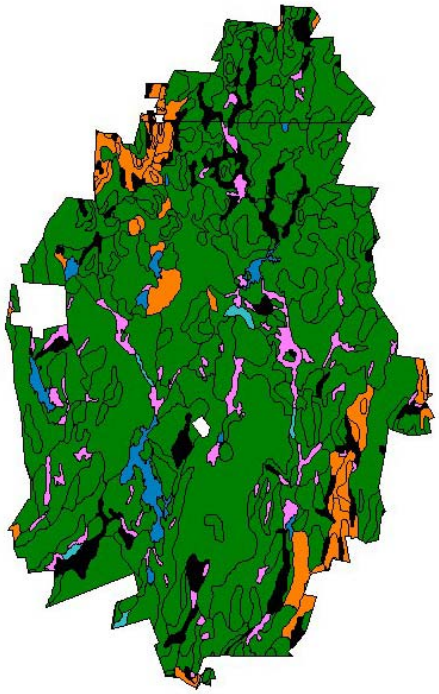


Figure 4 *Forest cover expected at Pisgah State Park due to soil. Green areas are pine/oak/maple types, orange are beech/birch/maple and pink areas are transition hardwoods (mostly red maple).*

The remaining green areas comprise about 85.4% of the acreage in Pisgah. They tend to be in the Berkshire-Tunbridge-Lyman soil association and tend to grow white pine, red oak and red maple with other species in mid successional stands and hemlock, black birch and beech in late successional stands. These soils generally are coarser in texture, are not as fertile or do not have as desirable moisture availability as the orange soils. Some soils are drier and some much wetter than the orange soils. Many of these soils have a compact pan layer that restricts water drainage. The low fertility and poorer water relationships encourage hemlock. Some ablation tills are loose and excessively drained and are expected to support beech and red maple forest types.

The remaining 6.7% of the acreage in Pisgah is currently unclassified and includes open water, wetlands and other soils that we can not classify at this time.

Future work at Pisgah should make a conscious effort to refine the classification of soil – vegetation relationships conducted in this document. Many of the soil factors determining which tree species grow on the site may be able to be better understood and forecasted with more experience and field work in the park.

Soils of Pisgah State Park – from Soil Survey of Cheshire County, New Hampshire, USDA Soil Conservation Service, 1989.

Soil Series	Taxonomic Description	Drainage	IFSG	Mid Succ.	Late Succ.
Becket	Coarse-loamy, mixed, frigid, Typic Haplorthod	Well drained	1A	Pine oak maple	Hemlock-Hdwd
Berkshire	Coarse-loamy, mixed, frigid, Typic Haplorthod	Well drained	1A	Pine oak maple	Hemlock –Hdwd
Bernardston	Coarse-loamy, mixed, mesic, Typic Dystrochrept	Well drained	1A	No. Hdwds	No. Hdwds
Cardigan	Coarse-loamy, mixed, mesic, Typic Dystrochrept	Well drained	1B	Pine oak maple	Hemlock –Hdwd
Chocorua	Sandy or sandy-skeletal, mixed, dysic Terric Borohemist	Very poorly drained	NC	Red maple	Hemlock –Hdwd
Colton	Sandy-skeletal, mixed, frigid Typic Haplorthod	Excessively drained	1C	Pine oak maple	Hemlock –Hdwd
Dutchess	Coarse-loamy, mixed, mesic, Typic Dystrochrept	Well drained	1A	No. Hdwds	No. Hdwds
Greenwood	Dysic Typic Borohemist	Very poorly drained	NC	Wetland	Wetland
Keasarge	Loamy, mixed, mesic Lithic Dystrochrept	Somewhat excessively drained	1B	Pine oak maple	Hemlock –Hdwd
Lyman	Loamy, mixed, frigid Lithic Haplorthod	Somewhat excessively drained	2A	Pine oak maple	Hemlock –Hdwd
Lyme	Coarse-loamy, mixed, acid, frigid Aeric Haplaquept	Poorly drained	2B	Wetland	Wetland
Marlow	Coarse-loamy, mixed, frigid, Typic Haplorthod	Well drained	1A	No. Hdwds	No. Hdwds
Merrimac	Sandy, mixed, mesic Typic Dystrochrept	Somewhat excessively drained	1C	Pine oak maple	Hemlock –Hdwd
Monadnock	Coarse-loamy over sandy or sandy skeletal, mixed, frigid Typic Haplorthod	Well drained	1B	Pine oak maple	Hemlock –Hdwd
Moosilauke	Sandy, mixed, frigid Aeric Haplaquept	Somewhat poorly drained	2B	Pine oak maple	Hemlock – Hdwd
Naumburg	Sandy, mixed, frigid Aeric Haplaquod	Poorly drained	2B	Wetland	Wetland
Ossipee	Loamy, mixed, dysic Terric Borohemist	Very poorly drained	NC	Wetland	Wetland
Peru	Coarse-loamy, mixed, frigid Aquic Haplorthod	Moderately well drained	1A	No. Hdwds	No. Hdwds
Pillsbury	Coarse-loamy, mixed, acid, frigid Aeric Haplaquept	Poorly drained	2B	Wetland	Wetland
Pittstown	Coarse-loamy, mixed, mesic Aquic Dystrochrept	Moderately well drained	1A	No. Hdwds	No. Hdwds
Rippowam	Coarse-loamy, mixed, nonacid, mesic Aeric Fluvaquent	Poorly drained	2B	Wetland	Wetland
Saco	Coarse-silty, mixed, nonacid, mesic Fluvaquentic Humaquept	Very poorly drained	NC	Wetland	Wetland
Searsport	Sandy, mixed, frigid Histic Humaquept	Very poorly drained	NC	Wetland	Wetland
Skerry	Coarse-loamy, mixed, frigid Aquic Haplorthod	Moderately well drained	1A	No. Hdwds	No. Hdwds
Stissing	Coarse-loamy, mixed, acid, mesic Typic Haplaquept	Poorly drained	2B	Wetland	Wetland
Sunapee	Coarse-loamy, mixed, frigid, Aquic Haplorthod	Moderately well drained	1A	Pine oak maple	Hemlock -Hdwd
Suncook	Mixed, mesic Typic Udipsamment	Excessively drained	1B	Pine oak maple	Hemlock -Hdwd
Tunbridge	Coarse-loamy, mixed, frigid Typic Haplorthod	Well drained	1A	Pine oak maple	Hemlock -Hdwd

Soils and Shade Intolerant Species

On all forested upland soils at Pisgah, if heavy disturbance occurs, the possibility exists for the development of early successional forests of birches and aspen and other associated early successional species. This forest cover type is generally independent of soil conditions and relies upon (1) level of disturbance – these tree species are considered to be indeterminate, rapid growing, shade intolerant species and so they can outgrow other species if adequate light exists, (2) amount of birch or aspen seed or sucker-stock available – birch and aspen seed is plentiful in northern New England due to past cutting levels including clear cutting. In other parts of the region where only light to moderate harvesting has recently taken place, adequate source of seed or aspen clones that serve as sucker-stock may not be adequate and may need to be developed if this forest type is desired; (3) amount of advanced regeneration within a stand – if a stand of trees has a strong and plentiful advanced regeneration stratum, these species may re-sprout aggressively and dominate the stand after regeneration cutting with birch and aspen serving as only a minor component of the species composition.

Pisgah Forest Cover Options

Within the Park, three broad forest types may occur.

- Mid and late successional northern hardwoods forests occur on fine textured high quality soils (about 7.9% of the acreage)
- Mid-successional pine/oak/maple and late successional hemlock/hardwoods occur on poorer quality soils (about 85.4% of the acreage)
- Early successional birch/aspen occur on all soils

Current Forest Cover

As indicated by the current resource inventory, 92.4% of Pisgah State Park is upland. Of this the vast majority is forested, with only 0.5% of the Park's acreage currently classified as some type of upland opening, including fields, old orchards and other openings. The remaining acreage consists of water and wetland areas.

Table 1 Upland Non-Forested Cover Types at Pisgah State Park

COVER TYPE	ACRES
Field	45.7
Old Field	4.2
Old Orchard	13.6
Open	1.3
Total Acreage	**64.8**

Pisgah lies in a transition forest between the northern hardwood forest cover types and the more southern pine-oak types. Based on the most current resource inventory for the Park a little over twelve (12) percent of the upland forest is dominated by hardwood types and almost twenty-seven (27) percent is occupied by mixed wood types, while fifty-three (53) percent of the forest is occupied by softwood types. As the soils information would indicate, hemlock is indeed the most extensive forest cover type, occupying thirty-nine (39) percent of the Park. In fact hemlock in combination with other species accounts for sixty –one (61) percent of the forest cover in the Park. The white pine-red oak-red maple type, at sixteen (16) percent, is the only non-hemlock type to be represented in excess of 1,000 acres. Early logging which released shade tolerant hemlock, combined with soil tendencies and protection from forest fires account for the abundance of hemlock. The white pine-red oak-red maple, which once included American chestnut as a major component, developed primarily from second growth white pine on old fields, where the hardwoods associated with this type quickly seeded in following pine logging.

Table 2 Acres by size class and forest cover type at Pisgah State Park						
	Size Class					
COVER TYPE	**1**	**2**	**3**	**4**	**5**	**6**
Aspen	9.0	3.4				
Beech			27.3	14.3		
Beech -Sugar Maple				28.4		
Black Birch	0.5					
Black Oak				103.0		
Hardwood	9.0					
Hemlock			25.3	5196.0	2.3	
Hemlock-Mixed HW				100.3		
Hemlock-Yellow Birch			24.3	1279.4		
Red Maple			215.9	528.9		
Red Oak				104.9	1.8	
Red Oak-Hemlock				23.6		
Red Oak-No HW				84.9		92.3
Red Oak-Red Maple			1.9	194.5		
Red Pine				4.1		
Red Spruce			6.1			
Sm-Beech-Yb			18.7	147.7		
Sugar Maple			14.7	28.6		
White Pine			135.7	203.2	41.3	
White Pine-Hemlock				1461.9		
Wp-Ro-Rm			34.9	1953.4	1.3	152.0
Total	**18.5**	**3.4**	**504.8**	**11457.0**	**46.7**	**244.3**

While the softwood areas are dominated by the later successional hemlock types, the limited hardwood areas are heavy to mid successional species like red oak and red maple. As the soils would indicate only a small percentage of the Park (a little over 2%) is in northern hardwood species. The lack of appropriate soils is compounded by the fact that much of the past agriculture took place on the better soils with northern hardwood tendencies, which are either being maintained as upland openings for wildlife use, or in the mid stages of succession. Early successional hardwood types currently account for only 0.1% of the Park's forest cover.

Much of the size class distribution of timber on the property is a result of heavy cutting done prior to State ownership, both in the wake of the 1938 hurricane, and in anticipation of state acquisition in the early 1960's. In the northern and eastern areas of the Park the abandonment of old agricultural lands in the early twentieth century and reversion of fields after state acquisition also lead to the current timber types. More than eighty five percent of Pisgah is currently classified in the small sawtimber size class (10-15 inches in diameter). The second most prevalent size class is poletimber at just under four percent; third is the un-even aged designation at just under two percent (though it should be remembered that this designation has only been applied thus far in Compartments 10 and 14).

Seedling, sapling and larger sawtimber size classes combined account for only 0.5% of the entire Park area, and all are located in the recently re-inventoried Compartment 10. No seedling, sapling or large sawtimber size class stands were noted in the 1981-1985 inventory; most of the currently classified seedling and sapling stands are the result of wildlife habitat restoration initiatives undertaken since 1997.

The exception is the black birch seedling stand southeast of the Park Headquarters on Old Chesterfield Road, which resulted from cutting done by Park staff and the Friends of Pisgah to create a vista. Both regenerating forest and large, mature stands provide critical wildlife habitat components for some of the State's species of critical concern, so the current dearth of these size classes in the Park is a concern for wildlife habitat diversity as well as sustainable forest management within the Park.

It is more difficult to qualify both the understory and regeneration vegetation layers in the Park. Resource inventory information for both (based on observations at sample points rather than plot data) indicates that generally both are quite variable. Observations are in large part a mixture of all the hardwood and softwood species which occur in the overstory (as well as American chestnut sprouts and witch hazel). Notations about density range from heavy to patchy to vacant. Hemlock, not surprisingly appears to be the most ubiquitous species, occurring in the understory, regeneration layer or both of virtually every upland forest stand in the Park. The number of observations of American chestnut sprouts in the regeneration layer and understory layer of many stands in the Park speak to its considerable presence on the property prior to the outbreak of Chestnut Blight in the early 1900's.

Desired Future Conditions

Ecology

Pisgah currently contains some forest stands that have never been harvested or have been only lightly harvested in the past. Since this forest condition is uncommon in New Hampshire and region wide in New England, it is desired to maintain the current stands in this condition. These stands can often be better maintained if they are located within a matrix of stands that also are lightly managed or left unmanaged so that natural processes can dominate.

Many of these lightly or un-managed stands are located within a very large exemplary natural community system mapped by the Natural Heritage Bureau of the NH Division of Forests and Lands. Exemplary natural community systems are examples of plant communities that best exhibit what the forest would be like in their natural state. At Pisgah a goal will be to maintain a substantial acreage within the exemplary natural community system in a state that is consistent with its purpose and condition.

Timber

Forest Structure

Table 3 shows that the current forest structure across the entire ownership of Pisgah State Park carries far more large sawtimber than recommended by DeGraaf et al (2007). A substantial amount of acreage within the Criteria 2 and 3 areas have not yet been determined to be suitable for timber harvesting. Acres that can not or should not be harvested due to physical restrictions of site including slope, wetness and shallow soils will be assigned to the Large Sawtimber category. Since these areas may not be suitable for timber harvesting, the DeGraaf et al recommendations can only be applied to the acreage available for treatment. To apply the DeGraaf et al goals to the entire acreage would mean that operable areas would need to be regenerated far more frequently to maintain the seedling, sapling and poletimber goals than would be sustainable in respect to providing high quality sawtimber to local sawmills. Removing the acreage of questionable operability from the goals will allocate an appropriate acreage to the development of valuable large sawtimber.

Table 3 Comparison of forest structure suggested by DeGraaf et al (2007) to current estimated forest structure of Criteria 2 and 3 land at Pisgah State Park.

Forest Size Class	DeGraaf et al (2007) in %	Pisgah Criteria 2 and 3 lands in %[11]
Seedlings	**5-15**	**0..23**
Saplings and Poletimber	**30-40**	**6.54**
Sawtimber	**40-50**	**92.62**
Large Sawtimber	**<10**	**0.60**

To maintain a sustainable flow of forest products, wildlife habitats and ecological conditions from the known operable acreage at Pisgah, stands will need to be managed in a manner that develops and maintains a balance of forest age and size classes upon the acreage available for timber harvesting. This will require maintaining a careful balance of acres ranging from regeneration through mature sawtimber to ensure that high quality sawtimber, habitat and recreation opportunities will always be available from the acres available for harvesting.

[11] Based on the 1985 natural resources inventory and the deduction of Criteria 1 land.

The desired forest structure to achieve and maintain this balance of sustainability was developed by DeGraaf et al (2007). These authors are scientists with expertise in wildlife population modeling, wildlife habitat management, timber management, silviculture, and forest growth. Their structural guidelines are based upon decades of research and are designed for New England forest types. These structure guidelines provide important broad level wildlife habitat conditions and reasonable rotation lengths for the development of high quality mature sawtimber.

The forest structure developed by DeGraaf et al (2007) recommends the following percentages of managed acres:

- *Regeneration,* 5-15%
- *Saplings and poles,* 30-40%
- *Sawtimber,* 40-50%
- *Large sawtimber,* <10%

These suggested percentages compared to the current forest structure are quite different. Table 3 shows that Pisgah carries a very large surplus in sawtimber sized stands, currently 95% compared to 40-50% desired. This is the only category that exceeds the recommended structural levels. Sawtimber then, is the primary source for developing seedling stands and large sawtimber stands which are both deficient.

Saplings and poletimber are also both deficient but the only reasonable source for these size classes are from seedlings for developing sapling stands and from sapling stands for developing stands in the poletimber size class. Large sawtimber is located in Criteria 1 lands, inoperable lands in other criteria and in special management areas.

Forest Composition

The forest at Pisgah will be composed of a diverse number of species. Some forest stands will contain a few key species and some stands will contain many species. Where soils permit, it is desired that the acres under active management at Pisgah reflect those forest conditions recommended by DeGraaf et al (2007) containing long rotation hardwoods (20-35%), short rotation hardwoods (5-15%), mast bearing oak stands (30-50%) and coniferous forest (10-40%).

Table 4 shows the comparison of recommended composition to current forest composition. The only forest cover category that exceeds the recommendations is coniferous cover which currently occupies 70.5% of the acres compared to the recommended 10-40%. Oak types occupy about 20% of the acreage, just slightly below the recommended 30-50%. Both short rotation and long rotation hardwoods are well below the recommended forest cover goals.

Table 4 Comparison of recommended forest composition to current composition at Pisgah State Park.

Forest Type	DeGraaf et al (2007) in %	Pisgah from 1985 inventory data in %
Long Rotation Hardwood	**20-35**	**8.6**
Short Rotation Hardwood	**5-15**	**0.1**
Oak – Mast	**30-50**	**20.8**
Conifer	**10-40**	**70.5**

The approximate forest composition recommended is attainable on the soils present at Pisgah. These conditions will not be attainable in the short term due to a lack of management prior to the development of this plan.

Regenerating softwood stands to young hardwood will help balance out the deficit in both short and long rotation hardwoods. Preferential silviculture in mixed stands of conifers and oaks will offer opportunities to increase the acreage in oak types.

Timber Management Approach for Pisgah State Park

Managed responsibly, Pisgah State Park contains a tremendous quantity of renewable timber resources which can help meet some of the regional demands of a rapidly growing population and contribute to the health of many local economies. In order to promote ecological sustainability, all timber management on State Lands meets or exceeds the recommendations in *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire* and in the *Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire.* In addition all timber harvests on State Lands are planned, prepared, and administered by Division of Forests and Lands staff foresters in an intensive 46 step timber sale process which involves review and input from the public and the State Land Management Team. This group includes multiple State agencies such as the Fish and Game Department's Game and Non-game programs, the Natural Heritage Bureau, the Division of Historic Resources, the Division of Parks and Recreation, the Trails Bureau and the Department of Environmental Services.

At Pisgah State Park the production of forest products will be guided by a system of three Management Criteria that are based upon varying levels of disturbance that conform to the desired future conditions discussed in the last section as well as incorporate the management guidelines for the other disciplines outlined in this Management Plan. Each Criteria are a series of standards governing the type and degree of disturbance which may occur. The spatial arrangement of the disturbance patterns across the landscape is crucial to this management approach. Starting with an unmanaged core, each successive Criteria will have a progressively higher level of disturbance, ranging from uneven aged management to even aged management. In this manner each Criteria will contribute to the overall biological diversity of the Park, while accommodating a wide variety of demands, and preserving the integrity of vulnerable natural resources. By using a timber management approach that considers the property on a landscape level and that accounts for interdependent resource uses, staff foresters will be able to anticipate and address concerns from other disciplines early on in the planning process when developing proposals for timber harvests.

The distribution of management criteria across the property has been proposed based upon park characteristics of the criteria. Over time as management occurs the position of criteria bounds may be revisited in the planning process by DRED with public input. Periodically, as components of the Pisgah plan are adjusted, the bounds of each criteria may be adjusted as well if appropriate.

Management Criteria 1, Undisturbed Landscape Component

As the second largest State Reservation, Pisgah State Park provides a unique opportunity to establish a large, relatively undisturbed area in the southwest part of the state. A large section of the Park, designated as Criteria 1, will receive little or no timber management and will be left to progress through natural disturbance regimes and the processes of forest succession. Such undisturbed landscape components have long been recognized as providing important habitats for many plants, animals and natural communities. In addition a large, relatively undisturbed area provides an excellent research opportunity as a baseline for timber management activities going on in other areas of the Park as well as on other State and private forest lands. Finally this area

will provide a recreational opportunity for Park visitors desiring a more remote outdoor experience.

It is recognized that while the lands designated as Criteria 1 presently contain only small pockets of undisturbed or "old growth" forests, much of the area may attain old growth characteristics over time through the natural process of succession. However the influences of atmospheric and biotic factors around the property will never allow Criteria 1 to revert completely to an undisturbed state. Still this plan recognizes the importance of relatively undisturbed sites and that unless some lands are set aside, free of direct human disturbance, such as the routine commercial harvest of timber resources, they will never begin to approach an undisturbed condition.

When choosing areas for Criteria 1 it was necessary to take advantage of the opportunities the landscape offered as well as the historic land use patterns. Consideration was given to the following:

- Areas of large, contiguous acreage with clearly delineated boundaries that are readily identified in the field.
- Areas containing sensitive species or sites.
- Areas which have received no past commercial management or little recent commercial management and contain mature and over-mature stands.
- Areas surrounded by stands suitable to uneven-aged management, which can serve as a transition zone into areas of even-aged management.
- Areas where the surrounding landscape components are controlled by ownership, remoteness, or existing site limitations.
- Areas which are more remote and less subject to human influences.

Areas representing the range of sites/habitats occurring on the property as a whole.

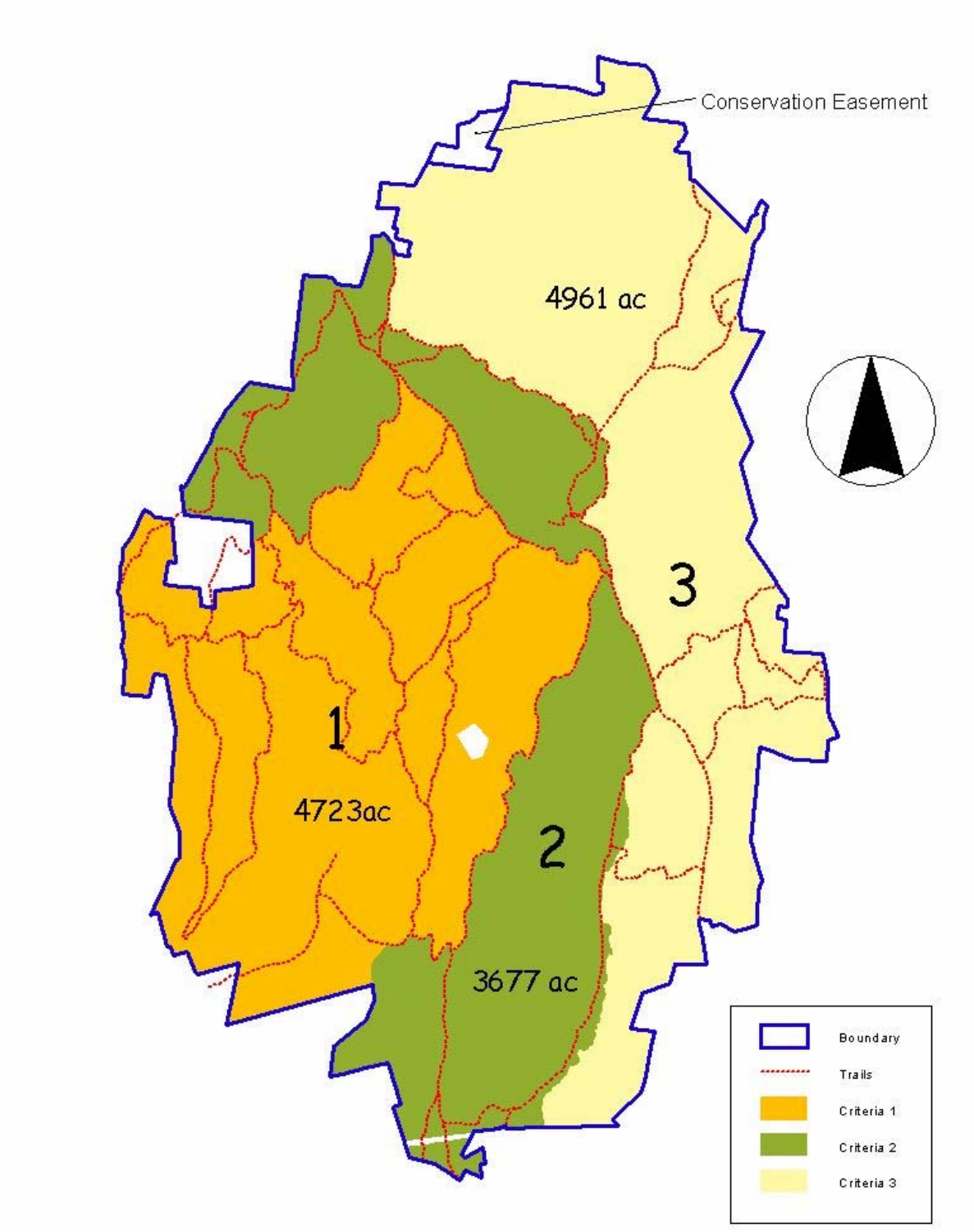
Based upon the guidelines above, the southwest portion of the Park presented the best opportunity for Criteria 1. Bounded by the Hinsdale Town Forest, sections of Reservoir Trail, Old Chesterfield Road, Dogwood Swamp Trail, and portions of the southern and western property boundaries, criteria 1 totals 4,723 acres. The surrounding area to the north, east and southeast is within the Park boundaries and readily lends itself to uneven-aged management. Although portions of the Park to the west and south are bounded directly by Routes 63 and 119, the remaining uncontrolled area around the west and south of the property is remote, with difficult access and site conditions. Shallow-to-bedrock soils, rock outcrops and very steep terrain make future development unlikely.

Criteria 1 is dominated by a softwood cover of hemlock with areas of northern hardwoods and contains Pisgah Reservoir, Kilburn Pond, North Round Pond, and Lily Pond as well as several smaller water bodies. Criteria 1 also covers approximately two thirds of the area identified by the Natural Heritage Bureau as an exemplary hemlock-hardwood-pine forest system. In addition several rare plant species and black gum – red maple basin swamps which are locally significant natural communities were located in Criteria 1. Much of the topography in Criteria 1 is steep and rocky as it contains much of the Pisgah Mountain Range. While there is little evidence of settlement in Criteria 1, much of the area, was owned by Dickenson Lumber *(New England Box Company)* and Mr. Wakefield Dort, and was salvaged extensively after the 1938 Hurricane. Despite this past land use, there are still several small areas of old growth forest that have been identified in Criteria 1, as well as an out lot owned and used for research by Harvard University that contains old growth that blew down but was never salvaged. Criteria 1 contains an extensive

network of trails with varying uses throughout the year, including some motorized vehicle access. The Hinsdale trail is the only sanctioned ATV trail and several others such as Reservoir Trail and Dogwood Swamp Trail allow snowmobile use.

Minimizing man-made disturbances in this exemplary natural community system, such as commercial timber harvesting will allow the natural progression of late successional species like hemlock and northern hardwoods and provide habitats for animals requiring these later seral

Figure 5 Pisgah State Park Management Criteria Areas



stages. While the goal of Criteria 1 is to allow the development of a relatively undisturbed area, it must be recognized that natural disturbances will occur and that some disturbances may be large and catastrophic. Non-natural, large scale disturbances are anticipated from introduced insects, diseases and other non-natural sources. As a result, in certain situations, management activities, including timber harvests may be necessary. Efforts to control the outbreak of exotic insects such as hemlock wooly adelgid, or efforts to curb the spread of invasive exotic plant species all may require management activities in Criteria 1. Any timber harvests within Management Criteria 1 will require a recommendation from the Forest Protection Bureau, the Natural Heritage Bureau, the Forest Management Bureau, and input from the State Lands Management Team, the DRED Lands Management Team and the general public. Recommendations for harvests will be based on an identified threat to other Criteria1 areas, adjacent managed timberland, or to the public health and welfare. All wildfires must be extinguished per RSA 224:11.

Management Criteria 2, Uneven-Aged Management

The area in Management Criteria 2 will serve as a transition between the unmanaged area in Criteria 1, and the area which will be most heavily disturbed in Criteria 3. Uneven-aged management will be implemented in Criteria 2 to promote long rotations of mid to late successional species across a balance of age classes. By receiving only light to moderate levels of man-made disturbance Criteria 2 will mitigate the hard edge impact which adjacent even-aged management could have on plants, animals, and natural communities occurring in Criteria 1.

- When choosing areas for Criteria 2 consideration was given to the following:
- Areas which serve well as a transition zones between Criteria 1 and Criteria 3.
- Areas of large, contiguous acreage with clearly delineated boundaries that are readily identified in the field.
- Areas which have received commercial management in the past.
- Habitats and cover types which are suited to the use of uneven-aged management such as hemlock stands.
- Sites which are more suited to the use of uneven-aged management due to limitations on the size of openings that can be created as a result of terrain or wetlands.
- Areas where aesthetic considerations favor uneven-aged management such as along heavily traveled trails and roads.
- Areas which provide opportunities for the demonstration of proper uneven-aged management techniques.

Based on these guidelines the area at Pisgah State Park chosen for Criteria 2 surrounds the north, east and southeast boundaries of Criteria 1 and is bounded to the north, east and south east by portions of Horseshoe Road, South Woods Trail, Nash Trail, Broad Brook Road and Broad Brook. Ranging in width from several hundred feet to several thousand feet, Criteria 2 totals 3,677 acres (see map 1).

Much like Criteria 1, Criteria 2 is dominated by a softwood cover of hemlock with some areas of northern hardwoods and contains several water bodies and wetlands, including Baker Pond, Fullam Pond, and Broad Brook. Criteria 2 contains about a third of the area identified by the Natural Heritage Bureau as an exemplary hemlock-hardwood - pine forest system. Natural Heritage also identified several additional black gum - red maple basin swamps which are locally significant natural communities. The Pisgah Mountain Range creeps in to portions of Criteria 2 as well, and as a result some of the area is steep and rocky, providing limited opportunities for timber harvesting. There is evidence of past settlement, agricultural use and timber management in Criteria 2 as documented by the abundance of stone walls, cellar holes and mill sites. Criteria 2

contains several trails including Broad Brook Trail which is open to both ATVs and snowmobiles.

The shade tolerant, late successional species occurring on the Berkshire - Tunbridge - Lyman soils in criteria 2 naturally regenerate in small openings and are well suited to uneven-aged management - a silvicultural system in which there is no final stand replacing harvest but rather a shifting mosaic of small openings across a stand over time. This retention of a perpetual forest cover results in a multi-aged stand favoring a range of shade tolerant, late successional species, moderately shade tolerant mid-successional species with a light component of shade intolerant species. Typically to be considered uneven-aged, stands need at least three distinct age classes, each at least 20 years apart. Timber harvests in Criteria 2 will follow the principles of uneven-aged management using two approaches; single tree selection and group selection.

Single tree selection will be used to remove individual stems across the range of size classes in a stand, at approximately 20 year intervals, resulting in a classic inverse J-curve distribution of size classes (heavier to seedling, sapling and pole size classes and decreasing through saw timber and mature saw timber size classes). This method is typically performed to encourage shade tolerant species, such as hemlock and northern hardwoods, which can regenerate and thrive in the smaller openings created by the removal of individual stems. A sustained flow is insured by the inverse J-curve structure that provides a surplus of trees in each diameter class as trees grow from one diameter class into the next.

Group selection will be used to remove groups of stems to create larger openings throughout a stand ranging in size from 1/10 to 1 acre each. Periodic harvests at approximately 20 year intervals will remove additional groups over time, eventually returning to the initial set of groups at the end of the rotation age. This method is typically performed to encourage regeneration of species of a wider range of shade tolerance. Smaller groups will encourage more shade tolerant species, such as hemlock and northern hardwoods; while larger openings will encourage less tolerant species such as white pine, red oak, red maple, and birches.

While each of these silvicultural techniques may be applied individually, they are most often applied together. When used in combination, single tree selection will be performed between group cuts, removing poorly formed stems, less desirable species and mature trees in an effort to enhance the growth and improve the quality of the residual stand. The cutting cycle for this combined method remains at twenty year intervals over the rotation age of the stand. In any given stand groups are established at year 0 and every 20 years there after, eventually returning to the initial set of groups at the end of the rotation age. Single tree selection occurs simultaneously between groups and eventually, over time, in the initial set of groups as they mature to commercial size.

Figure 6 *Group selection with single tree selection.*

The amount of acreage that can be harvested sustainably using this combined method of uneven-aged management can be calculated for Criteria 2 using a method of forest regulation called area control. Based on actual harvestable acreage, desired rotation age and a set cutting cycle, area control can establish the amount of acreage that can be harvested in groups and in single tree selection annually.

By subtracting out known areas of questionable operability and accessibility, wetlands and water bodies and any other areas not suitable for commercial management, the acreage that is known to be available for timber harvesting in Criteria 2 is reduced from 3,677 total acres to 1,522 acres. Additional wetlands and inoperable areas will undoubtedly be discovered as every portion of the Park has not yet been mapped at a fine level of detail. To account for this, an adjustment factor of 2/3 based on data for all State lands will be applied to further reduce the harvestable acreage to 1,005 acres (see map 2 on page 31).

As DRED foresters continue to conduct forest inventory in compartments within Criteria 2 and 3, some areas of questionable operability and accessibility including the acres removed by the 2/3 adjustment may be considered appropriate for harvesting upon a more detailed inspection. At the time of this plan these areas of questionable operability and accessibility have been designated by remote sensing methods and will be field checked using established natural resource inventory techniques by division foresters. At the completion of inventory work conducted in each individual compartment the operable acreage will be adjusted and area control regulation used to update the allowable harvest goals.

Because this area is a transition zone, acting as a buffer between a no management area and intensive management area, it is appropriate to encourage longer rotation ages ranging from 100 years to 140 years. An average rotation age of 120 years with a 20 year cutting cycle would then result in 6 age classes; 0-20, 21-40, 41-60, 61-80, 81-100, 101-120. In this scenario a set of groups would be cut in a stand at year 0, 20, 40, 60, 80, 100, and at year 120 the group cut at year zero would be harvested again. Additionally single tree selection would occur between groups in areas having attained the age of 60, 80, and 100 where commercial harvesting is efficient and economical.

Using these figures the total acreage can be divided by the rotation age to calculate the acreage that can be regenerated annually through group selection. Currently this would be 1,005 acres / 120 years = 8 acres regenerated annually through group cuts. Additionally, recalling that single tree selection would occur at age 60, 80, and 100 years, the acreage that is available for single tree selection annually can be calculated as three times the harvest acreage. This would be 8 acres x 3 = 24 acres harvested through single tree selection annually. The total annual allowable harvest for Criteria 2 would then be 8 group selection acres + 24 single tree selection acres to equal 32 total acres annually. The harvest acreage and volume is expected to change as individual compartment inventories are completed.

An important point that should be mentioned here is that while these allowable harvest acreages have been calculated on an annual basis, entries into Criteria 2 will be periodic. Harvests are not anticipated to occur every year but instead every 2 or 3 years and this may result in a larger harvest than the allowable acreage in a given year, but would not exceed the allowable harvest when averaged over time. For example an initial harvest in Criteria 2 may consist of 16 acres in groups and 48 acres in single tree selection for a total of 64 acres. A second harvest may not occur again for three years, at which time another 16 acres may be harvested in groups and another 48 acres in single tree selection for another 64 acres harvested. This would result in a total of 128 acres over 4 years which is still within the annual harvest of 32 acres per year -128 acres harvested / 4 years = 32 acres/year.

As mentioned earlier, the group selection portion of this harvest acreage will be broken up across a sale area into many individual openings ranging in size from 1/10 of an acre up to as much as 1 acre in size. It is also important to reiterate that the same sale area would not be re-entered for the next round of group cuts and single tree selection for about 20 years.

While the uneven-aged management guidelines above lay out the silvicultural techniques that will be used when harvesting timber in Criteria 2, there are multiple, cross-discipline considerations that will be evaluated and addressed on a project basis using the guidelines and recommendations found in this management plan as well as through the inter-agency State Lands Management Team review process for all timber harvests on State Lands. These would include but are not limited to:

- Use of buffers for all wetlands, water bodies and locally significant natural communities that meet or exceed the recommendations in *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire*.
- Use of appropriate erosion control devices and wetlands crossings as recommended by the *Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire*.
- Use of appropriate buffers for all historic resources such as cellar holes, wells, cemeteries, as well as using existing breaks in stone walls when available, as recommended by the Division of Historic Resources.
- Managing for critical wildlife habitats such as deer yards, wetlands, riparian zones, vernal pools, cavity trees and snags as recommended by Fish and Game.
- Managing the exemplary hemlock-hardwood - pine forest system in close conjunction with the Natural Heritage Bureau.
- Establishing aesthetic buffers along recreational trails and roads in conjunction with the Trails Bureau and Friends of Pisgah.
- The control of invasive, exotic plant and insect species will be conducted with recommendations from the Forest Protection Bureau.
- All wildfires must be extinguished per RSA 224:11.

Area control will help to ensure that Criteria 2 is harvested in a sustainable manner. By adhering to the established, allowable harvest acreages this cutting method will regenerate the appropriate amount of mature forest each cutting cycle and provide a continuous supply of younger age and size classes to replenish those that are harvested. This regulated cutting approach will eventually establish the desired proportions of various age and size classes as recommended by DeGraaf et al (2007) for the managed acres at Pisgah. Table 5 compares the forest structure that is anticipated to result from application of the Criteria 2 guidelines with those recommended by DeGraaf et al (2007). All in all the criteria 2 guidelines match up very well with the recommendations of DeGraaf et al for the managed acres. Since much acreage currently is not designated as managed acres, there will be a surplus of older forests compared to the recommendations in DeGraaf et al for the entire Criteria 2 lands. The reader must remember that the Area Control recommendations and DeGraaf et al provide for a balance of sustainable high quality timber products as well as habitats. Lowering the rotation age as a response to the

Table 5 Anticipated structure distribution for Criteria 2 lands at Pisgah State Park that are considered to be manageable.

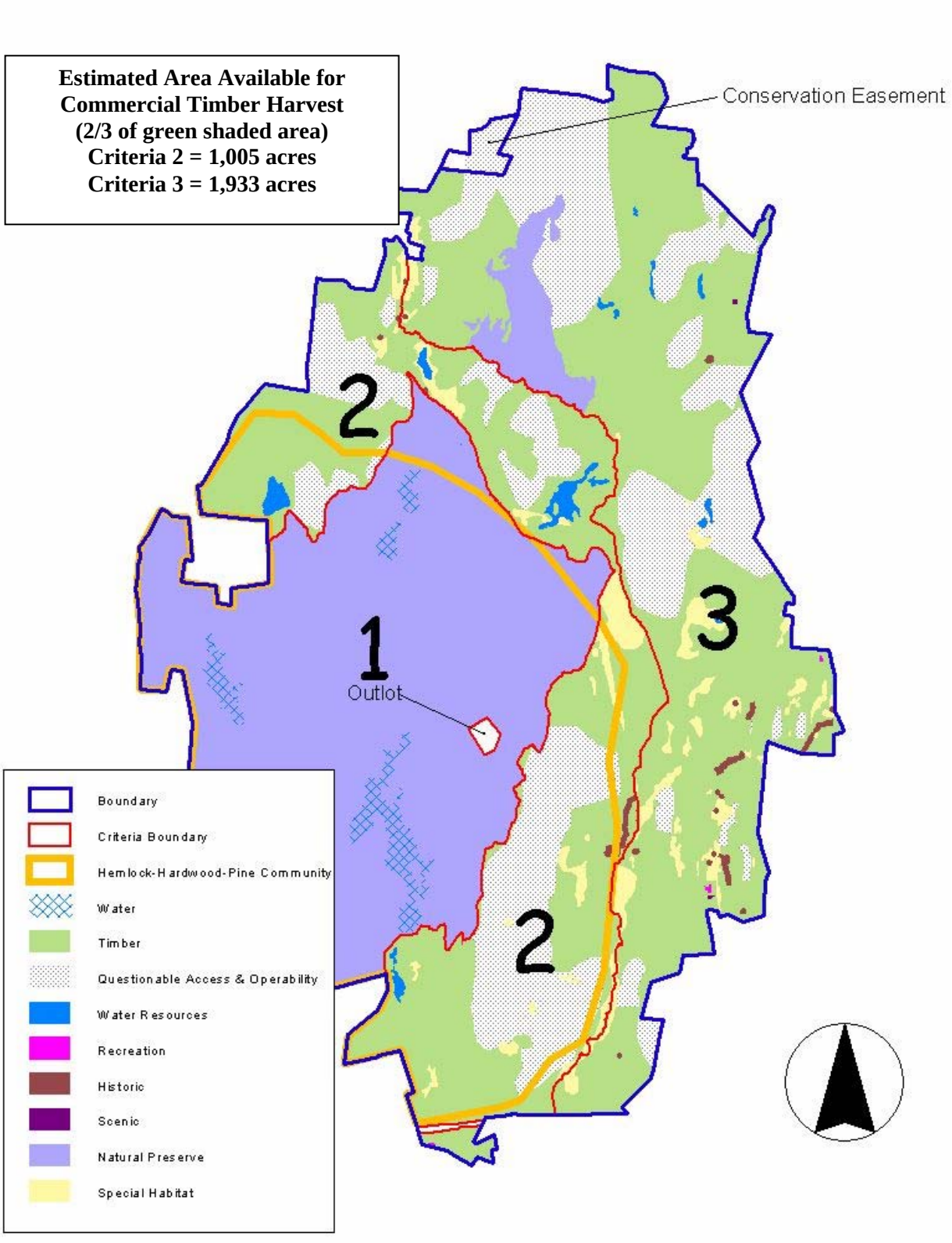
Size Class	DeGraaf et al (2007) *(in % of acres)*	Criteria 2 Anticipated *(in % of acres)*
Seedlings	**5-15**	**8**
Saplings and Poletimber	**30-40**	**33**
Sawtimber	**40-50**	**42**
Large Sawtimber	**<10**	**8**
Total		**100**

proportion of older forests on the Criteria 2 acres was not chosen because it will encourage harvesting stands before they are economically mature.

The harvesting of mature trees in groups will provide high quality timber products such as veneer and sawlogs. Tree tops and low quality or defective trees will also be harvested from groups as well as from single tree selection applied between the groups to provide low quality products such as pulpwood, firewood and biomass chipwood.

Division of Forests and Lands foresters are currently working with the American Chestnut Foundation to develop a blight resistant American chestnut hybrid using backcrossed Chinese Chestnut/American Chestnut pollen to fertilize local remnant seed sources. The final product will be a chestnut tree that is over 90% American, retaining the genetic resistance to the blight from the Chinese chestnut. When disease resistant chestnut seedlings become available, consideration will be given to replanting that species at Pisgah as part of an attempt to restore the once abundant chestnuts to their native range. Replanting groups and patches may be a good strategy for the introduction of chestnut at Pisgah.

Figure 7 Pisgah State Park



Management Criteria 3, Even-Aged Management

Many species of plants and animals are tied to early successional and young forest habitats. Early successional habitats are in decline in southern New Hampshire and are dependent on high levels of light resulting from large scale disturbances, such as those created in even-aged management. The size and location of Pisgah State Park allows for a rare opportunity to implement the practice of even-aged management on a wide scale to create much needed habitat in the southwestern part of the state. Where site conditions allow, Criteria 3 will emphasize large scale openings to create viable amounts of early successional and young forest habitat. Over time this will result in a balance of age classes, a balance of hardwood and softwood composition and a diversity of species throughout the area. In addition even-aged management will allow for more economical timber harvesting practices.

When choosing areas for Criteria 3, consideration was given to the following:

- Areas of large, contiguous acreage with clearly delineated boundaries that are readily identified in the field.
- Areas with a tradition of active commercial forest management and disturbance.
- Habitats and cover types well suited to even-aged silviculture such as early successional and young forests of intolerant or moderately tolerant tree species.
- Sites which favor the growth of shade intolerant, early successional species and moderately shade tolerant mid-successional tree species.
- Areas where the ability to create larger openings increases the feasibility of even-aged management.
- Areas where even-aged silviculture conflicts the least with other uses
- Portions of the Park bordered by heavily disturbed landscape components on abutting lands.
- Areas which provide opportunities for the demonstration of proper even-aged silvicultural techniques.

Using these guidelines the northern and eastern portions of the property presented the best opportunity for Criteria 3 (see map 1). Totaling 4,961 acres, Criteria 3 is bounded to the west by Criteria 2 and by the property boundaries to the north, east and south. The areas to the north and east, outside the property bounds, around Criteria 3 include some heavily disturbed landscapes out of State control. Land uses include fields, housing developments and areas of recent, heavy timber cutting.

Unlike the previous two Criteria which were dominated by hemlock, Criteria 3 is dominated by a mixed wood cover of white pine, red oak and red maple with areas of hemlock. While Criteria 3 does not contain any large water bodies, it does contain several wetlands including a very large emergent marsh-shrub swamp system identified by Natural Heritage as an exemplary natural community. Natural Heritage also identified several red maple - black ash - swamp saxifrage swamps which are locally significant natural communities. Criteria 3 also contains several large areas which are steep and rocky, providing limited opportunities for timber harvesting. There is much more evidence of past settlement, agricultural use and timber management in Criteria 3 as documented by the over abundance of stone walls, cellar holes, mill sites and mid-successional forests. Criteria 3 contains many roads and trails including the Chesterfield Road and Jon Hill Road which are both open to ATVs and snowmobiles.

Intolerant and mid-tolerant early and mid-successional species such as aspen, birches, oaks, and pine are readily encouraged and maintained by the use of even-aged management; a silvicultural

system which has a final harvest at the end of a stand rotation to remove the overstory and create or release a new stand. While this system may utilize many different intermediate harvest techniques, it is the final harvest that defines the practice. This stand-wide overstory removal results in the creation of larger openings in the forest than uneven-aged management, and encourages the regeneration of species, which due to their degree of shade intolerance, cannot be propagated in a closed canopy situation. Timber harvests in Criteria 3 will follow the principles of even-aged management using the intermediate and final harvest techniques outlined below.

During the long growing period between the time when a stand is established and eventually harvested it is desirable to enter the stand after it has reached commercial size to reduce the stocking at approximately 20 year intervals in order to maintain a satisfactory growth rate and in some cases establish regeneration. This can be achieved using the following intermediate harvest techniques.

Figure 8 *A nicely thinned stand of conifers and deciduous tree species.*

Thinning or improvement harvests reduce the stocking of a stand to a desired level, generally between the B and C line on the stocking charts, or between 40 and 60 percent relative density, to enhance the growth and improve the quality of the residual stand, typically by removing poorly formed trees and less desirable species first. This technique may be performed in single species stands such as white pine or in mixed stands such as pine-oak-maple.

Figure 9 *Photo of red oak crop trees released from competition by neighboring trees through a timber harvest.*

A crop tree release removes trees that compete with crop trees. Crop trees are well spaced stems that have been selected to grow in the stand until the end of the rotation. Crop trees are typically released on three to four sides of their crowns to facilitate rapid growth. Typically performed on younger, high value hardwoods, such as red oak, crop tree release may also be performed in softwoods such as white pine. Occasionally certain low value trees are selected as crop trees for their wildlife value. This technique may be performed as a single entry to final stocking (only crop trees left), or may be done in a manner that requires additional intermediate entries to further release crop trees as their crowns expand into the crowns of adjacent trees left in the residual stand. Taking the stand to final stocking during the initial entry reduces the chance of damage to the boles and roots of the crop trees that may occur during successive intermediate entries, however it also leaves the stand initially under stocked and vulnerable to damage or mortality from weather, pests, or disease throughout the rotation as there are no alternative stems to work with.

The shelterwood method is a multi-staged harvest method designed to develop advanced regeneration in a stand of trees. The first stage reduces the stocking of a stand to approximately the B-line on the stocking charts or about 60 percent relative density, and removes any understory competition to allow increased levels of light to reach the forest floor to establish regeneration.

Typically this technique is performed in softwood stands such as pine during a good seed year and on bare ground conditions to achieve scarification for regeneration, but it may also be performed in hardwoods such as red oak during a good acorn year. In the second stage a second entry is made to allow more light to reach developing regeneration that was established in the first stage cut. Typically the second cut is performed 10 to 15 years after the initial cut, however if the regeneration is well established and growing well, it is not unusual to proceed directly to the final stage (see overstory removal below) particularly in the case of hardwoods such as red oak.

Figure 10 *A successful white pine shelterwood cut on a New Hampshire state reservation .*

Once a stand has matured and reached the end of its rotation it may be harvested using one of the techniques below.

An overstory removal typically describes an operation where advanced regeneration has already been established and is now being released, such as during the final stage of a shelterwood harvest. In softwoods such as pine care must be taken to protect the delicate regeneration as the overstory is harvested. However in the case of tree species that sprout prolifically such as red oak, it may actually be desirable to sever the stems of the advanced regeneration during the overstory removal. This allows the regeneration to take advantage of the favorable root to shoot ratio and re-sprout at a much greater rate of growth.

Figure 11 *An overstory removal harvest was conducted to release established white pine regeneration at the State Forest Nursery.*

A clear cut is the final harvest of a mature stand which has had a series of thinnings or improvement cuts throughout the rotation. It may also be the final harvest of a crop tree release, or the removal of a stand predominately composed of unacceptable growing stock or at-risk trees. Typically this describes an operation where very little or no desirable regeneration has been established in advance and relies upon seed crops at the time of harvest as well as re-sprouting of severed stems to regenerate the stand. To be most effective silviculturally and from a wildlife habitat stand point, clear cuts should range in size from 5 to 30 acres. Often misunderstood and misused in the past, particularly in the western United States, the clear cut method is a sound even-aged silvicultural tool, particularly in the resilient forests of the northeast. Clear cuts should not be used on excessive slopes and should use adequate buffers around wetlands and water bodies as outlined in *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire* (2010).

A seed tree cut or deferment cut is similar to the clear cut above, however, well spaced overstory trees are left uncut as a seed source to establish regeneration and for an aesthetic quality to soften the visual impact of the harvest. Trees are typically retained at a rate of 10-20 stems per acre and may be removed once regeneration has been established during the first intermediate commercial harvest, or left for structural diversity within the new stand.

Figure 12 *Aspen root suckers regenerating in a clear cut.*

The amount of acreage that can be harvested sustainably using even-aged management can be calculated for Criteria 3 using **area control**. Based on actual harvestable acreage, desired rotation age and cutting cycle, area regulation can establish the amount of acreage that can be treated and regenerated annually.

By subtracting out known areas of questionable operability and accessibility, wetlands and water bodies and any other areas not suitable for commercial management, the acreage that is known to be available for timber harvesting in Criteria 3 is reduced from 4,961 total acres to 2,929 acres. Additional wetlands and inoperable areas will undoubtedly be discovered as every portion of the Park has not been mapped at a fine level of detail. To account for this, an adjustment factor of 2/3 based on data for all State lands will be applied to further reduce the harvestable acreage to 1,933 acres (see map 2).

Figure 13 *A seed tree cut conducted on a New Hampshire state reservation to regenerate northern red oak.*

As DRED foresters continue to conduct forest inventory in compartments within Criteria 2 and 3, some areas of questionable operability and accessibility including the acres removed by the 2/3 adjustment may be considered appropriate for harvesting upon a more detailed inspection. At the time of this plan these areas of questionable operability and accessibility have been designated by remote sensing methods and will be field checked using established natural resource inventory techniques by division foresters. At the completion of inventory work conducted in each individual compartment the operable acreage will be adjusted and area control regulation used to update the allowable harvest goals.

The management of even-aged stands in Criteria 3 will favor shorter rotations of 80 to 100 years. Where early successional species such as aspen and birch are being promoted, rotations may be as short as sixty years; rotations shorter than 60 years were not considered as they may deplete soil nutrient levels. A rotation age of 90 years and intermediate harvests at 20 year intervals would result in three harvests over the life of the stand. After the initial harvest at year zero,

intermediate harvests would be performed when the stand reaches commercial size, typically around age 50 and then again at age 70, followed by a final harvest at age 90.

Using the figures in this scenario the total acreage available for harvest can be divided by the rotation age to calculate the acreage that can be regenerated annually through one of the final harvest techniques mentioned above. Currently this would be 1,933 acres / 90 years = 21 acres regenerated annually. The acreage that is available for intermediate harvests occurring at years 50 and 70 can be calculated as twice the acreage available for final harvest. This would be 21 acres x 2 = 42 acres treated annually. The total annual harvest for Criteria 3 would then be 21 final harvest acres + 42 intermediate harvest acres = 63 total acres annually. The harvest acreage and volume is expected to change as individual compartment inventories are completed. If additional acreage is determined to be suitable for forest management activities, then consequently the harvest acreage and volume will increase proportionately.

Entries in Criteria 3 may alternate with entries in Criteria 2 and will probably occur every two to three years. This may result in a larger harvest than the allowable acreage in a given year but would not exceed the allowable harvest when averaged over time. For example an initial harvest in Criteria 3 may consist of 42 acres in clear cuts and seed tree cuts and 84 acres of thinning and crop tree release for a total of 126 acres. An additional harvest might not occur again for three years, at which time another 42 acres may be harvested in clear cuts and another 84 acres thinned for a total of 126 acres harvested. This would result in a total of 252 acres harvested over 4 years which is still within the annual harvest of 63 acres per year - 252 acres harvested / 4 years = 63 acres/year.

It is important to point out again that final harvests will be spread across Criteria 3 in openings ranging in size from 5 to 30 acres using a combination of clear cuts, overstory removals and seed tree or deferment harvests. It is also important to mention that the large scale openings created during these final harvests will only occur where appropriate. Much of the area in Criteria 3 such as wetland and trail buffers may never have a final harvest but will instead be treated using only intermediate harvest techniques to ensure proper protection of the resources.

The even-aged management guidelines above layout the silvicultural techniques that will be used when harvesting timber in Criteria 3, however, there are multiple, cross-discipline considerations that will be evaluated and addressed on a project level using the guidelines and recommendations found in this management plan as well as through the inter-agency State Lands Management Team review process for all timber harvests on State Lands. These would include but are not limited to:

- Use of appropriate buffers for all wetlands, water bodies and locally significant natural communities that meet or exceed the recommendations in *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire*;
- Use of appropriate erosion control devices and wetlands crossings as recommended by the *Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire*;
- Use of appropriate buffers for all historic resources such as cellar holes, wells, cemeteries, as well as using existing breaks in stone walls when available, as recommended by the Department of Historic Resources;
- Managing for critical wildlife habitats such as deer yards, wetlands, riparian zones, vernal pools, and cavity trees and snags as recommended by Fish and Game;

- Managing around the exemplary emergent marsh-shrub swamp system in close conjunction with the Natural Heritage Bureau; and
- Establishing Aesthetic buffers along recreational trails and roads in conjunction with the Trails Bureau and Friends of Pisgah.
- Control of invasive, exotic plant and insect species will be conducted with recommendations from the Forest Protection Bureau.
- All wildfires must be extinguished per RSA 224:11.

Area control will help to ensure that Criteria 3 is harvested in a sustainable manner. By adhering to the established, allowable harvest acreages this cutting method will regenerate the appropriate amount of mature forest each cutting cycle and provide a continuous supply of younger age and size classes to replenish those that are harvested. This regulated cutting approach will eventually establish the desired proportions of various age and size classes as recommended by DeGraaf et al (2007). Table 6 compares the forest structure that is anticipated to result from application of the Criteria 3 guidelines with those recommended by DeGraaf et al (2007). Over all the criteria 3 guidelines match up very well with the recommendations of DeGraaf et al. Large saw timber will be accommodated in the inoperable and inaccessible areas as well as in the buffer zones.

Table 6 Anticipated structure distribution for Criteria 3 lands at Pisgah State Park.

Size Class	DeGraaf et al (2007) *(in % of acres)*	Criteria 3 Anticipated *(in % of acres)*
Seedlings	**5-15**	**10**
Saplings and Poletimber	**30-40**	**40**
Sawtimber	**40-50**	**50**
Large Sawtimber	**<10**	**see text**
Total		**100**

Final Break Down

Based on this timber management approach, only a small portion of Pisgah State Park will be available for timber harvesting until a more detailed assessment of the site capabilities can be completed. The unmanaged core which makes up Criteria 1 comprises approximately 35% of the total property acreage. An additional 43% of the total property acreage, spread across both Criteria 2 and 3, is comprised of wetlands and other areas unsuitable for commercial timber harvest as well as areas that are uncertain as to operability and appropriateness for management activities. This leaves about 22% of the 13,361 property acres available for timber harvesting at this time. Within 12 to 18 months of the adoption of this plan, division foresters will field visit those areas determined to be of questionable operability and appropriateness for management activities and will make a determination of their status. When the Pisgah Steering Committee reconvenes in 12 to 18 months from the adoption of the plan, the adjusted manageable acreage from fieldwork by division foresters through reconnaissance and natural resource inventory will be re-examined. Forest management goals will be adjusted based on those new acreage estimates. Forest management goals will continue to be adjusted following the completion of compartment inventories.

Current land allocation to forest management activities breaks down to 1,005 acres, or 7.5% of the property, to be managed using uneven-aged silvicultural techniques in Criteria 2, and 1,933 acres, or 14.5% of the property, to be managed using even-aged silvicultural techniques in Criteria 3.

Table 7 Summary of management regime by criteria designation.				
Management Criteria	**Management Regime**	**Total Acres**	**Manageable Acres**	**Allowable Annual Harvest Acres***
Criteria 1	Undisturbed	4,723	---	---
Criteria 2	Uneven-aged	3,677	1,005	32 acres**
Criteria 3	Even-aged	4,961	1,933	63 acres***

* Harvests may exceed the allowable acreage in a given year but will average out over time.

** The Criteria 2 allowable annual harvest allows for 8 acres to be regenerated using group selection and 24 acres to be harvested using single tree selection.

*** The Criteria 3 allowable annual harvest allows for 21 acres to be regenerated and 42 acres to be thinned.

Key Findings

- High quality timber has the greatest possibility for value-added products and re-manufacturing jobs.
- Low quality wood can be sustainable substitutes for non-renewable fuel sources.
- Harvesting at Pisgah will contribute to regional jobs and the local economy and will provide a local sources of raw materials.
- Pisgah can produce high quality timber, especially white pine, red oak and black birch.
- Low quality fuelwood is relatively abundant and is often the byproduct of the production of high-quality timber.
- Harvesting can produce quality wildlife habitat and is necessary to create early successional and young forest habitat types.
- With the exception of portions of the northern and eastern areas of the park, Pisgah was not historically dominated by agricultural land uses, but rather by forest product extraction, excluding a few scattered areas on the western side that have no sign of past logging.
- Only 0.5% of the Park's acreage is upland open habitat types, 92% of the upland is forested.
- Hemlock and mixed hemlock cover types dominate the Park (61%) as a result of soil tendencies and past land use.

- Pisgah includes few soils capable of supporting northern hardwood cover types, and much of this area was in agriculture and is now in maintained upland openings or mid-successional cover types, leaving only 2% of the Park dominated by northern hardwood types.

- Lack of recent harvesting has resulted in only 0.1% of the forest cover in early successional or young forest cover types.

- The impact of the hurricane of 1938, and post storm salvage cutting can be seen across the Park, both in forest composition and structure.

- More than eighty five percent of Pisgah is currently classified in the small sawtimber size class (10-15 inches in diameter).

- Seedling, sapling and larger sawtimber size classes combined account for only 0.5% of the entire Park area.

- Past outbreaks by non native pests, specifically Chestnut Blight, have also significantly altered the makeup in portions of Pisgah.

- Significant portions of the Pisgah, especially on the western side of the park are inoperable or inaccessible for timber harvesting.

- Based on the timber management approach in this plan only 22% of Pisgah will be available for commercial timber harvest.

Recommendations

- Timber harvesting at Pisgah will focus on producing high quality products with low quality trees being extracted during early thinnings.

- Maintain a sustainable flow of forest products from Pisgah by developing a balanced structure of forest age and size classes upon the acreage available for timber harvesting.

- Develop a diverse forest composition of hardwood, softwood and mixed wood cover types.

- Implement a timber management approach using a system of three management criteria based upon varying levels of disturbance to guide the production of forest products and development of forest structure and composition at Pisgah State Park.

- A large, core section of the Park, designated as Criteria 1, will be left relatively undisturbed to progress through the natural processes of forest succession.

- A wide swath around the unmanaged core will be designated as Criteria 2 and will receive only light to moderate levels of disturbance by using uneven-aged management to promote long rotations of mid to late successional species across a balance of age classes.

- The remaining area around outer edge of the park will be designated as Criteria 3 and will receive the heaviest levels of disturbance by using even-aged management to emphasize large scale openings to create viable amounts of early successional and young forest habitat.

- Uneven-aged management techniques used in Criteria 2 will include single tree selection, group selection and a combination of both.

- Even aged management techniques used in Criteria 3 will include thinning/improvement harvests, shelterwood harvests, crop tree release, overstory removal, seed tree/deferment cuts, and clear cuts.

- Area control will be used to determine a sustainable harvest for Criteria 2 and 3 based upon operable acres, rotation age, and re-entry frequency.

- All timber harvest activities will meet or exceed the recommendations in *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire* and will follow *the Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire*.

- All management activities will receive review from the Fish and Game Department, the Natural Heritage Bureau, the Department of Historic Resources, and the Division of Parks.

References

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Sander, I. 1995. Northern Red Oak In: Silvics of North America USDA Forest Service, Agriculture Handbook 654.

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CHAPTER 3: PUBLIC ACCESS AND RECREATION MANAGEMENT[12]

This portion of the Plan specifies the recreational vision, planning principles, goals, policies, and strategies that will guide recreation and public access management decisions.

Vision and Guiding Principles

As stated earlier, the Pisgah State Park Steering Committee adopted a set of guiding principles and a vision for the management of the State Park. Three guiding principles that relate to public use and recreation are as follows.

- The State of New Hampshire and its partners will manage Pisgah State Park to protect and enhance its inherent natural, cultural, and recreational resources.

- Pisgah's large size renders it a landscape unto itself, minimizing disturbance to fish, wildlife, water, air, plants, natural communities and other natural and recreational resources. Pisgah management will maintain and enhance natural and recreational resources within its boundaries, and continue to collaborate with surrounding landowners.

- Pisgah offers unique opportunities for a variety of recreational activities. These activities will be managed in a way that promotes cooperation among recreational users, and doesn't have a significant negative impact on the park's natural resources.

Building upon these guiding principals the following vision for public use and recreation was adopted.

- Ensure the protection, thoughtful planning, and appropriate siting of recreation to meet the needs of residents and visitors. The state and its partner(s) must maintain any recreational improvements and monitor their impacts.

Setting and Experiential Qualities Criteria

To be acceptable, a change in use or management action must be consistent with the Vision and Guiding Principles contained in this Plan. In particular, it must:

- Maintain and/or enhance the backwoods character of the park
- Maintain the informal, remote, and dispersed qualities of the property
- Maintain a reasonable balance of uses, especially between motorized and non-motorized uses, on the property
- Avoid conflicts with enjoyment of the primary uses allowed on the property, especially those which depend upon a quiet and peaceful setting for a more solitary experience

[12] Chris Gamache and Johanna Lyons, Division of Parks and Recreation

- Maintain or enhance the separation of uses, especially motorized and non-motorized uses, which may conflict with one another
- Contribute to the local quality of life

Environmental Criteria

In addition to conforming to existing State regulations, a change in use or management action should:

- Protect and maintain surface and ground water quality and watershed integrity;
- Prevent or, where no alternative route is possible, minimize soil erosion;
- Maintain the scenic quality and forest character of the property;
- Protect seasonal wildlife nesting and other sensitive habitats; and
- Minimize noise.

Administrative Criteria

To be acceptable, a change in use or management action should:

- Be within the capacity of DRED, other State agencies, supporting organization(s) or other partners to adequately fund and execute implementation, maintenance, enforcement and monitoring of the use and associated facilities
- Minimize potential violations and consequent effects on State programs and resources, user experience, environment, and physical setting of the park
- Promote cooperation and coordination among land managers, law enforcement agencies, user groups, and organizations to enhance management and law enforcement of the property
- Promote understanding and a respectful relationship between users
- Be mindful of relevant State policies and other local, regional, and State plans including but not limited to:
    - Land and Water Conservation Fund program
    - State of NH Comprehensive Outdoor Recreation Plan (SCORP),
    - State of NH ATV Plan,
    - Local master plans

Technical Requirements / Needs of Use Criteria

To be acceptable, a change in use or management action should:

- Meet Best Management Practices (BMP) and technical specifications for the stated use
- Strive to achieve USDA Forest Service Accessibility Guidelines for Outdoor Recreation Facilities and Trails (See USDA Forest Service "Accessibility Guidebook for Outdoor Recreation and Trails", May 2006)
- Be flexible in its placement and design relative to changes in forest management activities, especially logging operations

Evaluation Criteria for Changes in Use or Management

To be acceptable, a change in use or management action should:

- Be consistent with DRED policy to protect forest land, achieve multiple use conservation purposes, and provide opportunities for natural resource-based outdoor recreation
- Not degrade the long term capability of the property to produce forest products
- Meet the management intent for zoned areas:
    - Riparian Areas
    - Wetlands
    - Wildlife Management Areas
    - Natural Heritage Areas
    - Cultural Heritage Areas
- Be in accordance with all applicable local, state, and federal laws and regulations

Monitoring

Monitoring recreation use and facility maintenance will be addressed through on-going site inspections and observations by DRED staff. Administrative and facility physical needs are addressed as DRED has the ability to do so. User safety and emergency repairs are given first priority.

Management Policies and Strategies

Overview of Land Management

The Divisions of Forests and Lands and Parks and Recreation cooperatively manage state-owned reservations for a variety of purposes as stated in RSA 227-H:1.

> *RSA 227-H:1 Declaration of Purpose.* It is hereby recognized and declared that state-owned reservations contribute to the conservation of natural resources and distinctive quality of life in the state. The public welfare of this state is served by the prudent acquisition and management of reservations to provide forest benefits and for the purposes of demonstrating sound forestry principles, protecting habitat for plants, animals, and other organisms, conserving forested watersheds, preserving areas of rare and exemplary natural beauty and ecological value, and providing for perpetual public access and use.

The property is managed by professional foresters, forest rangers, wildlife biologists, ecologists, and recreation specialists and staff is on the property throughout the year monitoring public use and resource management.

Permitted Uses

The following uses are permitted at Pisgah State Park:

- Bicycling
- Canoe / Kayaking
- Cross-country skiing
- Mushing
- Enjoying Open Space
- Fishing
- Hiking on Existing Trails
- Hunting
- Nature Observation
- Photography
- Picnicking
- Snowmobiling

- Snowshoeing
- Swimming
- Trapping
- Walking
- Wildlife Viewing
- ATV & Trail bike Trail Use
- Equestrian Use

Special Use Permits
Commercial uses and organized groups of ten or more people require a Special Use Permit from the Commissioner of DRED. Examples of uses for which a Special Use Permit is required include:

- Events
- Conservation / Forestry Education Classes and Tours
- Scientific Research

Requests for Special Use Permits must meet purposes of a state-owned reservation and/or be on the permitted activity list.

Prohibited Public Recreational Uses
Public use of state reservations is limited by statutes and administrative rules. Samples of recreational activities not permitted at Pisgah State Park include:

- Camping
- Campfires
- Motor vehicle use on park roads unless signed open to the public
- Any OHRV use other than on a designated OHRV trail
- Artifact hunting or digging
- Construction or installation of recreational structures, by the public, including permanent hunting stands
- Gathering or damaging any rare plants or damaging their habitats
- Dumping of refuse and waste

General Recreation and Public Access Policies
The following policies pertain in general to use and recreation:

Use Limitations
The State may control or limit public use and access in the interest of public safety or compliance with the management goals for the property. This could include restrictions on the type, timing, and location of uses needed to:

- Achieve compatibility with the property's management objectives including protection of fish and wildlife habitat values, unique or important natural communities or sites, and water quality;
- Manage recreational use to reduce conflicts between recreational activities; or
- Manage recreational use in a manner that does not unreasonably adversely impact the use of the property for production of forest products;

Dispersed Pedestrian Use
Dispersed pedestrian use of the property is any use not associated with or confined to a particular road or formal trail, and is allowed anywhere except when in conflict with forest management activities or safety. Uses involve walking on informal trails or bushwalking to hunt, trap, fish,

picnic, swim, cross-country ski, snowshoe, observe nature, otherwise enjoy open space, or engage in commercial guiding under a Special Use Permit.

Wildlife Management and Enforcement

The Department of Fish and Game manages and monitors wildlife and regulates hunting, fishing, and trapping on state-owned reservations, with the exception that the Department will be responsible for recreation facilities and improvements which support any of these activities.

Signage

Signage at the property will be kept to a minimum and follow guidance and standards issued by DRED. In general, signs will be limited to:

- Entrance signs at major access points
- Boundary signs (as needed)
- Blazing on designated trails
- Safety warning signs (as needed and appropriate)
- Signs identifying trailheads or entrance points to formal recreational facilities

Signs warning of danger, needed for safety, or to prevent damage to fragile features will be located close to the feature in question and in a location where they will not be overlooked by the target audience. Trails will be blazed as specified in DRED standards.

Dam Safety and Upkeep

Dams and their impoundments are important recreational and ecological attributes of the property. The dams are owned by DRED and dam management plans are on file with DES.

Proposals for Expanded Use

The following conditions should be met for any proposal for expanded or new uses for which DRED requires a partnering organization to move forward in this plan. Proposals must:

- Describe the specific provisions and improvements which will be in place for managing, funding, policing, and monitoring the use and include the following
- Map showing the designated trails and / or facilities, access points, and ancillary facilities or signage which will comprise the system
- Description of the public access management and law enforcement capacity which will be in place to respond effectively to the scale, location, and types of management and law enforcement problems expected
- Description of the institutional and financial capacity of the club (e.g. staff, organization, policies) to take primary responsibility for maintenance and repair of the trail system, and if damaged, restored to state standards
- Public outreach plan for making sure that educational information will be in the hands of, or highly visible to, each participant prior to trail use (permit system with conditions / trail head kiosk / brochure)

Such a partnering proposal must be reviewed by the DRED Lands Management and State Land Management Teams. If DRED accepts it, the following conditions must be in place before new or expanded uses may begin:

- Trails built to appropriate standards
- Parking lots with sufficient capacity, size, and toilet facilities to accommodate the number of users planned
- Signage / Information Kiosk(s)
- Funding
- Cooperative Agreements

Proposals may be implemented on a trial basis for a limited period during which time DRED must evaluate and approve or deny continuation of such use and/or stewardship. If a proposal is implemented, the right to continue such use will be contingent upon satisfactory compliance with all requirements.

Public Safety and Law Enforcement

DRED, through its forest rangers and other staff, works closely with local law enforcement agencies and NH Fish and Game Department to manage public use on the property. Forest Rangers and Conservation Officers generally enforce state laws and regulations on the property. Their time is focused on monitoring and responding to calls relating to public use including unauthorized camping, fires, fishing, hunting, and snowmobiling. The towns of Hinsdale, Chesterfield and Winchester Fire Departments provide fire and emergency medical services.

The following actions will be considered:

- Provide emergency contact and awareness information on printed literature, website, and available maps.
- Continue to support grants to local law enforcement agencies for the enforcement of off-highway vehicle laws

Public Information and Education

The Division of Parks and Recreation through its website maintains basic information about the park with links to resources for the public including the following:

- DRED will provide the public with up-to-date information about conditions and prescribed activities at the property on its website and at kiosks so people may make informed choices about their activities and the locations, times, and conditions in which they engage in them
- DRED will promote safety awareness concerning active forest management activities and the need to inquire on a regular basis about areas that should be avoided or are off-limits for safety and other reasons
- DRED will promote understanding of stewardship, related management issues, and ethics and individual responsibility for appropriate and respectful use and behavior

In addition the following will also be considered:

- DRED will use the website, kiosks, and brochures to provide timely and up-to-date public information
- DRED will coordinate with other state agencies and partners in their interpretive efforts regarding wildlife management and opportunities on the property
- DRED will coordinate with the local stakeholders and other state agencies to monitor safety conditions and user-behavior on the property

Facility Management

Pisgah State Park is an undeveloped park with basic public facilities scattered throughout. The visitor center and interpretive barn are developed public facilities which serve as a contact and administrative center. Roads and trails traverse the park providing a transportation network for non-motorized and motorized access. Other facilities include parking lots, scenic vistas, heritage sites and dams.

Park Buildings

Visitor Center

The 2,310 sq ft Pisgah State Park Visitor Center, located at 520 Old Chesterfield Road, Winchester, was constructed in 1996 by the Friends of Pisgah and gifted to the State. In previous years the Visitor Center was open and staffed by the Friends of Pisgah volunteers many Saturdays, Sundays and Holiday Mondays. The Division of Parks and Recreation currently has an administrative office at the center and funds the maintenance and upkeep of the building.

Management Alternatives

- Operation as an administrative office for DRED
- Entering into an agreement with the Friends of Pisgah or other partner for the operation, maintenance and upkeep of the facility
- Entering into an agreement with a caretaker for the operation, maintenance and upkeep of the building. The building will then be closed to public use
- Transferring the building to another state agency
- Closing the building to public use and turn off utilities and securing the facility

Management Direction

The Department will not maintain an office at the property. The Department will consider entering into an agreement with a partner organization for the operation, maintenance and upkeep of the facility. If an agreement is not be reached by fall of 2011 the Department will close the building to public use, and turn off the utilities, and secure the facility for the winter.

Garage

The 1,146 sq ft garage located at the Horseshoe Trailhead was built in 1982 and is used by the Bureau of Trails for storage of equipment and tools.

Pit Toilets

There is one pit toilet located the Horseshoe Road parking area. No other pit toilets are currently planned for other property access points.

Barn

The Blood Farm Barn was given to the Friends of Pisgah by Cheshire County in May 2004. The barn was disassembled by the Friends of Pisgah working with The Timber Framers Guild and Preservation Timber Alliance, Inc. A foundation was poured and the barn reconstructed in the fall of 2004 adjacent to the visitor center. The building was donated to the Division of Parks & Recreation by the Friends of Pisgah with the intent of it being utilized for displaying historic items from the area.

Management Alternatives

- Deed land the barn sits on and provide easement to a partner organization
- Close the building to public use, and turn off utilities, and securing the facility

Management Direction

DRED accepted the Barn from the Friends of Pisgah and owns the building at this time. DRED will seek to enter into an agreement with a partner organization to use the main space for exhibits and programming. If a suitable partner organization can not be found, close the main space to public use and secure it. The lower level of the barn will be used by DRED for storage and other administrative uses.

Roads and Parking Lots

The Park is served by four maintained parking areas. Kilburn Lot (Rte 63), Route 119, the Visitor Center and Horseshoe Road are maintained by the Division of Parks and Recreation, Trails Bureau. The Friends of Pisgah assist with trash removal at the Kilburn Lot and the Visitor Center.

During the winter, the parking areas at Kilburn and Horseshoe Road are plowed by the Bureau of Trails and the parking area at Route 119 is plowed by the Pisgah Mountain Trail Riders Snowmobile Club. The Town of Winchester plows to the gate in the winter and used to plow to the Visitor Center. The Visitor Center lot has not been plowed for the past two winters and funding has not, and is not anticipated, to allow for plowing in the future.

The primary roads to access the Park are Horseshoe Road, Reservoir Road, Broad Brook Road and Old Chesterfield Road. Vehicle traffic is managed by gates at the entrance to each road and these gates are closed in the winter and during spring mud season. The roads are gravel surfaces and are maintained by the Division of Parks & Recreation, as funding allows. The Bureau of Trails and Parks Bureau staffs have historically graded and repaired drainage features. The Division of Forests & Lands provides for road repairs and upgrades which coincide with timber management operations.

From 2005 to 2008 the road system sustained heavy damages from significant rain events. The Bureau of Trails and Park Bureau staff worked for many months to repair the roads to allow for continued vehicle access on the property. FEMA funding was secured for these repairs.

Management Alternatives

- Open the gate at Fullam Pond on Old Chesterfield Road to allow vehicle access through from Chesterfield to Winchester. Maintain this one road through the property and gate the other roads to conventional motor vehicle traffic
- Keep gates at road entrances closed year round to reduce routine maintenance needs and continue property access via currently permitted trail uses
- Continue to maintain the existing roads, as DRED has in previous years, as funding allows

Management Direction

- Continue to maintain the existing roads, as DRED has in previous years, as funding allows

Trails

The primary recreation at Pisgah State Park is trail use. DRED manages its trail systems through multiple-use (shared use) of trails when possible. The trails are monitored and maintained by the Bureau of Trails and the Friends of Pisgah.

Six trailheads and parking areas are located at the park; Visitor Center on Chesterfield Road, Route 119, Kilburn Lot on Rte 63, Horseshoe Road, Pisgah Reservoir and the northeast corner of the park. These parking lots provide access to 25 named trails; Hubbard Hill Trail, Davis Hill Trail, Kilburn Trail, Kilburn Loop, Baker Pond Trail, Pisgah Ridge Trail, Reservoir Trail, Old Chesterfield Road, South Woods Trail, Fullam Pond Trail, Knob Trail, Beal's Road, Old Spofford, Snow Brook Trail, Orchard Trail, Jon Hill Road, Nash Trail, Lily Pond Trail, North Ponds Trail, Parker Trail, Chestnut Hill Trail, Dogwood Swamp Trail, Doolittle Trail, Hinsdale Trail and South Link.

Management Alternatives

- Continue to allow for use on specified designated roads and trails
- Evaluate loop trails for ATVs, equestrians, and bicycles
- Evaluate partnering with external organizations for trail maintenance

Management Direction

- Enter into a MOA with trail maintenance organizations for cooperative management of trail systems which will include annual work plans.
- Conduct public use survey of the trail systems as necessary to assist in property management.

Dam Management

DRED is the registered owner and operator of three dams at Pisgah State Park, and is responsible for the maintenance and upkeep of the dams and it's supporting structures. DRED has on-file Emergency Action Plan for the Pisgah Reservoir Dam (#255.11) with the NH Department of Environmental Services, Dam Safety Bureau.

The Pisgah Reservoir Dam, built in 1870, is a gravity stone-masonry dam with earth fill that supports a service road. The dam impounds 110 acres and is 30 feet high, 90 feet long, with a 20

foot top-width. A 60 ft side-channel overflow spillway dike is located approximately 100 ft east of the dam. A 130 ft long dike blocks a saddle just west of the dam. The faces of the dike, which runs perpendicular to the dam, are masonry block.

Two additional registered dams are on the property. Fullam Pond Dam (#045.09) was build in 1988 and impounds an area of 25.3 acres and has a height of 33'. The dam at Tufts Pond (#255.22) was breached in 1983 according to the NH Dam Safety Bureau.

The impoundments that these dams create provide recreation sites and wildlife habitat. In the wildlife management section it was stated that these impoundments provide habitats that would not naturally occur on the property. While these ponds are remote, they do provide recreational resources for nature observation, fishing and boating.

Management Recommendation

- Continue to maintain these facilities in collaboration with the Dam Safety Bureau and NH Fish and Game for wildlife management and public use as funding and staffing permit.

Recreation Use Management

As stated in the experiential qualities section of this plan, recreational use will:

- Maintain a reasonable balance of uses, especially between motorized and non-motorized uses
- Avoid conflicts with enjoyment of the primary uses allowed on the property, especially those which depend upon a quiet and peaceful setting for a more solitary experience
- Maintain or enhance the separation of uses, especially motorized and non-motorized uses, which may conflict with one another; and contribute to the local quality of life

Pedestrian Trail Use

Analysis of Prior Use

The remoteness of much of the property's terrain is a major draw and feature of the existing hiking trail system with the park. The park is criss-crossed by extensive systems of hiking trails that are also used for cross country skiing and snowshoeing in the winter. The higher elevation ridge between Pisgah Reservoir and Rte 63 offers great views of the Connecticut River Valley to the west and some views of Mt. Monadnock to the east. The majority of the hikers and other winter users enjoy the remote access and solitude offered by the hiking trail system in Pisgah.

Management Alternatives

DRED proposes no major changes to the current trail management.

Policies

- Continue to manage and maintain hiking and access trails in good, safe, environmentally-sound, and experientially-appropriate condition
- Evaluate, in a timely fashion, proposals from one or more organizations willing to partner in the development and management of a trail in the park

Actions

- DRED will enter into a hiking trail maintenance agreement with partner organizations to formalize the trail maintenance responsibilities
- DRED will continue to provide technical assistance on trail maintenance needs and solutions and help coordinate volunteer trail activities in the park
- DRED will work with partner organizations, as needed, to improve trail signage on the hiking trails and general information available on kiosks

Snowmobile Use

Analysis of Prior Use

One of the dominant uses on the Forest, snowmobiling has been central to the local winter economy and provides some funding for road and trail maintenance within park. DRED's Trails Bureau and local clubs groom and maintain approximately 40 miles of snowmobile trails depending on forest management activities, available snow cover and funding. The Bureau of Trails grooms with State-owned equipment and plows the Horseshoe Parking Area and Kilburn Parking Lot for public trailhead access.

Three local snowmobile club trail systems surround the park and lead into/out of the property; Winchester Trail Riders, Pisgah Mountain Trailriders and Chesterfield Snowmobile Club groom up to the property boundaries. NH Corridor Trail 5 traverses the park from the southern end (Rte 119) to the northern end (Horseshoe Lot). Corridor 5 is the longest corridor trail in the NH Snowmobile Trail System, starting at the Massachusetts state line and terminating at the Canadian Border Crossing in Pittsburg.

Management Alternatives

- DRED proposes no changes in current snowmobile trail management or maintenance. DRED will continue to communicate with local area clubs and if appropriate will seek their assistance in trail maintenance.

Policies

- DRED will continue to work in partnership with the local snowmobile club(s) and NHF&G in the planning and management of the annual network.
- Snowmobiling events require a Special Use Permit in advance
- A map of the groomed trail system will be created annually by local organizations or the state and made available to the public free or for purchase, depending on funding
- Marking of trails with signs will be performed in accordance with the "Trail Signing Handbook: Guidelines for Signing Snowmobile Trails" (State of New Hampshire), or such successor standard, to indicate location of the trail, direct snowmobile use in appropriate areas, provide safety warnings where needed, and restrict access by vehicles other than snowmobiles.
- Trail maintenance will be performed using best management practices as described in "Best Management Practices for Erosion Control During Trail Maintenance and Construction" (State of New Hampshire), or such successor standard. These provisions will apply to maintenance performed during both the winter and off-season periods. Maintenance activities include, but are not limited to, installation and replacement of bridges and culverts, protection of bridge surfaces from damage due to snowmobiling,

rock and stump removal, smoothing the trail surface, placement of gravel and natural fill, installation of broad-based dips, water bars and ditches to divert runoff, removal of fallen trees, cutting back encroaching vegetation, and wintertime grooming.
- Removal of any litter from the trails and any signs that are intended exclusively for the management of snowmobile use shall occur following each snowmobiling season.

Actions
- DRED will work with clubs and other partners to provide information (e.g., written material, education programs, websites) on management concerns, user behavior problems, and strategy for restoring and enhancing a quality family-oriented experience.
- DRED, through its Bureau of Trails, will continue to evaluate existing trails for future improvements to accommodate current grooming needs and rider experience expectations.

Bicycle Trail Use

Analysis of Prior Use

Bicycle use has been a permitted use within the park and continues to be a popular activity. Bicycles currently share use of gravel roads and trails with the motorized users as well as using Old Chesterfield Road, the Reservoir Trail, Beal's Road, Nash Trail and Fullam Pond Trail. The designated bicycle system has only one large loop available for bicycle use.

Management Alternatives

New England Mountain Bike Association (NEMBA), Brattleboro/Keene Chapter, has presented a request to expand loop opportunities within the central and northern portion of the park to include use of 7 other trails for bicycle designation. The original request was for 9 trails but NEMBA reduced the request to keep the Kilburn area for foot travel only to reduce conflicts with hikers.

Policies
- Continue bicycle use on designated roads and trails within the park
- Bicycle use is permitted on designated and signed open trails and roads on DRED reservations
- Season mud closures apply to all trail uses except hiking

Actions
- DRED will work to designate the Hubbard Hill, Baker Pond, North Pond, Snow Brook and Parker Trails to include bicycle use.
- DRED would enter into an MOA with a local bicycle volunteer organization to assist with trail maintenance and adoption for bicycle related trail work

ATV Use

Analysis of Prior Use

Wheeled OHRV uses (ATV & Trail bike) have been a permitted use in Pisgah since the 1980's. There are approximately 20 miles of designated trail for summer motorized use. The trail system is a combination of existing gravel roads and trails within the park. Summer maintenance is currently performed by DRED, via the Bureau of Trails. The park sees high summer use and is a popular riding destination for local residents as well as riders from Massachusetts and Vermont; there are very few public riding opportunities in either of these states.

The current designated trail system is predominantly dead end trails which terminate at Pisgah Reservoir, Fullam Pond parking area, the visitor center or property lines. ATV use expansion has been a point of discussion, perhaps with the greatest and strongest range of opinions, under this planning process. The 2003 NH Statewide ATV/Trailbike Plan (Woodlot Alternatives) recommended expanding ATV trail opportunities within the park to incorporate loop trails instead of dead ends. Currently there are no trails connecting out of the property onto private lands, however, they have existed in the past.

Bureau of Trails staff spend multiple weeks every summer doing trail maintenance and construction projects and update signage when needed. The Park Manager does some routine maintenance of trails and roads and does the majority of the routine tree clearing after storms.

Management Alternatives

- *Status quo* - the existing trail system would remain as it does currently with no new trail designation or closure.
- Loop trail opportunity within the Criteria 3 Zone. DRED would review and propose one loop trail opportunity in the eastern portion of the park for expanded ATV use. If a loop trail was a viable option approved for designation DRED would review certain dead end opportunities for closure to put emphasis on the loop trails.

Policies

- Use of designated roads and trails in Pisgah will continue for public wheeled OHRV use.

Actions

- DRED, through its Bureau of Trails, will continue to manage and maintain the existing summer motorized trail system and continue to work with local volunteer clubs to increase volunteer trail maintenance when possible.
- The Bureau of Trails will work with local volunteer club(s) to increase interest in starting a Volunteer Trail Patrol program within the park.
- DRED will continue to work with NH Fish and Game Department, Division of Forests and Lands Rangers and local law enforcement to monitor existing use and demand.
- DRED, during the life of this plan will research, within existing statutory authority, the potential to develop ATV trails within management criteria 3. If feasible DRED will develop new trails in management criteria 3 and close existing trails within management criteria 1.

Equestrian Use

Analysis of Prior Use

Equestrian use is, and has been, a permitted activity in Pisgah for many years. The designated use is currently limited to the gravel roads and gravel surfaced trails within the park and is shared with motorized summer use and bicycle use. While parking is permitted at all trailheads, equestrians primarily use the Horseshoe parking area, and the greatest concentration of use is along the Old Chesterfield Road and trails near Fullam Pond.

Management Alternatives

- Continue to allow for use on specified Designated Roads and trails only.
- Create loop trails to allow for one or two additional opportunities. The Monadnock Happy Trails Association has made a request to expand equestrian use on two trails to create loop opportunities within the park.

Policies

- DRED will consider creating interesting loop trails 10-20 miles in length, separated where possible from motorized uses, in configuring equestrian trails.
- Use will only be permitted during the time period between May 23rd (mud season end) and snowfall
- Equestrian use is permitted on road width trails and roads on DRED properties and other trails designated and signed open to their use.

Actions

- DRED will keep abreast of research on the potential for horses to introduce harmful invasive plant species (e.g. some in the knotweed family).
- DRED will continue to review, for possible approval, the current request for expanding loop trail opportunities in Pisgah. If appropriate, the trails will be upgraded and designated for equestrian use and an MOA will be created with the Monadnock Happy Trails Association, or other volunteer equestrian organization, for maintenance assistance.
- DRED will work with local equestrian organizations on the designation of Reservoir Trail to include horses.

Mushing

Analysis of Prior Use

Mushing is a permitted use in Pisgah currently, but it is unknown if it is an active recreational use at this time.

Management Alternatives

- No changes are being proposed to the current management of Mushing in the park.

Policies

- Mushing is permitted on road width snowmobile trails on DRED properties and other trails signed open for that use.

Actions

- Continue current trail management to allow for designated Mushing use within the park.

Boating and Paddling

Analysis of Prior Use

Non-motorized boat use occurs at Pisgah Reservoir and Fullam Pond, as well as on some of the other small water bodies in Pisgah. There are no public boat launches within the property and all access is currently from gated roads at public parking areas, which accommodate carry-in opportunities for canoes and kayaks.

Special Use Permits have been approved for special access via vehicle to Pisgah Reservoir for boating events.

Management Alternatives

- No changes to the current management are being proposed. The gates at Fullam and Pisgah Reservoir are not being proposed to be opened for expanded access.

Policies - None

Actions

- Continue to encourage non-motorized boat use of the ponds and reservoir within Pisgah
- Monitor boating and paddling use and size associated parking to ensure maintenance of remote, backwoods character
- Continue to issue Special Use Permits for groups seeking occasional access to water bodies for boat events

Nature Observation, Hunting, Fishing, and Trapping

Analysis of Prior Use

The dispersed pedestrian activities, nature observation, hunting, fishing and trapping are uses on the property and are primarily managed by NH Fish and Game Department under special agreement with DRED. Public access and recreation facility improvements are DRED's responsibility. No significant change in user numbers or problems has been reported by DRED or NHF&G.

While hunting use relative to certain habitats and associated game species occurs throughout the Park, it is recognized that on-going forest management does impact the productivity of locations over time. Areas receiving heavier hunting pressure today may change as young forests mature and are harvested.

Management Alternatives

No alternatives were proposed; the public expressed little interest in additional recreation improvements for these generally dispersed uses, other than to express the desire for these activities to continue on the property.

Policies

- Continue current cooperation and coordination with NHF&G for fishing, hunting, and trapping activities

Actions

- Coordinate with NHF&G on their interpretive efforts for wildlife management and observation.

Key Findings

- State-owned reservations contribute to the conservation of natural resources and distinctive quality of life in the state
- Change in use or management action must be consistent with the Vision and Guiding Principles contained in this Plan.
- In addition to conforming to existing State regulations, a change in use or management action should protect and maintain surface and ground water quality and watershed integrity, prevent or, where no alternative route is possible, minimize soil erosion, maintain the scenic quality and forest character of the property, protect seasonal wildlife nesting and other sensitive habitats, and minimize noise.
- Change in use or management action should meet Best Management Practices (BMP) and technical specifications for the stated use, strive to achieve USDA Forest Service Accessibility Guidelines for Outdoor Recreation Facilities and Trails (See USDA Forest Service "Accessibility Guidebook for Outdoor Recreation and Trails", May 2006), be flexible in its placement and design relative to changes in forest management activities, especially logging operations.
- Be consistent with DRED policy to protect forest land, achieve multiple use conservation purposes, and provide opportunities for natural resource-based outdoor recreation.

Recommendations

- The Department will not maintain an office at the property. The Department will enter into an agreement with a partner organization for the operation, maintenance and upkeep of the facility. If an agreement is not reached by fall of 2011 the Department will close the building to public use, and turn off the utilities, and secure the facility.
- DRED accepted the Barn from the Friends of Pisgah and owns the building at this time. DRED will seek to enter into an agreement with a partner organization to use the main space for exhibits and programming. The lower level of the barn will be used by DRED for storage and other administrative uses.
- Continue to maintain the existing roads, as DRED has in previous years, as funding allows
- DRED will enter into MOAs with trail maintenance organizations for management assistance of the trail system, where appropriate
- DRED will continue to provide technical assistance on trail maintenance needs and solutions and help coordinate volunteer trail activities in the park

- DRED will work with the Friends of Pisgah to improve trail signage on the hiking trails and general information available on kiosks
- DRED will work with clubs and other partners to provide information (e.g., written material, education programs, websites) on management concerns, user behavior problems, and strategy for restoring and enhancing a quality family-oriented experience.
- DRED, through its Bureau of Trails, will continue to evaluate existing snowmobile trails for future improvements to accommodate current grooming needs and rider experience expectations.
- DRED will work to designate the Hubbard Hill, Baker Pond, North Pond, Snow Brook and Parker Trails to include bicycle use and will continue to review Pisgah Ridge Trail for trial bicycle use.
- DRED, through its Bureau of Trails, will continue to manage and maintain the existing summer motorized trail system and continue to work with local volunteer clubs to increase volunteer trail maintenance when possible.
- The Bureau of Trails will work with local volunteer club(s) to increase interest in starting a Volunteer Trail Patrol program within the park.
- DRED will continue to work with NH Fish and Game Department, Division of Forests and Lands Rangers and local law enforcement to monitor existing use and demand.
- DRED will keep abreast of research on the potential for horses to introduce harmful invasive plant species (e.g. some in the knotweed family) and designate the Reservoir Trail for equestrian use.
- Continue to encourage non-motorized boat use of the ponds and reservoir within Pisgah
- Monitor boating and paddling use and size associated parking to ensure maintenance of remote, backwoods character
- Continue to issue Special Use Permits for groups seeking occasional access to water bodies for boat events

CHAPTER 4: MANAGEMENT DIRECTION AND IMPLEMENTATION

The State of New Hampshire and its partners will manage Pisgah State Park to protect and enhance its inherent natural, cultural, and recreational resources. Farming never occurred in a large undeveloped area in the southwest part of Pisgah State Park, an area that now supports a relatively undisturbed ecosystem with fragments of old-growth forests "where nature, not the hand of man, is clearly dominant"[1]. Management will protect this area from human caused degradation and promote natural processes.

Pisgah's large size renders it a landscape unto itself, minimizing disturbance to fish, wildlife, water, air, plants, natural communities and other natural and recreational resources. Pisgah management will maintain and enhance natural and recreational resources within its boundaries, and continue to collaborate with surrounding landowners.

Pisgah offers unique opportunities for a variety of recreational activities. These activities will be managed in a way that promotes cooperation among recreational users, and doesn't have a significant negative impact on the park's natural resources.

Pisgah has a strong and well-documented history of human use, evidence of which is still observable within the park. The state and its partners will protect historic resources, and encourage programs to educate local residents and visitors about the Park's heritage.

Pisgah contains thousands of acres of productive forests that provide jobs, forest products, wildlife habitat, energy, and recreational opportunities. The state and its partners will manage Pisgah State Park's forest resources in a thoughtful and respectful manner to support and enhance forest products and other ecological and recreational resources that sustain the local and regional communities.

Pisgah has supported long- and short-term ecological research by local and regional universities, and local nongovernmental organizations. The state and its partners will encourage continuance of existing research, and initiation of new research, to enhance park management and advance management of state and private lands throughout New Hampshire.

Over the next 25 years, the state will strive to manage Pisgah State Park consistent with the vision of the Pisgah State Park Steering Committee.

Designate a natural area(s) dedicated to developing old growth and mature ecosystem conditions by permitting natural ecological processes to occur with minimal human intervention, and employ active management only to protect the area(s) from human-caused degradation.

DRED designated two natural areas at Pisgah State Park that contain plants and natural communities of state and regional significance. The natural areas will be zoned in the state's tax database, and managed to promote natural ecological processes.

The largest natural area encompasses 4,723 acres of an exemplary ***hemlock – hardwood - pine forest*** in the southwest part of the park. This forest system represents an unusually large, non-fragmented example of the matrix forest of southwestern New Hampshire. The system's land use history distinguishes it from other forestlands in the region. The system was not used for agriculture or its soil tilled, although it has been subject to timber harvests for over 200 years.

The primary matrix forest type of this system is the ***hemlock - beech - oak - pine forest*** Hemlock is the most abundant tree species, with substantial amounts of red oak and American beech, and lesser numbers white pine and black birch (*Betula lenta*). Most of the forest has a mid to late successional condition, with a few small patches that have been identified as old growth in other studies. The Natural Heritage Bureau observed characteristics of old growth forests including unusually high volumes of coarse woody material (e.g., large logs). Past cutting history is evidenced throughout the forest by old stumps.

Small (10 to 20 acre) inclusions of ***sugar maple - beech - yellow birch forest*** occur within the hemlock - beech - oak - pine forest. Typified by sugar maple, yellow birch, and beech, the forests occur on rocky slopes. The herb layer in Pisgah State Park is characterized by rock polypody (*Polypodium virginianum*), hay-scented fern (*Dennstaedtia punctilobula*), sessile-leaved bellwort, and Christmas fern, but lacks the lush cover found in more northerly examples of this community. In addition, there are areas of the transitional community ***hemlock - oak - northern hardwood forest***, where the northern hardwood species sugar maple and yellow birch mix with hemlock, red oak, and beech.

The second natural area encompasses 100 acres of exemplary ***emergent marsh – shrub – shrub swamp***. This system is an extensive complex of open wetland communities occupying the headwaters of Broad Brook in the northern end of the park. The watershed of these headwaters is located almost entirely within Pisgah, and is essentially completely forested. The wetlands have been heavily influenced by beaver activity, and there are currently at least two active beaver dams and lodges. Although beaver-influenced natural community systems of this type are common at Pisgah, this example is the largest group of connected wetland openings in the park, and the only one that meets the Natural Heritage Bureau's size and ecological integrity criteria for exemplary status.

The dominant communities in the system are emergent marshes, particularly the ***tall graminoid emergent marsh***. This community is typically dominated by the grass bluejoint (*Calamagrostis canadensi*), often in association with tussock sedge *(Carex stricta*). Peat mats develop in areas that are more isolated from the influence of active stream channels and where water flow has been restricted, resulting in a ***fenny marsh*** community. This community typically has a mixture of marsh species, such as bluejoint and common cattail (*Typha latifolia*), and fen sedges such as bottle-shaped sedge (*Carex utriculata*) and hairy-fruited sedge (*Carex lasiocarpa*).

DRED and/or other stakeholders will conduct additional surveys of non-native invasive plants at Pisgah State Park. The goal of the surveys is to develop a plan to control existing invasive plants and prevent establishment of new populations, thereby protecting natural areas and other significant natural communities.

Ensure the protection, thoughtful planning, and appropriate siting of recreation to meet the needs of residents and visitors. The state and its partner(s) must maintain any recreational improvements and monitor their impacts.

To ensure the experiential qualities outlined in this plan, recreational use will:

- Maintain a reasonable balance of uses, especially between motorized and non-motorized uses
- Avoid conflicts with enjoyment of the primary uses allowed on the property, especially those which depend upon a quiet and peaceful setting for a more solitary experience
- Maintain or enhance the separation of uses, especially motorized and non-motorized uses, which may conflict with one another; and contribute to the local quality of life

Pisgah State Park is an undeveloped park with basic public facilities scattered throughout. Roads and trails traverse the park providing a transportation network for non-motorized and motorized access. Other facilities include parking lots, scenic vistas, heritage sites and dams.

Monitoring recreation use and facility maintenance will be addressed through on-going site inspections and observations by DRED staff. Administrative and facility physical needs are addressed as DRED has the ability to do so. User safety and emergency repairs are given first priority.

Encourage educational programs to help visitors fully enjoy the park. Educational uses will not have significant negative impact on the park's natural resources.

DRED will promote and encourage programs in Pisgah State Park to facilitate visitor enjoyment and local education initiatives. DRED will promote the benefits and opportunities offered by state parks to local nongovernmental organizations, and primary, secondary, and post-secondary schools, and encourage these entitites to integrate Pisgah State Park into their curriculums. Moreover, these entities will be encouraged to design programs that enhance public value of the Park, for example through status and trend monitoring or development of informational brochures.

DRED will also take specific actions to educate the public about Pisgah State Park.

- The Natural Heritage Bureau will develop a Biodiversity Guide
- The Forest Management Bureau will periodically conduct stand visits coincident with timber harvests
- The Division of Parks and Recreation will provide public use and recreation information for the property.
- Approach a "Friends" group about maintaining and staffing the existing exhibits

Where appropriate, practice sustainable forestry operations that yield forest products, provide a diversity of wildlife habitats and conditions, and protect documented occurrences of rare species and exemplary natural communities.

Currently only 22 percent of 13,361 acre Pisgah State Park is known to be suited to commercial timber harvesting due to protection of natural and cultural resources, and the prevalence of inoperable and inaccessible terrain and several thousand acres of still to be determined operability. This translates to less than 2,000 acres of currently manageable forest, and less than 100 acres of management per year.

DRED's timber harvest focus will be on the production of high quality products. Low quality trees will be extracted during early thinnings. This focus will maintain a sustainable flow of forest products from Pisgah State Park by developing a balanced structure of forest age and size classes, and develop a diverse forest composition of hardwood, softwood and mixed wood cover types.

The timber management approach uses a system of three management criteria based upon varying levels of disturbance to guide the production of forest products and development of forest structure and composition at Pisgah State Park. A large section of the western Park, designated as Criteria 1, will remain relatively undisturbed and progress through the natural processes of forest succession. A wide swath to the east of the unmanaged section will be designated as Criteria 2. This section will receive only light to moderate levels of disturbance using uneven-aged management to promote long rotations of mid to late successional species across a balance of age classes. The eastern part of the park will be designated as Criteria 3 and will receive the heaviest levels of disturbance using even-aged management to emphasize large scale openings. These openings will create viable amounts of early successional and young forest habitat.

All timber harvest activities will meet or exceed the recommendations in *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire*(DRED and SPNHF 2010), and follow *Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire* (DRED and UNH Cooperative Extension 1996). The Fish and Game Department, the Natural Heritage Bureau, the Department of Historic Resources, and the Division of Parks will review all operation plans.

DRED will maintain a diversity of forest types and structures across the Pisgah State Park landscape. This diversity will be accomplished by using a range of management methods that range from 'no management' to produce old-growth forest characteristics, to uneven-aged management with groups 1/10 to 1 acre in size, to even-aged management with openings equal to or greater than 5 acres in size.

Unmanaged forest areas will succeed to old growth forest. No New Hampshire vertebrate wildlife are known to require old growth forest, although a few species will benefit (e.g,. blue-spotted and Jefferson salamanders). Other species will use old growth forests in addition to their primary habitat. Unmanaged, uneven-aged, and even-aged management will provide habitat for numerous species including wood and spotted turtles, American black duck, American woodcock, Canada warbler, northern goshawk and red shouldered hawk, ruffed grouse, veery, wood thrush, whip-poor-will, bobcat, bear, moose, and beaver. In addition, uneven-aged management will support blue-spotted and Jefferson salamanders.

Snags and downed woody material will be left in place and allowed to decompose unless hazardous to human health or likely to cause property damage. DRED will strive to leave at least 8 snags or cavity recruitment trees with a minimum 15 inch dbh on each acre of timbered forest. Dead and dying trees within or near wetlands will not be harvested or removed.

DRED will maintain existing shrublands, and create additional old field and shrubland habitats in a mosaic of grass/forb and shrub patches. Management will strive for shrub patches ranging from 5-10 acres in size, and avoid irregular patch shapes and edges. In addition, DRED will seek opportunities to create and maintain shrublands by restoring natural hydrology in wetlands, removing unneeded man-made dams, and allowing colonization and abandonment of beaver ponds. Wildlife species benefiting from shrubland management include wood and spotted turtle, American bittern, American black duck, American woodcock, Canada warbler, Northern goshawk and red shouldered hawk, ruffed grouse, veery, wood thrush, whip-poor-will, bobcat, bear, moose, and beaver.

DRED will create additional wildlife openings - small, non-forested areas dominated by a mix of grasses, forbs, and shrubs - to provide important soft mast, herbaceous food, and insect foraging opportunities for wildlife. The openings will benefit snakes, migratory songbirds, raptors, bobcats, white-tailed, deer, and, bear. The openings will range from 0.25-0.5 acres in size.

The Forest Management Bureau works closely with the Natural Heritage Bureau when planning timber operations. In support of Pisgah State Park planning, Natural Heritage staff conducted an ecological inventory of the property from 2006 through 2008 with the goal of locating and identifying occurrences of rare plant species, exemplary natural communities, and natural community systems. Three threatened and endangered plant species and two exemplary natural community systems were identified. In addition, Natural Heritage identified two features of local significance: red maple - black ash - swamp saxifrage swamp and black gum - red maple basin swamp. The occurrences of these wetland communities are too small to be considered exemplary at a statewide scale. However, they are noteworthy in contributing to the vascular plant diversity of the park.

Forestry operations will protect threatened and endangered plant species and local significant features by managing in accordance with the most recent edition of *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire* (New Hampshire Division of Forests and Lands, DRED, and the UNiversity of New Hampshire Cooperative Extension). Management practices include consulting with the Natural Heritage Bureau prior to operations, seasonal restrictions, and buffer establishment.

The two Pisgah State Park exemplary natural community systems are designated Natural Areas. Natural Areas are *an area that is relatively unaffected by human activity and which contains plants, wildlife, natural communities, geological features, or scenic values of state, regional, national, or global significance* (RSA 217-A:3 IX). Management activities within exemplary natural communities and natural community systems are restricted to those with specific ecological goals. For example, commercial timber harvests would not be permitted, but invasive species control, prescribed fire, or other treatments to improve the ecological integrity of the community would be encouraged.

Identify, document, study and interpret historical and cultural resources for the public. Key historic resources are preserved and protected from damaging activities.

Pisgah State Park contains numerous features of archaeological and historical significance including early settlements and mill sites, farms, a unique canal system, and an extensive network of stonewalls. Undoubtedly, additional areas and individual sites of archaeological and historical significance that have yet to be discovered or explored including prehistoric and Native American sites.

DRED will make Pisgah State Park available to the Department of Cultural Resources, Division of Historical Resources, and local educational institutions to investigate as yet unidentified or undocumented historical and cultural resources. Moreover, DRED will make Pisgah State Park available to the Division of Historical Resources and local educational institutions for cultural and historical studies curriculums that use the park as a laboratory. Any identified historical and cultural resources are the sole property of the State of New Hampshire, and will be provided to the Division of Historical Resources.

DRED will zone as historic any extensive areas of concentrated features of archaeological and historical significance. Historic zones will be protected by a buffer recommended by the Department of Historical Resources. Discrete sites with individual features of archaeological and historical significance will also be protected with a buffer.

DRED will contact the Division of Historical Resources prior to any activity or project that might result in ground disturbance. Historical Resources will be invited to assess the work site for features of archaeological or historical significance. Historical Resources will recommend practices for protecting identified historical and cultural resources, including, but not limited to, flagging the protected area, pre-activity site walks with contractors, buffers, and seasonal restrictions.

DRED activities that require crossing a stone wall will use existing openings whenever possible and practical. In the event that a new opening is necessary, DRED will determine the location of the breach in concert with Historical Resources based on potential impacts to other cultural resources and future activities. In accordance with Historic Resource recommendations, DRED will not rebuild stonewalls, but will instead maintain permanent openings.

Establish a mechanism whereby the state and its partners can identify research needs, evaluate research proposals, and manage basic and applied research at Pisgah State Park.

- DRED will assemble a non-statutory committee to identify research needs and manage basic and applied research at Pisgah State Park.

The committee will meet electronically or face-to-face as frequently as necessary to identify research needs and manage research.

No research will be permitted at Pisgah State Park without a Special Permit or a letter indicating that a Special Permit is unnecessary. Special Permits are obtained from DRED Land Management Bureau.

Special Permit requests should include detailed information about the proposed research, including:

- Where at Pisgah State Park the proposed research will be conducted
- The need for the proposed research
- Expected benefits to the state and the public
- Equipment
- Disturbance to Park resources
- When the proposed research will be conducted

Issued Special Permits will include standard and project specific conditions, and insurance and bond requirements if applicable.