Fire Management Plan for
Ossipee Pine Barrens Preserve
Second Edition

May 20, 2015

Prepared for:

The Nature Conservancy
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I. Site Description

A. Ossipee Pine Barrens

The Ossipee Pine Barrens contain over 2,000 acres of pitch pine - scrub oak woodland found on glacial outwash features in east-central New Hampshire. These are what remain of an estimated 5,800 acres that existed historically prior to habitat loss and fragmentation from development (McCarthy 1994). The Ossipee Pine Barrens represent one of two variants of this community found in New Hampshire. The other, the Merrimack Valley variant, is found at the Concord Pine Barrens (Sperduto and Nichols 2011). Much of the pine barrens found in the Merrimack River Valley have now been developed, leaving the Ossipee Pine Barrens as the state's largest intact pine barrens.

The pitch pine - scrub oak woodland is a state and globally rare natural community (G2G3 S1S2) with less than twenty occurrences throughout the range. That range extends from southwestern Maine to south-central New Hampshire. These are restricted to glacial outwash features at Ossipee in New Hampshire and the Waterboro Barrens in Maine (NatureServe 2013). This community is similar to larger barrens found in New Jersey, Long Island and southeastern Massachusetts, but is much smaller and contains unique but less diverse flora and fauna (NatureServe 2013). In addition to the pitch pine - scrub oak woodland, there are six other exemplary communities. The Ossipee Pine Barrens provide habitat for 19 lepidoptera tracked by the New Hampshire Natural Heritage Bureau (NHB), and an additional 47 lepidoptera of conservation interest. There are also 15 birds of conservation concern. Ossipee is an important breeding habitat for whip-poor-wills, common nighthawks, eastern towhees, vesper sparrows, and brown thrashers, which are rare outside of pine barrens habitats in the State (Lougee 2009).

Fire and disturbance is a key factor in the persistence of the pitch pine - scrub oak woodland, and the community will gradually become dominated by less fire tolerant species without active ecological management. This is evidenced by the encroachment of white pine, red maple and American beech into the pine barrens communities. There has been a significant loss of open pine barrens habitat over the past fifty years (Finton 1998). The amount of available habitat for rare fauna has decreased and the quality of what remains has become degraded. Fire suppression has resulted in a buildup of fuels, creating a potential for catastrophic wildfire that could threaten life and property, particularly as the surrounding area has become increasingly developed. Catastrophic wildfires could have undesirable ecological consequences as well.

B. Purpose of This Fire Management Plan

The first edition of this plan was completed in 2006. Soon after, The Nature Conservancy began implementing mechanical treatments and prescribed burns to reduce fuel loads, establish buffers between the pine barrens and nearby residences, and to restore and maintain

a viable pine barrens ecosystem. Since 2006, TNC has implemented mechanical treatments and prescribed fire across several hundred acres, and increased the size of the Ossipee Pine Barrens Preserve to over 2,800 acres (Lougee 2009).

This fire management plan fulfills TNC's requirements for an approved site fire management plan (Heumann 2012). This plan includes ecological goals, objectives and a program of actions to be implemented over the next five to ten years to:

- Restore and maintain the pitch pine - scrub oak woodland community and structural variants
- Enhance habitat for nineteen lepidoptera and five shrubland and early successional birds
- Manage fuels to reduce the potential for wildfire that may threaten life and property

Management will continue to include mechanical treatments to reduce fuels and improve habitat combined with prescribed burns to maintain the pitch pine - scrub oak woodland community and structural types. Mechanical treatments will include mowing of dense tall scrub oak and timber harvesting to reduce canopy cover and remove encroaching fire intolerant tree species. Prescribed burning will be used to reduce residual fuels from mechanical treatments, to maintain the natural community and habitat by promoting the germination of pitch pine and the persistence of fire maintained plants, and to reduce fuels. This plan provides for an adaptive management approach to balance the ecological needs of the conservation targets and the need to reduce fuels. Monitoring, documenting methods, and reviewing results will direct future management. The Nature Conservancy will work with state and local partner organizations to reduce hazardous fuels and apply prescribed fire to maintain natural communities and rare species populations.

Over the next five years, approximately 500 - 750 acres will be treated using mechanical fuel reduction methods and prescribed burning on Conservancy and partner-owned lands (Map 1). More areas may be treated depending on resources and the results of treatment of this first set of management units. The Nature Conservancy will also work with partner organizations and landowners to reduce fuels within the WUI.

II. Conservation Targets

A. Inventory and Mapping of Natural Communities and Rare Species Populations

1. Mapping and Describing of Natural Communities at Ossipee Pine Barrens

NHB documented the pitch pine – scrub oak woodland community in 1990. While they mapped the community, they did not map the structural types described above or other cover

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0 1 Miles

- Ossipee Pine Barrens Preserve
- Other Conservation Lands
- Pitch pine areas (transparent)
- State Road
- Local Road
- Private Road
- Class VI Road
- Town Boundaries

Rivers & Streams

- Intermittent
- Perennial

Site Location & Conservation Ownership

Ossipee Pine Barrens Fire Management Plan

Data Sources and Notes:

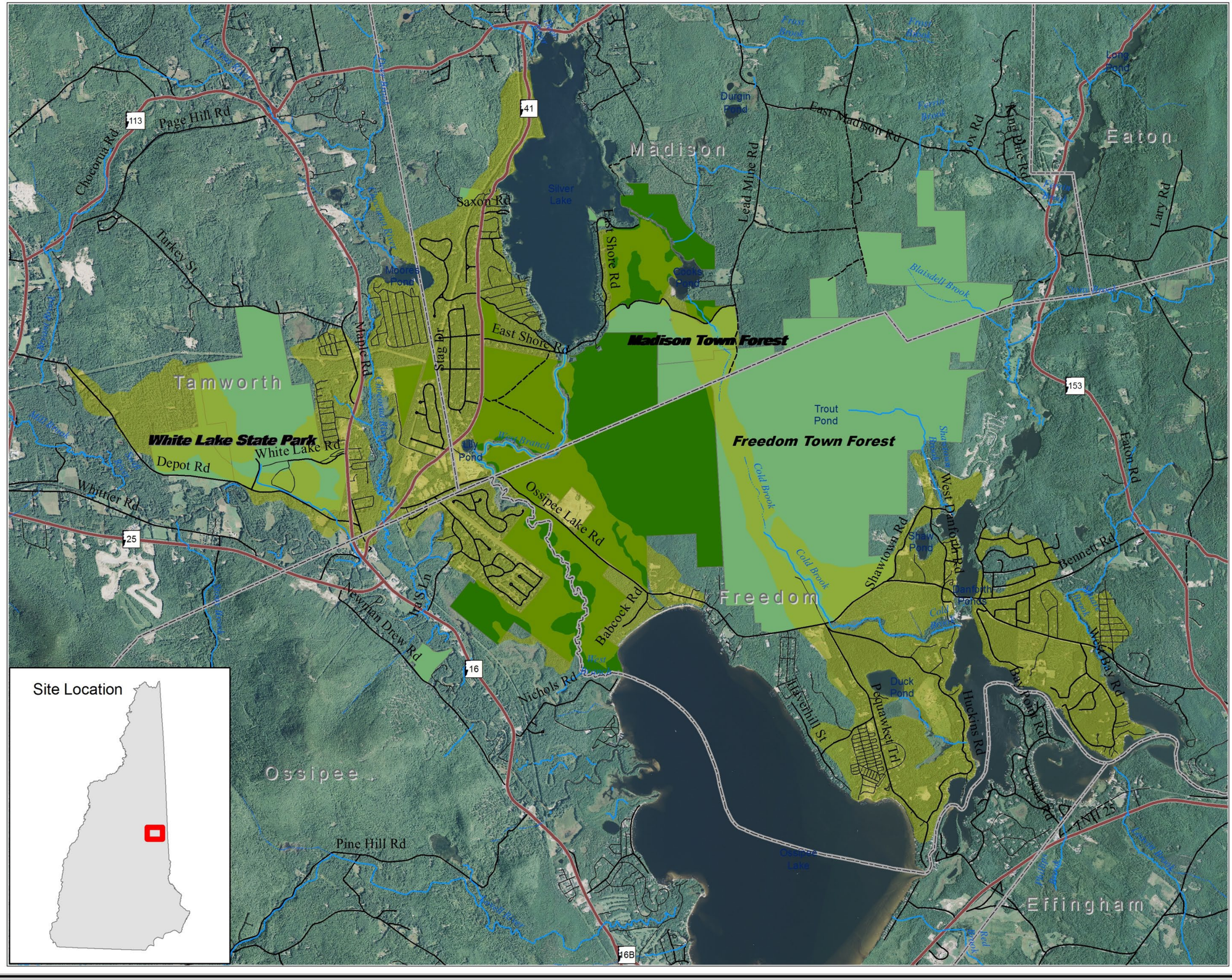
All data, except that noted below, are available from Complex Systems Research Center, Durham, NH
www.granit.sr.unh.edu

Estimated Historic Extent of the Ossipee Pine Barrens, The Nature Conservancy, New Hampshire Chapter, updated 2004.

Aerial image captured for the U.S. Dept. of Agriculture 2014

Scale 1:50,000

Map prepared on 3/27/15 by TNC



types. Finton (1998) mapped the extent of pine barrens, associated communities and human land uses for much of the site to compare recent cover (1992) with historic cover (1947). Patterson (2001) evaluated vegetation and fuel types at the West Branch and Hobbs tracts of the Ossipee Pine Barrens Preserve. Dacey (2003) described vegetation and land use history on the West Branch, Triangles and Hobbs tracts owned by The Nature Conservancy . She developed eight vegetation types and hypothesized processes that have led to the current vegetation found at Ossipee.

Staff of the New Hampshire Chapter of The Nature Conservancy mapped vegetation and landcover, fuel types and canopy cover within an 8,000 acre study area (Lougee 2005). For the pitch pine - scrub oak woodland community, structural types were mapped using the classification from Finton (1998) with some modifications based upon Dacey (2003). Other cover types were mapped using Sperduto and Nichols (2004) and the National Wetlands Inventory. The thirteen fuel models from Anderson (1982) were used along with custom fuel models developed by Patterson. These maps were produced using a combination of field data, GIS data, and aerial photography and satellite image interpretation and classification (Lougee 2005). In 2013, staff of the New Hampshire Chapter of The Nature Conservancy mapped vegetation and fuel types within existing treatment units. The fuel models developed by Scott and Burgan (2005) were used (Map 2).

2. Lepidoptera Surveys

NHB surveyed the site in 1986 (McCarthy 1994). The New Hampshire Chapter of The Nature Conservancy, in cooperation with NHB, surveyed the site for lepidoptera in 1996 (McCarthy and VanLuven 1996) and more recently in 2003. Kart (2003) surveyed for summer adult lepidoptera in 2002. Brown (2013) surveyed in 2012 with a focus on assessing impacts of prescribed burning on lepidoptera.

3. Bird Surveys

NHB records on birds date to 1981 and 1996. Hopping (1996) evaluated the abundance and habitat selection of breeding birds. He identified 91 species, 30 of which were classified as breeding, 20 classified as probable breeders and three as potential breeders. Kart (2003) surveyed for selected shrubland breeding birds on the western side of the site. More recently (Hunt 2004), the Audubon Society of New Hampshire in partnership with The Nature Conservancy conducted a nocturnal birds survey (whip-poor-wills, common nighthawks, woodcock, and owls) of the Ossipee Pine Barrens and the larger Ossipee Watershed. Hunt recently completed assessments of Whip-poor-will (2013a) and shrubland bird (2013b) habitat.

B. Pitch Pine - Scrub Oak Woodland

The focal conservation target is the exemplary pitch pine - scrub oak woodland community and the habitat it provides for the lepidoptera and bird conservation targets. This community is dominated by *Pinus rigida* (pitch pine) and a shrub layer of *Quercus ilicifolia*

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0 0.6 Miles

NH DOT Roads

- State Road
- Local Road
- Private Road
- Class VI Road
- Wetlands

Prescribed Fire

- 2007-2012
- Town Boundaries

Rivers & Streams

- Intermittent
- Perennial

Fuel Types as of 2015

Ossipee Pine Barrens Fire Management Plan

Data Sources and Notes:

All data, except that noted below, are available from Complex Systems Research Center, Durham, NH
www.granit.sr.unh.edu

Fuel Types fo the Ossipee Pine Barrens, The Nature Conservancy, New Hampshire Chapter, updated 2015.

Aerial image captured for the U.S. Dept. of Agriculture 2014

Scale 1:30,000

Map prepared on 3/27/15 by TNC

Fuel Types

Non Burnable
- NB1
- NB8
- NB9

Grass
- GR1
- GR3
- GR3/SH3

Shrub
- SH1
- SH2
- SH3
- SH4
- SH9

Timber Litter
- TL1
- TL2
- TL3
- TL6
- TL9

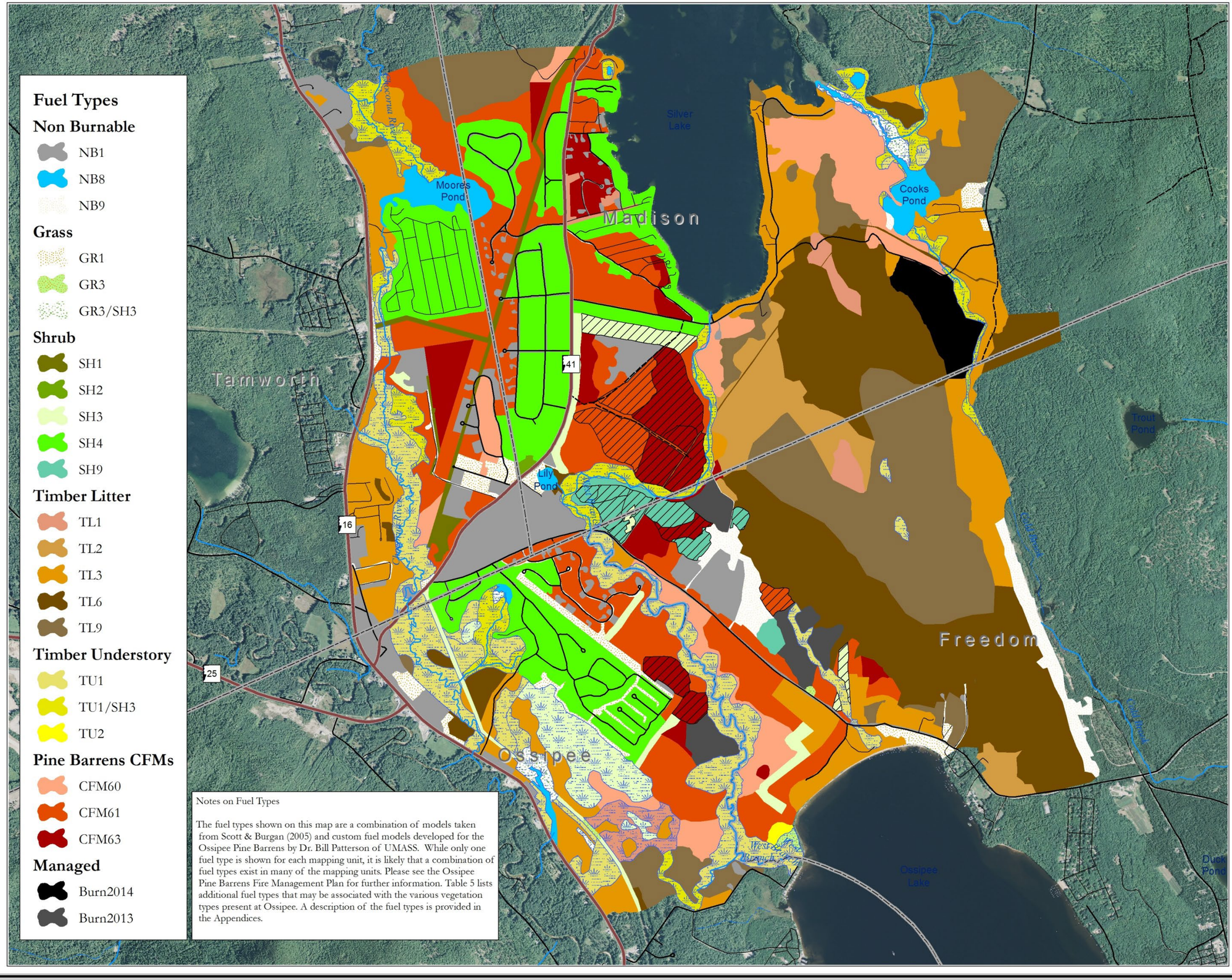
Timber Understory
- TU1
- TU1/SH3
- TU2

Pine Barrens CFMs
- CFM60
- CFM61
- CFM63

Managed
- Burn2014
- Burn2013

Notes on Fuel Types

The fuel types shown on this map are a combination of models taken from Scott & Burgan (2005) and custom fuel models developed for the Ossipee Pine Barrens by Dr. Bill Patterson of UMASS. While only one fuel type is shown for each mapping unit, it is likely that a combination of fuel types exist in many of the mapping units. Please see the Ossipee Pine Barrens Fire Management Plan for further information. Table 5 lists additional fuel types that may be associated with the various vegetation types present at Ossipee. A description of the fuel types is provided in the Appendices.



(scrub oak). Other common species include *Vaccinium angustifolium* (narrow-leaved, lowbush blueberry), *Vaccinium pallidum* (lowbush blueberry), *Corylus americana* (American hazel-nut), *Aronia melanocarpa* (black chokeberry), *Comptonia peregrina* (sweet fem), *Carex lucorum* (Blue Ridge sedge), *Schizachyrium scoparium* (little bluestem), *Piptatherum pungens* (slender mountain ricegrass), *Oryzopsis asperifolia* (roughleaf ricegrass), *Gaultheria procumbens* (wintergreen), and *Pteridium aquilinum* (bracken fern). Canopy structure varies widely depending on land use and fire history, ranging from closed canopy pitch pine forests to scrub oak barrens which generally lack an overstory (Sperduto and Nichols 2011, Lougee 2005).

C. Fauna

1. Lepidoptera

The lepidoptera target includes state-listed species known to occur at Ossipee.

Table 1. Lepidoptera targets

Sources: New Hampshire Chapter of The Nature Conservancy, New Hampshire Natural Heritage Bureau 2013b. Nomenclature is from the New Hampshire Natural Heritage Bureau 2013b.

Scientific Name	Common Name	Rank	Last Observed at Ossipee (Collector in Parenthesis)
Apantesis carlotta	Charlotte's Tiger Moth	G5 SU	2002 (J. Kart)
Erynnis brizo brizo	Sleepy Duskywing	G5T5 S2	1985 (D. Schweitzer)
Eumacaria madopata (formerly *E. latiferrugata*)	Brown-bordered Geometer Moth	G4 S2S4	1985 (D. Schweitzer)
Glena cognataria	Blueberry Gray	G4 S3?	2002 (J. Kart)
Grammia speciosa	Bog Tiger Moth	G5 SU	2002 (J. Kart)
Lithophane lepida lepida	Pine Pinion Moth	G4T1T3 S1S2	2003 (J. Lougee)
Lithophane thaxteri	Thaxter's Pinion Moth	G4 SU	2003 (J. Lougee)
Lycia rachelae	Twilight Moth	G4G5 S2	2003 (J. Lougee)
Nepytia pellucidaria	False Pine Looper	GU S1	2012 (C. Brown)
Satyrium edwardsii	Edwards' Hairstreak	G4 S3	
Speranza exonerata (formerly *Itame sp. 1 nr. Inextricata*)	Pine Barrens Itame	G3G4 S1S2	2002 (J. Kart)
Sympistis dentata (formerly Apharetra dentata)	Blueberry Sallow	G4 S2	2012 (C. Brown)
Xestia elimata	Southern Variable Dart Moth	G5 S3S4	2012 (C. Brown)
Xylena thoracica	Pinion Moth	G4 S2	2003 (J. Lougee)
Xylotype capax	Barrens Xylotype	G4 S2	1985 (D. Schweitzer)
Zale lunifera (formerly *Zale sp. 1 nr. Lunifera*)	Pine Barrens Zale	G3G4 S1	2012 (C. Brown)
Zale oblique	Oblique Zale	G5 S2	2012 (C. Brown)
Zale submediana	Noctuid Moth	G4 S3	2003 (J. Lougee)
Zanclognatha martha	Pine Barrens Zanclognatha Moth	G4 S1	2012 (C. Brown)

Other species of conservation concern collected by Jon Kart in 2002, and listed in his report, may be included in future monitoring, but the priority will remain with species tracked by NHB.

2. Other Invertebrates

NHB confirmed that the dragonfly Martha's Pennant (*Celithemis martha* G4 S2) was reported in 2011 in the vicinity of Cooks Pond. The dragonfly Southern Pygmy Clubtail (*Lanthus vernalis* G4 S2) was listed within a mile of the Ossipee site.

3. Reptiles and Amphibians

Smooth Green Snake (*Opheodrys vernalis* G5 S3), a species of Special Concern in New Hampshire, is found in the pitch pine - scrub oak community elsewhere in the State.

4. Early Successional and Shrubland Birds

This target consists of the following species: common nighthawk (*Chordeiles minor* G5 S2B), listed as Endangered in New Hampshire, vesper sparrow (*Pooecetes gramineus* G5 S2S3B), a Special Concern species, whip-poor-will (*Caprimulgus vociferus* G5 S3B), also Special Concern, eastern towhee (*Pipilo erythrophthalmus* G5 S4B), prairie warbler (*Dendroica discolor* G5 S4B), and brown thrasher (*Toxostoma rufum* G5 S3). These species are rare and/or declining in New Hampshire and the eastern parts of their ranges and pine barrens represent critical habitat for them (NatureServe 2005, Rich et al. 2005). These species were also used in the decision by New Hampshire Audubon to designate the Ossipee Pine Barrens as an Important Bird Area. Other species found at the site that should be tracked include field sparrow, chestnut-sided warbler, woodcock, olive-sided flycatcher, and black-billed cuckoo. Depending on future status and population trends, some of these species may be added as targets.

D. Other Conservation Targets

Several other exemplary natural communities occur on the Ossipee Pine Barrens Preserve and surrounding areas, and abut the pitch pine – scrub oak woodland community. These communities are listed below. NHB (2013a) descriptions of the communities can be found in Appendix I.

- Red maple floodplain forest (S2S3)
- Hudsonia inland beach strand community (S1)
- Kettle-hole bog system
- Medium level fen system
- Sandy Pond Shore
- Pitch pine-heath swamp (S1S2)

Many of these communities have been influenced by fire, and may require ecological management in the future. Additionally, management of the pitch pine – scrub oak woodland, including mechanical treatments and prescribed fire, should be done in a manner that does not result in negative impacts to these communities.

III. Ecological Processes at Ossipee Pine Barrens

A. Ecological Processes in the Pitch Pine-Scrub Oak Woodland Community

1. Historic Land Use

Sperduto (2000) reports that the town of Ossipee was covered by a mixture of forest types, including "pine plains" at settlement, which occurred around 1770 (Finton 1998). These pine barrens were probably a mixture of pitch, white and red pines. Patterson (2001) analyzed historic accounts that listed red, pitch and white pine in the Ossipee area in the early 1800's indicating that fires occurred prior to European settlement. Pitch pine may have dominated the sandy soils while red pine dominated more mesic conditions, with less frequent fire than in the pitch pine communities. Patterson also reported that existing stands show a history of 19th and early 20th century fires. No pollen core analysis has been completed.

Studies in other pine barrens (Motzkin et al. 1996) as well as within Ossipee (Finton 1998) indicate the importance of historic land use (agriculture, logging, etc.) in the formation of pine barrens and associated communities. Finton (1998) reports the Ossipee Pine Barrens were considered poor for agriculture, and there is no evidence of plowing (Finton 1998, Patterson 2001). Land that is left fallow following plowing and clearing to bare soil is favorable for pitch pine regeneration. Herbaceous and graminoid species also can seed in on bare soil, but it may take more than 100 years for scrub oak, huckleberry and blueberry to regain their former abundance, since they do not spread readily by seed (Jordan et al. 2003).

Logging for white pine and other valuable species may have helped increase pitch pine. Scrub oak and other pine barrens species may also have increased following logging and the historic fires documented by Patterson (2001). The railroads were an anthropogenic source of fire that favored establishment of pitch pine. In the past fifty years, silvicultural practices targeting the retention and cultivation of white pine, due to its higher commercial value, have caused the degradation of some sites historically dominated by pitch pine - scrub oak woodlands (Lougee 2005).

Based on Finton's analyses, the largest changes in land cover from 1947 to 1992 were an increase in developed land, from 250 acres in 1947 to 1,705 in 1992, and this trend has continued to the present day. Finton (1998) calculated transition matrices between vegetation types. From 1947 to 1992, 67.2% of pitch pine - scrub oak barrens, 53.8% of pitch pine - scrub

oak thicket, and 22.5% of scrub oak barrens transitioned to pitch pine - scrub oak forest, indicating a general increase in canopy cover. This transition to increased canopy cover was likely a result of fire suppression leading to increased canopy cover, both from white and pitch pine.

Dacey (2003) created a graphical model indicating that, absent disturbance, there would be a general trend from open canopy types to semi-open canopy and then more mature pitch pine over time. Dense young pitch pine would also succeed to mature pitch pine. From mature pitch pine, the path would lead to a mix of pitch pine, white pine and hardwoods to white pine - hardwoods. The time of these transitions was variable.

Dacey concluded that logging over the past fifty years was the main determinant of current vegetation, based on her studies of the Hobbs and West Branch tracts (Dacey 2003). Intensity of logging was positively correlated with pitch pine regeneration and cover of white pine, scrub oak and blueberry, while negatively correlated with hardwoods and mature pitch pine. She also noted scrub oak developing fresh leaves after early summer frost, a phenomenon important in coastal pine barrens, and which may help to maintain areas of open scrub oak shrubland at Ossipee in the absence of active management (Aizen and Patterson 1995, Jordan et al. 2003).

2. Fire

There is extensive literature on the ecological processes of pitch pine barrens (Forman 1979, Olsvig 1980, Bernard and Seischab 1996). Pitch pine barrens depend on coarse, droughty, nutrient poor, acidic soils and periodic disturbance, primarily by fire.

The last major fire to occur in the Ossipee Pine Barrens was in 1957. Approximately 3,000 acres burned through pitch pine - scrub oak communities and hardwood forests. The fire reportedly carried through the pitch pine canopy as well as through hardwood forests on Jackman Ridge (Lougee 2005). Prior to the 1957 fire, the 1947 fire that burned in much of southern Maine may have impacted some areas south of Ossipee Lake Road, but there is little evidence it affected the western side of the Ossipee Pine Barrens (Patterson 2001). However, this fire was known to have burned much of the pine barrens east of Ossipee Lake (personal communication, Jeff Lougee). The railroad bed to the west of Route 41 was another source of fires in the 1940's, but these were suppressed at Route 41 by local firefighters (Lougee 2005). Patterson (2001) found pitch pine stands established after fires occurring between 1898 and 1912.

Pine barrens plant species have evolved several adaptations to allow them to survive fire. For example, pitch pine can produce seed as young as three years of age, allowing them to quickly colonize areas following disturbance. Pitch pine seedlings survive and grow best under the conditions of full sunlight and exposed mineral soil that usually follow severe fires. Mature pitch pines are moderately fire tolerant due to thick bark and moderately long needles (Ledig and Little 1979). Pitch pine are one of only four species of pines that have the capacity to

resprout from dormant epicormic buds located both beneath the trunk's bark and on the root crown. Pitch pine top-killed by fire can successfully resprout from the base until about 20-40 years of age (Jordan et al. 2003).

Scrub oak is also fire adapted, and recovers rapidly from a hot crown fire. Scrub oak develops a significant root mass that can survive fire. Destructive fires may kill the tops of plants, but individual plants readily resprout from their root stocks and base. Scrub oak also grows best under conditions of full sunlight. Although most post-fire recovery of scrub oak results from root sprouts, occasional seedling regeneration occurs.

Other pine barrens shrubs including blueberry, huckleberry, sweet fern and wintergreen, and herbaceous and graminoid species also rapidly resprout from underground roots and rhizomes following fire. Periodic fire is required to open the canopy and provide the light levels required by herbaceous species typical of openings in the pine barrens.

Many pine barrens plants have characteristics that facilitate fire including a high content of flammable terpenes, oils, phenolics and waxes, many of which are for defense against insects and other herbivores. These are based on carbon rather than nitrogen, which is found in plants growing in areas with higher nutrient levels (Coley, et al, 1985). Barrens plants have a high-surface-to-volume and dead-to live tissue ratios. In addition, they create highly flammable litter that has low water-absorbing and holding capacity and low-nutrient content (especially low phosphorus content, which in certain forms is a fire suppressant). However, these adaptations mean that, while they can tolerate infertile soils and frequent fire, they do not have the ability to grow quickly and compete for sunlight (Chapin 1980). The low nutrient litter left by barrens plants creates conditions inhospitable to fast-growing competitors found in more nutrient enriched conditions.

Variations in plant species composition and abundance result from alterations in environmental conditions (light, temperature, nutrient availability) and interactions between plant species (competition, recruitment, senescence, etc.). Pine barrens species create conditions conducive to fire and in which fire intolerant species are less likely to become established or survive. By comparison, in northern hardwood forest communities, fire is much less frequent, intense or severe. As soil organic content and nutrients increase and light reaching the forest floor decreases, shade tolerant species such as sugar maple, red maple, beech and birch begin to dominate the understory (Tilman 1988). These species utilize nutrients more efficiently than pitch pine and other disturbance adapted species (Little 1979, Streng and Harcombe 1982). Absent fire, hardwood species, such as red maple, American beech, and red oak would likely become dominant at the Ossipee Pine Barrens, depending on seed source, soil conditions and random events. This would result in the replacement of pitch pine-dominated communities and their highly flammable, low nutrient litter by mesic vegetation that produces litter resistant to igniting and carrying flame, and which decays to form soil rich in organic matter (Little 1979, Streng and Harcombe 1982).

3. Soils and Microclimate

The sandy soils of Ossipee were deposited in a broad outwash plain during the end of the Wisconsinan glaciation. These sandy soils demarcate the transition between the pitch pine - scrub oak woodland and hardwood forests found primarily on glacial till. Within pitch pine barrens, exposed sand can be very hot in the sun and dry out quickly after rainfall. In many northeastern pine barrens, small changes in soil and topography can determine the spatial arrangement of structural types. Topographic changes affect plant species composition and abundance due to variations in sunlight and moisture availability. Localized differences in the amount of organic matter can also alter soil moisture and nutrient conditions for plants. However, Dacey (2003) concluded that land use history was much more important in explaining differences in vegetation types than these environmental variables.

4. Herbivory

Insects, rabbit and deer feed on pine barrens plants. Severe insect outbreaks may have profound effects on forest and woodland composition. Browsing by rabbit and deer on tender pine sprouts may kill some of the pines that resprout after fire. Browsing also can reduce the survival of pitch pine seedlings (Unnasch 1990, Gill 1997). Scrub oak seedlings can become established only during the first few years following fire, due to decreased (acorn-consuming) mouse populations (Unnasch 1990).

B. Ecological Processes for Rare Species

Several rare lepidopteran species found at Ossipee utilize the fire dependent communities for habitat. Table 2 provides a list, by species, of flight times, food plants and habitat characteristics which vary between species. Early successional and shrubland nesting birds depend on the unique structure of pine barrens, which results from fire. Eastern towhees and prairie warblers utilize and nest in shrubs. Nighthawks and whip-poor-wills prefer open sandy soils for nesting. Table 3 provides information on nesting, habitat and area requirements.

The Ossipee Pine Barrens have been fragmented, primarily by development, though there are also natural sources of fragmentation, including large riparian and wetland systems . While fragmentation affects habitat suitability for many species, at Ossipee it probably affects population dynamics most for lepidoptera and other invertebrates. As habitat becomes fragmented, a population may be separated into subpopulations by unsuitable habitat. These subpopulations may expand and contract in size, and disappear altogether as habitat quality changes or as individuals either succeed or fail to move between subpopulations (Hanski and Simberloff 1997). Where areas of unsuitable habitat separate these subpopulations, dispersal and interaction between them may be difficult, if not impossible. This will result in the ultimate disappearance, first of subpopulations and later of the entire population.

While there is an extensive literature on the effects of fire on various fauna (Brown, 2013, Brown and Smith 2000, Smith 2000, Kirkland et al. 1996), the impacts of fire on many rare species populations are not well known. Estimates of lepidoptera mortality from fire range from

80-95% (Kart 2003). The lepidoptera at the Ossipee Pine Barrens vary in the seasonal timing of life cycle stages and the locations where larvae or pupae reside. The following summarizes the vulnerability of lepidoptera:

a. All species are vulnerable at some or all stages of their life cycle
b. Some species may spend some of their life cycle in litter or soil and be protected from low severity fires
c. Adults may be able to fly from a unit during fire management depending on their flight ability
d. All species need food and nectar sources, particularly following emergence
e. The most likely mechanism for persistence is recolonization of disturbed (treated) areas from nearby refugia.

However, these species often have specific habitat requirements that are created and maintained by fire so that, absent fire, they will ultimately be lost.

Designing management units and treatments to foster rare lepidoptera is highly complex and requires:

a. Retaining substantial unburned areas so that species can recolonize burned units
b. Providing patchiness with enough litter for species that overwinter or otherwise reside in litter layers that may be consumed in fire
c. Maintaining the variety of food plants used by different species
d. Designing fuel treatments to reduce hazardous fuels and assure that catastrophic wildfires do not burn entire management units.

Management for shrubland nesting birds is also complex but there are significant differences. Bird species of concern are not present at the site during the dormant season and adults can flee fire when present. Nests, eggs and fledglings may be lost during growing season burns, but adults may be able to establish new nests in undisturbed areas early in the nesting season. The key management challenges include:

a. Providing the structure necessary for nesting, which may include scrub oak that is relatively tall and which presents a potential hazardous fuel
b. Providing areas of mineral soil for some birds, such as common nighthawk, while providing for litter for foraging for others, such as eastern towhee
c. Designing treatment to allow for vegetation structure to form that meets the habitat requirements of bird species across a sufficient area while meeting goals of reducing non pine barrens vegetation and providing for habitat requirements of lepidoptera.

Fire can have a significant negative impact during the breeding season on amphibians and reptiles. Amphibians that breed in wetlands and vernal pools may disperse to upland areas for foraging in the non-breeding season. In general, wetlands should have sufficient water to

minimize impacts from fire on amphibian populations. Many salamanders move underground or under organic debris during the non-breeding season, and allowing for patchy burns and the development of adequate coarse woody debris will mitigate some losses to amphibians. Limiting the size of both prescribed burns and wildfires may help reduce negative impacts during the breeding season.

Table 2. Life cycle and habitat requirements of rare lepidoptera found in the Ossipee Pine Barrens

Nomenclature follows New Hampshire Natural Heritage Bureau 2013. Sources: New Hampshire Chapter of The Nature Conservancy; Mark Mello, Tim Simmons, Tim McCabe, Dale Schweitzer, Dave Wagner, personal communication; various Massachusetts Natural Heritage Bureau species fact sheets; Covell 1984; McCabe 1991; Allen 1997; Opler and Krizek 1984; Opler and Malikul 1992; Wagner et al. 2001; Mello 2002; Goldstein 2002; Schweitzer 2002; Wagner et al. 2003; Cech and Tudor 2005; Wagner 2005; NH Fish and Game Department 2005; Schweitzer et al. 2011; Wagner et al. 2011; NatureServe 2013.

Species	Eggs	Larvae	Pupae	Adult	Larval Host Plants	Habitat Characteristics
Apantesis carlotta Charlotte's Tiger Moth G5 SU		Wagner (2003) reports two or more generations with mature caterpillars throughout the year	Pupae overwinter	In New Jersey adults fly April to May and in July	Likely a generalist of forbs, feeding mostly at night. Other species in genus use several herbaceous plants	Dry, sandy, grassy areas
Erynnis brizo brizo Sleepy Duskywing G5T5 S2	Deposited on leaves of host plants	May into October and overwinter	April to May	May to June Uses *Vaccinium* and *Rubus* as well as other nectar sources	Presumably only *Quercus ilicifolia* in the north, but a generalized oak feeder in southern parts of range.	Pitch pine-scrub oak barrens and open, oak-dominated woodlands
Eumacaria madopata Synonym: *Eumacaria latiferrugata* (2 broods) Brown-bordered Geometer Moth G4 S2S4	Late June and late August	After adult period to October	October to adult period, so pupae overwinter	Late May to late June; Late July to mid-August	*Prunus pumila, Prunus pensylvanica*, and possibly *Aronia* sp. Not *Prunus serotina*	Pitch pine-scrub oak barrens with exposed sand including blow outs and dunes.
Glena cognataria Blueberry Gray (2 broods) G4 S3	Mid-late to late July	Late June or late August to October	October to May and June, in soil.	Late May to mid-June Late July to mid-August or August to September in New England	*Vaccinium, Prunus pensylvanica* and *P. pumila*	Pitch pine-scrub oak barrens, heathlands, bogs and other wetlands with ericaceous shrubs
Grammia speciosa Bog Tiger Moth G5 SU	June	Overwinter	May to June	Late June and early July	Probably numerous low plants, including herbaceous species.	Bogs and fens; Pitch pine-heath swamp at Ossipee
Lithophane lepida lepida[1] Pine Pinion Moth G4T1T3 S1S2	April	Early May to mid-July	Mid-July to mid-September; August	Overwinter, possibly in litter	New growth of pine foliage	Sandy pitch and red pine forests and barrens
Lithophane thaxteri Thaxter's Pinion Moth G4 SU	Late April to early May	Early May to late July	August	Overwinter, active in October and late March to May (Schweitzer 2002)	Mostly low Ericacae and Myricaceae: *Comptonia peregrina* and other Ericaceae, *Myrica* sp., *Chamaedaphne calyculata*, possibly *Vaccinium* sp.	Pitch pine-scrub oak barrens and bogs

[1] Schweitzer commented that *Lithophane* aestivates as prepupal larvae for much of the summer. *L. thaxteri* probably completed feeding in late June or early July, aestivates and then pupates in mid to late August. *L. lepida* matures later.

Nomenclature follows New Hampshire Natural Heritage Bureau 2013. Sources: New Hampshire Chapter of The Nature Conservancy; Mark Mello, Tim Simmons, Tim McCabe, Dale Schweitzer, Dave Wagner, personal communication; various Massachusetts Natural Heritage Bureau species fact sheets; Covell 1984; McCabe 1991; Allen 1997; Opler and Krizek 1984; Opler and Malikul 1992; Wagner et al. 2001; Mello 2002; Goldstein 2002; Schweitzer 2002; Wagner et al. 2003; Cech and Tudor 2005; Wagner 2005; NH Fish and Game Department 2005; Schweitzer et al. 2011; Wagner et al. 2011; NatureServe 2013.

Species	Eggs	Larvae	Pupae	Adult	Larval Host Plants	Habitat Characteristics
Lycia rachelae Twilight Moth G4G5 S2	Late March to early May	Late April through October	October to early April in soil	Late March to mid-April	Polyphagous but likely *Betula, Salix* and *Populus* spp.	Pitch pine-scrub oak barrens
Nepytia pellucidaria False Pine Looper GU S1	Overwinter	Probably June to August	August to September	Mid and late September	*Pinus rigida* *Pinus banksiana, Pinus strobus*	Pine forests and barrens on sandy soils
Satyrium edwardsii Edward's Hairstreak G4 S3	Overwinter	Late May into June	June	Late June to late July in Michigan	Mostly *Quercus ilicifolia* in New England and possibly *Q. velutina*	Pitch pine scrub oak barrens on sandplains with blueberry; also acidic bogs with ericaceous vegetation. Nectar sources incude *Asclepias*, *Apocynum, Solidago*, and *Rhus*.
Speranza exonerata Synonym: *Itame* sp 1 Pine Barrens Itame G3G4 S1S2	Overwinter	Spring	Mid to late June	July	*Quercus ilicifolia*	Pitch pine-scrub oak barrens especially scrub oak thickets, possibly those recently burned
Sympistis dentata Synonym: *Apharetra dentata* Blueberry Sallow Moth G4 S2	Overwinter in soil	Mid-May to late June	Late June-Early July in soil	Early July to mid-August	*Vaccinium* sp. preferred; also Kalmia and other Ericaceae	Pitch pine-scrub oak barrens, bogs, and other similar communities with blueberry
Xestia elimata[2] Southern Variable Dart G5 S3S4	Late September	October through mid-June in litter.	Mid June to mid-July in soil	Mid-July to mid-September	*Pinus rigida, Pinus strobus, Vaccinium* sp.	
Xylena thoracica Pinion Moth G4 S2	April	mid-May to late July	August	Overwinter in litter and active in April and May	*Vaccinium* sp. and *Prunus* sp. preferred by captive larvae, otherwise polyphagous (Wagner et al. 2003).Scrub oak observed by Schweitzer (2002)	Pitch pine-scrub oak barrens and bogs

[2] Schweitzer reports that in New Jersey, adults are flying in September to early October, larvae feed through fall and winter and become mature from late November through April. Larvae aestivate until August and then pupate, so they may mature in May in New Hampshire.

Nomenclature follows New Hampshire Natural Heritage Bureau 2013. Sources: New Hampshire Chapter of The Nature Conservancy; Mark Mello, Tim Simmons, Tim McCabe, Dale Schweitzer, Dave Wagner, personal communication; various Massachusetts Natural Heritage Bureau species fact sheets; Covell 1984; McCabe 1991; Allen 1997; Opler and Krizek 1984; Opler and Malikul 1992; Wagner et al. 2001; Mello 2002; Goldstein 2002; Schweitzer 2002; Wagner et al. 2003; Cech and Tudor 2005; Wagner 2005; NH Fish and Game Department 2005; Schweitzer et al. 2011; Wagner et al. 2011; NatureServe 2013.

Species	Eggs	Larvae	Pupae	Adult	Larval Host Plants	Habitat Characteristics
Xylotype capax Barrens Xylotype G4 S2	Overwinter	Late April to late June	Mid July (possibly) through mid-September in soil	Mid-September through October	Undocumented, probably polyphagous; *Vaccinium* sp. *Quercus* sp. and *Prunus* sp. likely	Usually found in areas with pitch pine.
Zale lunifera Synonym*: Zale* sp. 1 Pine Barrens Zale G3G4 S1	May to early June	Late May to mid-July Possibly in organic soil	Mid July through early May, in soil/humus	May to early June	*Quercus ilicifolia* leaves and catkins	Pitch pine-scrub oak barrens especially scrub oak thickets
Zale obliqua[3] Oblique Zale G5 S2	July through mid-August	Mid-August to mid-September in soil/peat	Mid-September through June in litter or humus	July through mid-August	Mature needle of *Pinus rigida*	
Zale submediana Noctuid Moth G4 S3	July to mid-August	Mid-August to mid-September in soil/litter	August through following April in litter or humus	June or July to early August	Early instars eat young pine needles; later instars eat older needles	
Zanclognatha martha Pine Barrens Znaclognatha G4 S1	Following adults in mid-summer	Late June or July to following June (Schweitzer 2002)	Late June to early July	Mid-July- early August (NH Fish and Game Dept. 2005) June to early August (Schweitzer 2002)	*Pinus rigda*	Inland pitch pine - scrub oak barrens especially late successional barrens with older pitch pine and dense ericaceous shrub layer (Wagner et al. 2003)

[3] Schweitzer reports that adults occur from June to July in New Jersey, larvae follow immediately and mature in approximately six weeks. *Zale submediana* follows the same pattern, but two months earlier.

Table 3. Habitat characteristics for target birds at the Ossipee Pine Barrens

Sources: Hunt 2013 a and b, Bringham et al. 2011, Kart 2003, Jones and Cornely 2002, Cink 2002, DeGraff and Yamasaki 2001, Cavitt and Haas 2000, Dechant et al 2000, Greenlaw 1996, Foss 1994, Vickery et al. 1994, Ehrlich et al. 1988, Pam Hunt, New Hampshire Audubon, personal communication to TNC NHFO, The State of NH Birds Report (2010).

Species	Migratory/Breeding Period[4]	Nesting Site Characteristics	Territory/Home Range	Other Habitat Characteristics
Eastern Whip-poor-will G5 S3B NH Trend: Declining	Birds arrive in New Hampshire, Vermont and Massachusetts from late April to mid to late May. Birds depart Massachusetts from August to late September, though may stay into October Eggs are laid from mid-May to the end of June, and eggs hatch after about 19 days. On average, fledge at 20 days.	No nest created. Rather, eggs are laid on leaf litter.	In New Hampshire, home ranges contained an edge community (wetland or power line-right-of-way) or regenerating forest or shrubland of at least 3 ha. Home ranges were from 1-13 ha.	In New Hampshire, oak and pine are key habitat types. Generally little or no underbrush but found in open pitch pine communities and near open areas used for foraging. At Ossipee, Hunt found habitat to be either adjacent to extensive openings or a mix of open forest, shrubs and openings through thinned mature forests and edges, such as power line rights-of-way were used. Feeds aerially on insects, particularly moths.

[4] Periods vary across the range, so locations closest to Ossipee were used.

Sources: Hunt 2013 a and b, Bringham et al. 2011, Kart 2003, Jones and Cornely 2002, Cink 2002, DeGraff and Yamasaki 2001, Cavitt and Haas 2000, Dechant et al 2000, Greenlaw 1996, Foss 1994, Vickery et al. 1994, Ehrlich et al. 1988, Pam Hunt, New Hampshire Audubon, personal communication to TNC NHFO, The State of NH Birds Report (2010).

Species	Migratory/Breeding Period[4]	Nesting Site Characteristics	Territory/Home Range	Other Habitat Characteristics
Common nighthawk G5 S1B NH Endangered NH Trend: Declining	Migration periods not well known but arrive in southern US in April. Foss (1994) reports they arrive in New Hampshire in early to mid-May. Birds depart starting in July. Eggs laid from early May to late May to late July in Massachusetts and New York. Fledging may occur from mid-July to as late as mid-August. Incubation lasts 16-20 days. One clutch per year in northern part of range. Young fledge 17-23 days after hatching.	Sandy soils, old stumps, gravel rooftops (less so with changing building construction techniques) but primarily sandy patches surrounded by debris. At Ossipee, nesting sites include harvested and burned open areas.	Highly variable, with averages ranging from 10.4 to 86 ha.	Open and semi open habitats, especially savanna, grassland, fields, urban areas. Feeds on insects. Seems to prefer areas with low productivity vegetation, such as grazed areas and proximity to water. Nighthawks are aerial foragers.
Eastern towhee G5 S4B NH Trend: Declining	Birds arrive in north from late April to early May and depart mid-late September to mid-October. Eggs laid from mid-May to August. Incubation takes 12-13 days. Fledglings may leave in 10-11 days.	On surface in scratched depression with leaves, grass, bark, hair though may nest in low shrub up to five feet above ground.	Ranges from 0.7 – 2.44 ha in MA and NJ, varying with habitat. Kart (2003) reported ranges from 0.5 to 3.3 ha at Ossipee	Forest edge, chaparral, riparian thickets, and woodlands. Feeds on terrestrial invertebrates, seeds, and fruits.

Sources: Hunt 2013 a and b, Bringham et al. 2011, Kart 2003, Jones and Cornely 2002, Cink 2002, DeGraff and Yamasaki 2001, Cavitt and Haas 2000, Dechant et al 2000, Greenlaw 1996, Foss 1994, Vickery et al. 1994, Ehrlich et al. 1988, Pam Hunt, New Hampshire Audubon, personal communication to TNC NHFO, The State of NH Birds Report (2010).				
Species	**Migratory/Breeding Period[4]**	**Nesting Site Characteristics**	**Territory/Home Range**	**Other Habitat Characteristics**
Prairie warbler G5 S4B NH Trend: Unknown	Birds arrive late April to through mid-May. Depart mid-August to late October in Massachusetts. Eggs are laid from late May to late June. Eggs hatch in 10 to 15 days, and fledglings fly in 9 to 10 days.	In shrub or tree, generally less than one foot above 3-6 feet above ground on fork or against trunk.	Ranges based on habitat from 0.4 to 3.5 ha. 75% of males may reclaim territory in successive years. Approximately 2 ha (Pam Hunt)	Dry brushy clearings, forest margin, pine barrens. Favors areas with some coniferous cover. Food is primarily insects.
Brown thrasher G5 S3 NH Trend: Declining (-15.5%)	Birds arrive late April in New York and Massachusetts. Foss (1994) reports arrival in early April and sometimes in late March. Departure is not well documented, but generally late August to late September in Massachusetts. Eggs are laid from early May to late June. Eggs hatch in 11-14 days, and nestlings fledge in 12-4days.	Shrub 3-6 feet or ground, with preference to thorny shrubs.	Breeding territories range from 0.5-1.1 ha, but can vary with ranges in natural habitats from 1 male/3 – 4 ha.	Brush and shrubland, deciduous forest edges and clearings, suburbs. Food includes insects, berries and acorns.
Vesper sparrow G5 S2S3B NH Special Concern NH Trend: Declining	Birds arrive in late Aril in New York. Departure begins in mid-July and extends to September and October. Eggs laid from mid-April and early May to mid-August. Incubation is 11-13 days and young leave nest in 7-12 days. There are 2-3 broods per year.	Nest is on ground in hollow or dug depression and is hidden by vegetation such as grass, forbs, shrubs or small trees and near logs or dead branches. Nests consist of woven cup of grasses.	Territory sizes from 0.29 to 9.19 ha, depending on habitat quality.	Dry, open uplands with short, sparse patchy herbaceous vegetation with some bare ground and low to moderate shrub or tall forb cover. Avoids wet areas and require perches such as fences, trees, shrubs, etc.

IV. Fire Regime Proposal to Achieve Ecological Goals and Objectives

A. Justification for Fire and Fuels Management

Fire is a key process for the long-term persistence of the pitch pine - scrub oak woodland community and rare species at the Ossipee Pine Barrens. Ecological management is needed to maintain the conservation targets and will entail the use of mechanical treatments and prescribed burning to meet the ecological and fuel reduction goals and objectives described below.

B. Ecological Goals

Based on a review of the various studies completed at Ossipee Pine Barrens, the New Hampshire Chapter of The Nature Conservancy developed the following ecological goals to direct management at Ossipee Pine Barrens.

1. Restore and maintain 1,500 to 2,000 acres of pitch pine - scrub oak woodland community

2. Protect terrestrial and wetland natural communities that provide connections for species movement between pitch pine - scrub oak woodland community patches and that provide buffer to increase safety of fire management within pine barrens and other fire dependent communities

3. Maintain a diversity of structural types[5] within pine barrens habitats to provide the following proportions: 20-30% pitch pine - scrub oak forest, 50-60% pitch pine - scrub oak woodland, 10-20% pitch pine - scrub oak thicket and 5-10% scrub oak shrubland, and small areas (less than 10 acres) of old growth pitch pine - scrub oak forest and of pitch pine-heath.

5. Within pitch pine - scrub oak and oak forest communities, maintain dominance by characteristic species as described by NHB (see Section II.B. above)

6. Increase structural diversity within the pitch pine - scrub oak woodland, pitch pine - scrub oak thicket and scrub oak shrubland by creating greater variation in the cover and height of the shrub and canopy layers.

7. Provide sufficient suitable habitat to maintain viable populations of rare and declining lepidoptera by maintaining structural diversity of pine barrens habitats.

[5] See Appendix I and Lougee 2005. These structural types were adopted from Finton (1998), Patterson (2001) and Dacey (2003) and are described in Appendix I.

8. Provide sufficient suitable habitat to ensure that early successional shrubland birds of conservation concern continue to successfully breed at the site.

9. Provide landscape connectivity for species movement and dispersal by maintaining native pine barrens vegetation within commercial and residential developments, along roads and along rights-of-way consistent with reducing fire hazards in the WUI.

C. Operational Goals

In addition to the above ecological goals, the following operational goals will guide a program based on developing partnerships for adaptive management and fuel reduction.

1. Partnerships and Adaptive Management

The Nature Conservancy intends to work with partner organizations, including the U.S. Forest Service, U.S. Fish and Wildlife Service, New Hampshire Division of Forest and Lands, New Hampshire Department of Fish and Game, Audubon Society of New Hampshire, and local communities, including fire departments, conservation commissions, and property owners. Additionally, New Hampshire has developed a Prescribed Fire Council, and the Conservancy will work closely with the numerous partners engaged with this group as it continues to implement a fire management program at Ossipee. With support from these organizations, agencies and individuals, The Nature Conservancy will implement a dynamic program of adaptive management that 1) uses mechanical treatments and prescribed burning, 2) assesses the efficacy of management actions through ecological monitoring, and 3) ensures that all management activities focus on ecological goals while providing and promoting safety.

2. Fuel Reduction

Through ecological management of the pine barrens, The Nature Conservancy intends to reduce the potential for wildfire that would threaten life and/or property in surrounding area. This will include significantly reducing fire hazard potential within the WUIby reducing fuels near houses and other developments.

3. Limiting Impacts to Neighboring Properties

Management will be carried out with due consideration of neighboring land owners by scheduling fire and other forms of ecological management to reduce impacts from noise, smoke and other possible nuisances. The Nature Conservancy may partner with the NH Division of Forest and Lands to provide educational materials so that landowners can reduce hazards on their properties, or support the development of Firewise Communities.

D. Desired State of Conservation Targets

1. Pitch Pine - Scrub Oak Woodland

The pitch pine - scrub oak woodland will consist of a varied natural community, dominated by pitch pine, scrub oak, blueberry, sweet fern, and patches of herbaceous and graminoid vegetation. Pitch pine cover will range from 10 to 50%. Where there are significant firebreaks and where surrounding lands will not be threatened, pitch pine canopy cover may exceed 50-60%. In the WUI, scrub oak may need to be reduced in average height and cover to reduce potential wildfire intensity and initiation of canopy fires (Duveneck 2005, Patterson and Crary 2004).

Scrub oak height and cover will be maintained to an average of less than 2.5 meters tall and less than 50% cover across treatment units. Some areas of tall, dense scrub oak should remain for structural diversity and nesting habitat for some shrubland birds. Height and cover reductions are most important in areas where tall and dense scrub oak could generate canopy fires or threaten adjacent development.

The overall depth and cover of litter will be reduced through application of fire. However, litter is important for lepidoptera, amphibians and birds. Mineral soil exposure across management units will range from 10-30% for regeneration of plant species requiring mineral soil and for nesting habitat for common nighthawk and whip-poor-will (see Table 3).

White pine, red maple, American beech and other species less tolerant of fire that may encroach on the pitch pine - scrub oak woodland will be reduced through management treatments.

Lougee (2009) proposes a program of early invasive species control and management. Invasives species are in low abundance. Management units should be free of invasive species. Cygan (2011) provides a list of invasive species found in New Hampshire.

2. Lepidoptera

There should be an abundance of food plants for the lepidoptera listed in Table 2. Plants should present their complete phenology, including new shoots and flowering scrub oak catkins required by some species, such as *Zale lunifera*. Herbaceous openings should be present that may be used by some species, including some not listed as targets but part of the lepidoptera fauna (Schweitzer, personal communication).

Refugia are needed as most lepidoptera are vulnerable to fire and mechanical treatment at some or all stages of their life cycle. Therefore, disturbance to any management unit should be limited to no more than 35% in the same year. Patchy burns should be implemented that result in 10-30% unburned areas throughout management units to provide sufficient areas of

litter and organic material for species that overwinter in leaf litter or pupate in soil and humus layers. This may also be accomplished by conducting growing season burns when the Keetch-Byram drought index (Keetch and Byram 1988) is less than 200-300. The area managed with dormant season burns should be less than 20% of the total within a management unit; these burns reduce food sources for early spring feeders (Schweitzer personal communication).

3. Early Successional and Shrubland Birds

In some cases, shrubland nesting birds have very different requirements from those of the lepidoptera and management actions for one may result in habitat loss or degradation for the other. These impacts should be minimized by maintaining the overall spatial arrangement of pitch pine - scrub oak woodland structural types across the landscape.

Habitat for common nighthawk and whip-poor-will includes creating areas of reduced litter to provide suitable nesting habitat (see Table 3). For prairie warbler, brown thrasher and eastern towhee, suitable habitat consists of woodlands and shrublands of 20-40 contiguous acres, which should be sufficient for 5-10 nesting pairs. Shrubs should be high enough to allow for nests 3-6 feet above ground. Eastern towhee needs leaf litter in such areas as well. As with lepidoptera, 10-20 percent of burns should be scheduled in the dormant season to limit direct impacts on nesting birds.

Vesper sparrows are found in relatively specialized habitat along power line rights-of-way at Ossipee. Management of that habitat is done by Public Service of New Hampshire.

4. Other Conservation Targets

Further work is needed to determine the specific management needs of the other invertebrates, reptiles and amphibians and natural communities at Ossipee. Management of the pitch pine - scrub oak woodland for lepidoptera and early successional and shrubland birds should provide habitat and refugia for other fauna. The other natural communities are primarily wetland communities where fire will not be specifically used, but may be allowed to burn into those communities to create more natural transition areas. Section VII lists further studies to outline management needs for these communities.

E. Management Unit Descriptions and Objectives

The site has been broken up into eight management units totaling 3,228 acres (see Map 3 below). “Treatment units” are the areas within the management units where prescribed fire and mechanical treatments will be planned and carried out.

1. Lower West Branch (14 Treatment Units)

The Lower West Branch Management Unit is one of the most intact areas of the Ossipee Pine Barrens with 638 acres of contiguous conserved land. Key natural features of this unit

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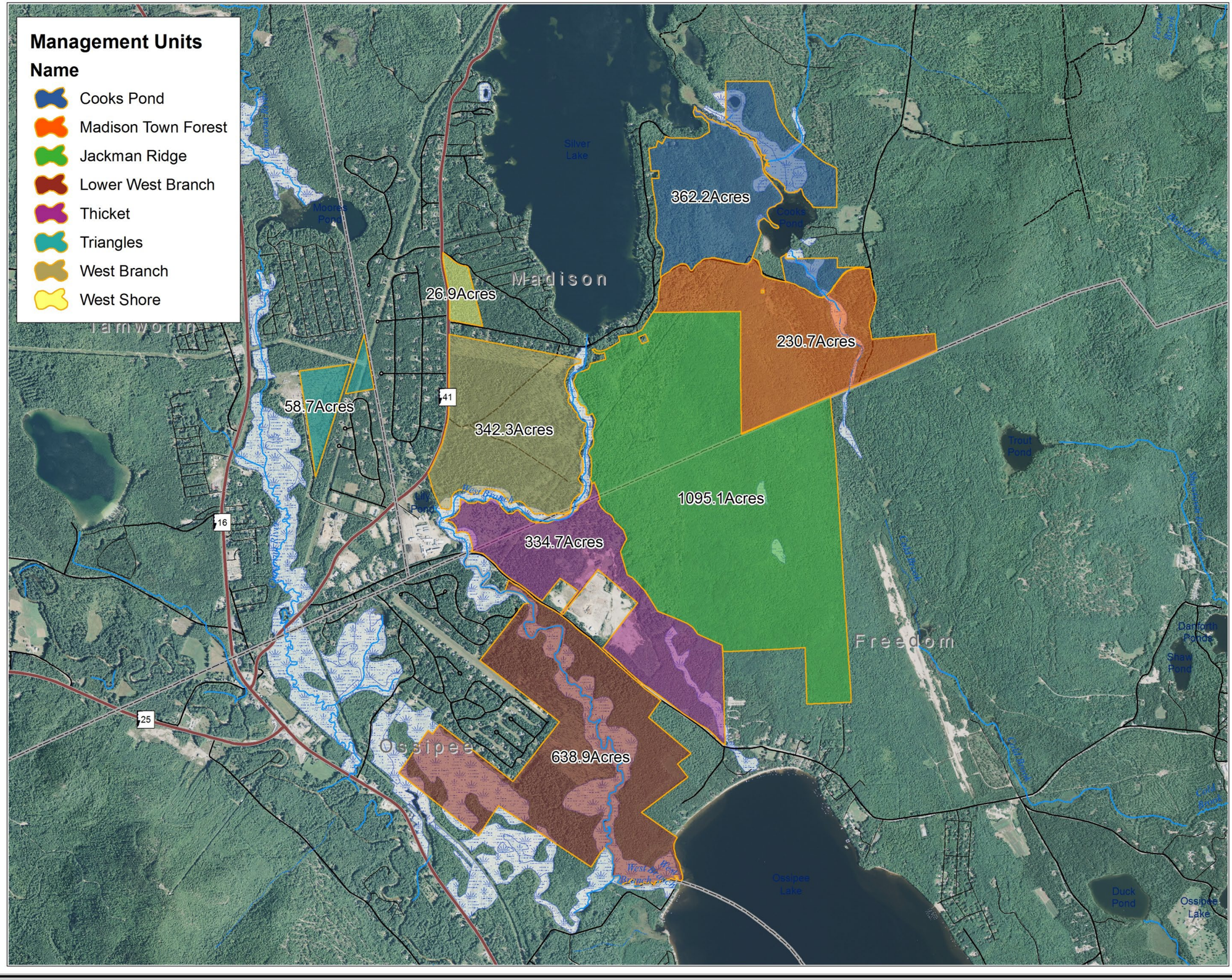
0 0.6 Miles

NH DOT Roads

- State Road
- Local Road
- Private Road
- Class VI Road
- Wetlands
- Town Boundaries

Rivers & Streams

- Intermittent
- Perennial



Management Units

Ossipee Pine Barrens Fire Management Plan

Data Sources and Notes:

All data, except that noted below, are available from Complex Systems Research Center, Durham, NH
www.granit.sr.unh.edu

Management Units, The Nature Conservancy, New Hampshire Chapter

Aerial image captured for the U.S. Dept. of Agriculture 2014

Scale 1:30,000

Map prepared on 3/27/15 by TNC

include: 381 acres of pine barrens vegetation; an exemplary red maple floodplain forest along the lower reach of the West Branch River; one of the State's best and only known examples of a pitch pine heath swamp; and several rare plants near the shore of Ossipee Lake on the Hobbs parcel.

Ecological Management Objectives

a. Restore and maintain the approximately 380 acres of pine barrens vegetation.
b. Ensure the Management Unit continues to be free of invasive plant species, with particular emphasis on the West Branch River floodplain and the pitch pine heath swamp west of Windsock Village.
c. Manage fuel loads to reduce the wildfire hazard to the Windsock Village and Soaring Heights communities, and the residences along Babcock Road.
d. Maintain ecologically viable occurrences of pitch pine heath swamp on the Mustapha tract, red maple floodplain forest along the West Branch River, and the sandy pond shore ecosystem and adjacent fen on the Ossipee Lake frontage on the Hobbs tract.

2. Thicket (14 Treatment Units)

The Thicket Management Unit is located on the north side of Ossipee Lake road below Jackman Ridge, and includes approximately 335 acres. It extends from the West Branch River on the west and northwest side to Camp Calumet on the east side and connects the preserve across Ossipee Lake Road. It includes the single largest patch of open scrub oak and pitch pine - scrub oak thicket remaining on the landscape. In the center of the unit are two privately owned lots.

This Management Unit also includes a number of disturbed areas that have been targeted for restoration to pine barrens vegetation. The western portion of the unit is largely dominated by open scrub oak and pitch pine - scrub oak thicket communities. The unit has had several commercial activities over the years, including gravel mining, septage lagoon facilities, stump dumps, and some limited plantation forestry. These commercial uses were largely centered on the areas immediately surrounding the modern day commercial activities taking place on neighboring lands.

This entire unit was burned in the spring of 1957 by the large fire that started and escaped from the location of the present day Madison Lumber Mill. The limited number of fire intolerant tree species present in this Management Unit, along with the large stands of aspen on the adjacent slopes of the Jackman Ridge, are evidence of the 1957 fire.

Ecological Management Objectives

a. Restore and maintain the approximately 240 acres of pine barrens vegetation found within the unit. Of particular importance is the restoration and maintenance of

roughly 140 acres of open scrub oak and pitch pine/scrub oak thicket sub-communities.

b. Ensure the Management Unit continues to be free of invasive plant species, with particular emphasis on the West Branch River and in the disturbed areas around the former gravel pits on the Kennett 9 & 10 tracts.
c. Manage fuel loads to reduce the wildfire hazard to Camp Calumet, residences along Ossipee Lake Road, and the abutting businesses.
d. Restore the approximately 40 acres of disturbed areas in the unit to pine barrens vegetation.

3. Jackman Ridge (1 Treatment Unit)

The Jackman Ridge Management Unit is the largest unit at over 1,000 acres and largely consists of hardwood forests. The unit includes much of the Jackman Ridge extending from Camp Calumet in the south to East Shore Drive and Silver Lake in the north. The shallow, stony soils on the upper portion of the ridge support dry red oak - white pine forests. The lower elevations and slopes of the ridge support more transitional hardwood forest with significant quantities of aspen. There are two unique black gum red maple swamps along the ridge. This area serves as an important "smoke-shed" for the pine barrens areas located to the west, as prevailing winds during prescribed burning disperse smoke towards the Jackman Ridge.

Ecological Management Objectives:

a. Allow for a natural transition from pine barrens to oak and hardwood forests on Jackman Ridge by allowing fires from the adjacent unit to burn into litter using minimal fire breaks.
b. Track invasive insect outbreaks and determine needed management and restoration as needed.

4. West Branch (8 Treatment Units)

The West Branch Management Unit is bounded by the West Branch River on the east and south, Route 41 to the west, and East Shore Drive to the north. At 330 acres, it is the single largest patch of contiguous, intact pine barrens vegetation left at the Ossipee Pine Barrens and in New Hampshire. The entire parcel is located in the Town of Madison. Prior to TNC acquisition, this parcel was used by the Kennett Company as a spring "mud-lot" where they conducted a limited amount of timber management, including areas thinned for white pine and clearcuts from the 1930's in even-aged stands of pitch pine.

The 1957 fire only impacted a small portion of the property in the southwestern corner. This part of the management unit has the least amount of fire intolerant species, which were likely burned out in the fire.

Ecological Management Objectives

a. Restore and maintain 327 acres of pine barrens vegetation found within the unit.
b. Ensure the Management Unit continues to be free of invasive plant species, with particular emphasis on managing and preventing the spread of Japanese knotweed currently located in the southwest corner of the property.
c. Manage fuel loads to reduce the wildfire hazard to the residences along East Shore Drive and Route 41.

5. Triangles (3 Treatment Units)

The Triangles Management Unit consists of two isolated tracts of the preserve in Tamworth located to the west of the Carved in Bark development. The larger, western parcel had most of the white pine removed from 2005-2008, resulting in an open canopy pitch pine - scrub oak thicket across much of the property. The smaller, eastern parcel is bisected by powerlines and includes pitch pine - scrub oak woodland and areas of dense young pitch pine.

Ecological Management Objectives

a. Restore and maintain roughly 60 acres of pine barrens vegetation within the unit.
b. Reduce fuels and the wildfire hazard to surrounding properties, which surround the unit.

6. West Shore (1 Treatment Unit)

The West Shore Management Unit is just across East Shore Drive from the West Branch Management Unit and includes 27 acres of pitch pine - scrub oak woodland. It also includes significant road frontage on East Shore Drive, Route 41, and West Shore Drive.

Ecological Management Objectives

a. Restore and maintain roughly 25 acres of pine barrens vegetation within the unit.
b. Reduce fuels and the wildfire hazard to surrounding properties, which surround the unit.

7. Cooks Pond (3 Treatment Units)

The Cooks Pond Management Unit is the northernmost portion of the preserve and includes approximately 362 acres. It abuts the Goodwin Town Forest (Madison) on its south side, and is located in one of the most unfragmented areas of conserved lands in and around the Ossipee Pine Barrens. Significant features of this Management Unit include: approximately 144 acres of transitional pitch pine - scrub oak woodland/forest; dry red oak - white pine forest, mixed forest types and significant shore frontage along Cooks Pond and the Cooks River; a portion of an exemplary kettle hole bog system in the northern corner of the property; and

several ice-contact deposit features.

The unit is bound by Lead Mine Road on the south, East Shore Drive on the west and the old "Winter road" to the east. Limited timber harvesting was conducted in the late 1980's on the eastern side of the unit, but otherwise there has been very little disturbance (anthropogenic or otherwise) on the land in several decades. Although documentation is limited, fires reportedly burned through this area in the 1950's, some emanating from the railroad bed to the west in Tamworth. Some of these fires may have burned up the west slopes of Stacy Mountain.

Ecological Management Objectives

a. Restore and maintain the approximately 170 acres of pine barrens vegetation found within the unit.
b. Ensure the Management Unit continues to be free of invasive plant species, with particular emphasis on the Cooks River and Cooks Pond areas.
c. Manage fuel loads to reduce the wildfire hazard to the residences on East Shore Drive.
d. Maintain ecologically viable occurrences of the kettle-hole-bog-pond ecosystem.

8. Madison Town Forest (3 Treatment Units)

The Madison Town Forest Management Unit consists of the approximately 130 acres of pine barren vegetation found on the Goodwin and Burke Town Forests (owned by the Town of Madison, NH), which are abutting lands to the south of Lead Mine Road. Prescribed fire was implemented on approximately 2/3 of this Management Unit in 2014, and all white pine and hardwoods were harvested in 2010 and 2011. The primary ecological management objective for the Management Unit will be to restore and maintain the 130 acres of pine-barrens vegetation, which connects to the barrens that extend north onto the Conservancy's Preserve within the Cooks Pond Management Unit.

F. Fire Regime Proposal

The Stewardship Plan for the Ossipee Pine Barrens (Lougee 2009) describes management actions completed since 2005, and these are summarized in Table 4. Map 4 shows the treatment units with planned prescriptions and priority (Tier).

The historic or pre-settlement fire return interval for Ossipee is not well understood, and prescribing a fire return interval is not practical. While mechanical and prescribed fire treatments are planned and timed to optimize their benefits, and make as much progress as possible on the ecological and fuel reduction goals outlined in this plan, the results are inherently variable. Because of this, the implementation of mechanical and prescribed fire treatments at the site will be based on an adaptive management cycle utilizing the monitoring protocols outlines below in Section VI to measure progress on the stated goals.

Treatment Units

Planned Mang. Approach

- Mechanical Only
- Rx Fire
- Mow & Rx Fire
- Harvest & Rx Fire
- Mow, or Mow & Rx Fire on 5-year rotation
- Disturbed Area Restoration

Treated 2007 - 2014

- Burn, mow, or harvest

- Ossipee Pine Barrens Preserve
- Madison Town Forest

NH DOT Roads

- State Road
- Local Road
- Private Road
- Class VI Road
- Town Boundaries

0 0.6 Miles

Data Sources and Notes:

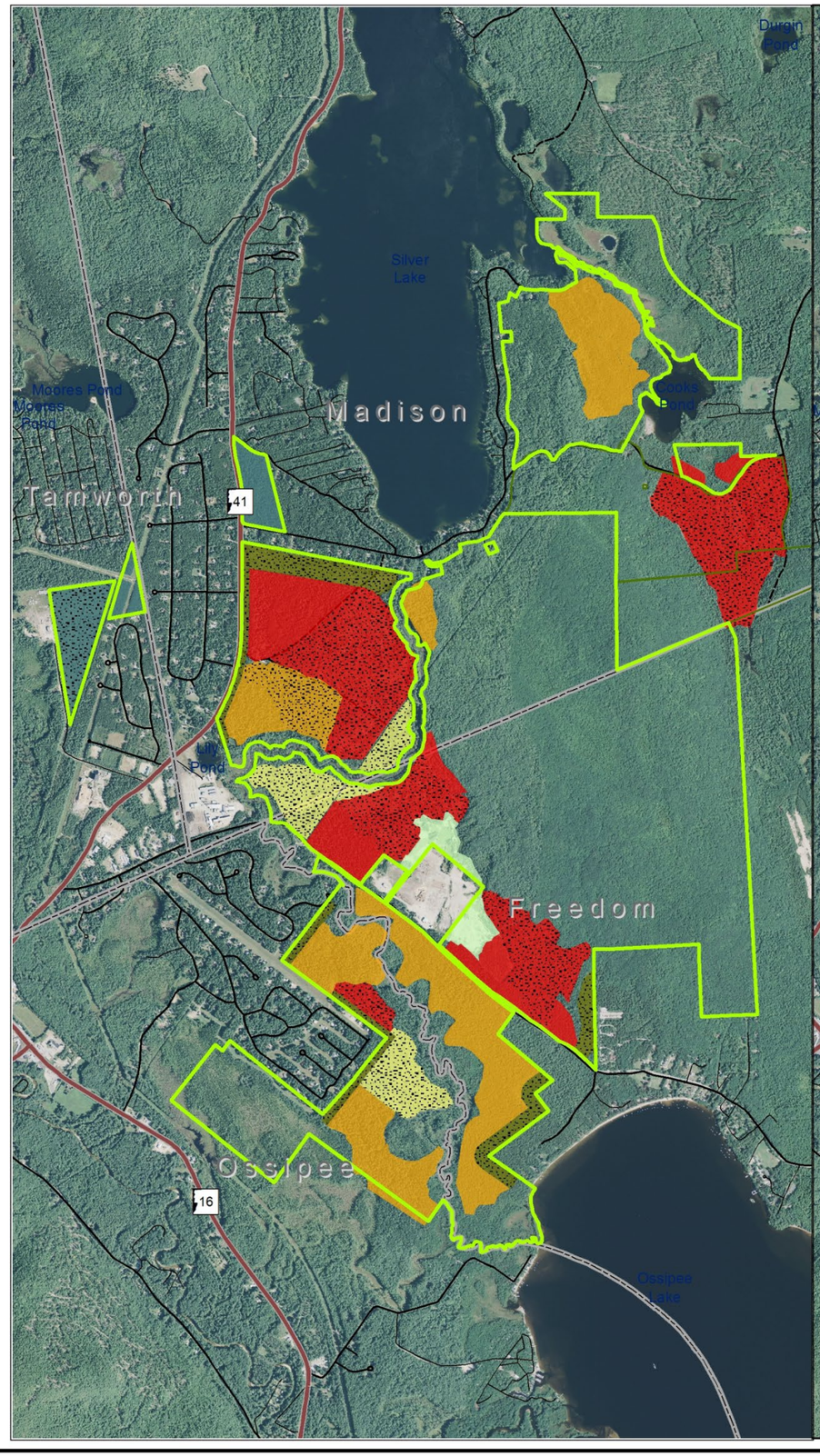
All data, except that noted below, are available from Complex Systems Research Center, Durham, NH www.granit.sr.unh.edu

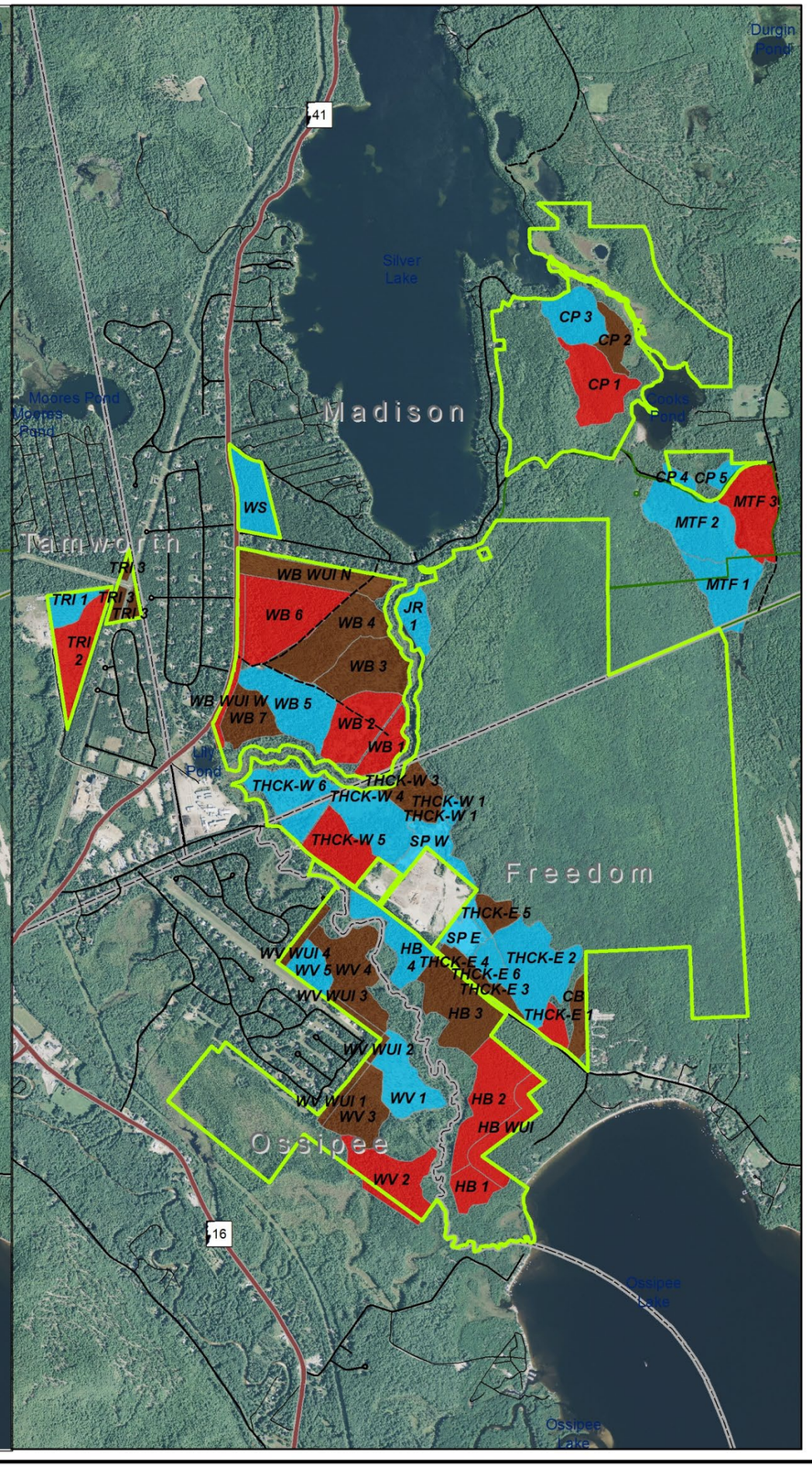
Treatment Units, The Nature Conservancy, New Hampshire Chapter

Aerial image captured for the U.S. Dept. of Agriculture 2014

Scale 1:30,000

Map prepared on 3/27/15 by TNC





Treatment Units

Priority

- Tier 1 (2015 - 2017)
- Tier 2 (2017 - 2019)
- Tier 3

Treatment Unit	Label	Acres
Calumet Buffer	CB	12.7
Cooks Pond 1	CP 1	38
Cooks Pond 2	CP 2	14.5
Cooks Pond 3	CP 3	27.2
Cooks Pond 4	CP 4	4.9
Cooks Pond 5	CP 5	7
Hobbs 1	HB 1	15
Hobbs 2	HB 2	47.1
Hobbs 3	HB 3	46.6
Hobbs 4	HB 4	27.5
Hobbs WUI	HB WUI	23.7
Jackman Ridge 1	JR 1	15.5
Madison Town Forest 1	MTF 1	38.6
Madison Town Forest 2	MTF 2	48.9
Madison Town Forest 3	MTF 3	40.8
Sand pit east	SP E	12.1
Sand pit west	SP W	25.3
Thicket East 1	THCK-E 1	8.6
Thicket East 2	THCK-E 2	56.1
Thicket East 3	THCK-E 3	4.9
Thicket East 4	THCK-E 4	8.8
Thicket East 5	THCK-E 5	11
Thicket East 6	THCK-E 6	9.6
Thicket West 1	THCK-W 1	4.6
Thicket West 3	THCK-W 3	22.7
Thicket West 4	THCK-W 4	39.4
Thicket West 5	THCK-W 5	31
Thicket West 6	THCK-W 6	38.9
Triangle 1	TRI 1	13.1
Triangle 2	TRI 2	32.5
Triangle 3	TRI 3	10.2
West Branch 1	WB 1	17.7
West Branch 2	WB 2	37.1
West Branch 3	WB 3	41.6
West Branch 4	WB 4	47.5
West Branch 5	WB 5	43.3
West Branch 6	WB 6	59.7
West Branch 7	WB 7	24.4
West Branch WUI North	WB WUI N	33.9
West Branch WUI West	WB WUI W	13.1
West Shore	WS	26.9
Windosck Village 2	WV 2	42.4
Windsock Village 1	WV 1	32.8
Windsock Village 3	WV 3	30.5
Windsock Village 4	WV 4	43.6
Windsock Village 5	WV 5	15.2
Windsock WUI 1	WV WUI 1	6.4
Windsock WUI 2	WV WUI 2	2.6
Windsock WUI 3	WV WUI 3	5.3
Windsock WUI 4	WV WUI 4	7.1

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Guidelines for optimizing the benefits of ecological management treatments for the rare lepidoptera and birds, and minimizing the potential for negative impacts, have been described above in Section IV.D. Combined with these guidelines, the following shall guide the fire regime for the site:

- During the restoration phase when the ecological metrics (scrub oak height and cover, mineral soil exposure, dominance of fire intolerant tree species, relative abundance of pitch pine saplings) described in Section IV.D. are outside of the desired ranges, mechanical treatments and prescribed burning can be used more frequently to make further progress on the goals. Shorter rotations will have to be
- weighed against the potential negative impacts to the conservation target lepidoptera and birds, and other organisms.

- During the restoration phase, prescribed burns should be primarily conducted during the growing season. Due to a variety of factors, growing season burns have greater ecological effects, and are generally safer to conduct in areas of high fuel loads.

- During the restoration phase, high severity fire may be desirable to maximize progress on the ecological and fuel reduction goals. This will be weighed against the need to maintain refugia within the treatment unit, perhaps due to a lack thereof in the surrounding area.

- Timber harvesting should be utilized during the restoration phase to remove fire intolerant tree species, especially larger diameter stems that may survive prescribed burns and continue to be a seed source for additional recruitment.

- Mowing of scrub oak should be utilized when burning in the WUI, in areas where the application of prescribed fire is not practical, or in treatment units with unusually high fuel loads or other operational hazards (such as powerlines).

- If fuel loading in the surrounding area and within the treatment unit permits, and other risks have been mitigated, dormant season burning can be used once the maintenance phase has been reached. This will help to extend the fire season, and allow for implementing burns when duff moisture levels are higher, thereby minimizing the use of resources on mop-up and post-burn monitoring.

- Prescribed fire will be applied in a manner that balances the need to make progress on ecological and fuel reduction goals, while maintaining sufficient refugia for conservation target wildlife and other organisms that are negatively impacted by fire.

Table 4. Management actions undertaken since 2005

Management Unit	Acres	Treatment Unit	Past Treatments
Madison Town Forest	42.586	Madison 1	1. All white pine and hardwoods harvested in April/May 2010 2. Burned 9/24/2014
Madison Town Forest	31.29	Madison 2	1. All white pine and hardwoods harvested in 2011 2. Burned 9/26/2014
Madison Town Forest	51.941	Madison 3	All white pine and hardwoods harvested in 2011
Lower West Branch	9.719	Bacon 1	All white pine and hardwoods harvested prior to TNC ownership - harvest conducted in February/March 2004
Lower West Branch	23.652	Hobbs Buffer	50% of the stand basal area removed and a majority of scrub oak also removed during harvest in 2010
Lower West Branch	15.182	North Atlantic Air Buffer 1	1. Stand basal area reduced to 30 square feet per acre and scrub oak mowed for first 50 feet from boundary line. Harvesting completed in April/May and mowing completed in late August/early September 2007. 2. All scrub oak and white pine and hardwoods up to 6 inches dbh mowed in late August
Lower West Branch	12.616	Windsock Village 1-1	1. All white pine and hardwoods harvested prior to TNC ownership - harvest conducted in February/March 2004 1. All scrub oak and small diameter hardwoods and white pine mowed prior to burning. Mowing completed in May 2009 2. Burned 9/13/2011
Lower West Branch	18.835	Windsock Village 1-2	1. 150' WUI Buffer area adjacent to houses mowed of all scrub oak and small diameter trees for fuel reduction purposes. Mowing completed in May 2009 2. All white pine > 6 inches dbh harvested in April/May 2010 3. Burned 9/14/2011
Lower West Branch	22.828	Windsock Village 2	1. All white pine and hardwoods harvested prior to TNC ownership - harvest conducted in February/March 2004 2. All scrub oak and white pine and hardwoods up to 6 inches dbh mowed in November/December 2012 3. Burned 9/19/2013
Lower West Branch	4.246	Zito Buffer	All scrub oak and white pine and hardwoods up to 6 inches dbh mowed in late August of 2013
Thicket	12.663	Calumet Buffer	1. Stand basal area reduced to 30 square feet per acre and scrub oak mowed for first 100 feet from eastern boundary. Harvesting completed in April/May and mowing completed in late August/early September of 2007. 2. All scrub oak and small diameter hardwoods and white pine mowed for fuel reduction purposes. Mowing completed in August of 2011. 3. Burned 9/17/2012
Thicket	4.573	South Jackman Ridge 1	1. Interior lines mowed in middle of unit in 2005 2. All scrub oak mowed prior to burning. Mowing completed in May 2009 3. Burned 8/7/2009
Thicket	10.973	South Jackman Ridge 2	1. Scrub oak mowed within 20' of the unit perimeter and several ignition lines mowed into unit in 2008 2. Burned 9/5/2008
Thicket	56.145	South Jackman Ridge 7	Burned 10/3/2013
Thicket	9.884	Thicket 3	1. Scrub oak mowed with a 3' lifter on the mower head to minimize sand and duff mixing in order to reduce lag time needed before burning. Mowing completed in October/November 2005 2. Burned 9/19/2007
Thicket	6.673	Thicket 4	1. Scrub oak mowed with a rotary mower leaving much of the V. angustifolium and leaf litter intact in June 2007 2. Burned 9/19/2007
Thicket	34.69	Thicket 7-1	Burned 9/21/2010
Thicket	4.722	Thicket 7-2	1. All scrub oak and small diameter hardwoods and white pine mowed prior to burning. Mowing completed in late July/early August 2010 2. Burned 9/21/2010
Thicket	22.673	Thicket 8	1. Scrub oak mowed within 20' of unit perimeter and several ignition lines mowed into unit 2009 2. Scrub oak, white pine and hardwoods mowed in November/December 2012 3. Burned 8/8/2009 4. Burned 8/19/2013
Thicket	6.657	Thicket West 1	1. Scrub oak mowed prior to burning in May 2009 2. Burned 8/28/2009

Management Unit	Acres	Treatment Unit	Past Treatments
Thicket	15.567	Thicket West 2	1. All scrub oak mowed prior to burning. Mowing completed in May 2009 2. All scrub oak and small diameter hardwoods and white pine mowed prior to burning. Mowing completed in August 2011 2. Burned 9/12/2011
Triangles	13.103	Triangle 1	All White Pine removed in March 2005
Triangles	24.055	Triangle 2	All White Pine removed in April/May 2007
Triangles	4.26	Triangle 3	White pine removed 2008
West Branch	6.029	East Shore Drive Buffer 1	1.50% of basal area removed from the canopy and all scrub oak mowed within 100' of the northern boundary (the mower head was run into the duff to maximize fuel reduction). Harvesting completed in March and mowing completed in October/November 2005 2. Scrub oak mowed with a rotary mower leaving much of the V. angustifolium and leaf litter intact. Mowed in June 2007. 3. Burned 9/3/2008 4. All scrub oak and white pine and hardwoods up to 6 inches dbh mowed in late August 2013
West Branch	27.871	East Shore Drive Buffer 2	1. Stand basal area reduced in March and scrub oak mowed within 100' of northern boundary in October/November 2005 2. Scrub oak mowed in May 2009 3. Burned 8/27/2009 4. All scrub oak and white pine and hardwoods up to 6 inches dbh mowed in late August 2013
West Branch	13.112	Route 41 Buffer	1. Stand basal area reduced to 40-50 square feet per acre In April/May and scrub oak mowed in August/September for first 50 feet from boundary line in 2007 2. All scrub oak and small diameter hardwoods and white pine mowed for fuel reduction purposes. Mowing completed in August 2011
West Branch	43.302	West Branch 11	Burned 2010
West Branch	5.745	West Branch 1-1	1. Scrub oak mowed with a rotary mower leaving much of the V. angustifolium and leaf litter intact in June 2007 2. Burned 9/21/2007
West Branch	11.953	West Branch 1-2	1. Scrub oak mowed with a rotary mower leaving much of the V. angustifolium and leaf litter intact in June 2007 2. Burned 9/22/2007
West Branch	23.9	West Branch 4-1	1. White pine >6" dbh harvested in 2010 and scrub oak mowed within 20' of unit perimeter 2. Burned 9/22/2010
West Branch	23.561	West Branch 4-2	1. Scrub oak mowed within 20' of unit perimeter and one ignition line mowed into unit in 2010 2. Burned 9/22/2010
West Branch	23.268	West Branch 5-1	1. Scrub oak mowed within 20' of unit perimeter and several ignition lines mowed into unit in 2008 2. Burned 9/4/2008
West Branch	13.805	West Branch 5-2	1. Scrub oak mowed within 20' of unit perimeter and several ignition lines mowed into unit in 2008 2. Burned 9/4/2008
West Branch	41.572	West Branch 8	1. Scrub oak mowed within 20' of unit perimeter and several ignition lines mowed into unit in 2009 2. Burned 9/8/2009 3. White pine > 6" dbh harvested April/May 2010

V. Guidelines for Prescribed Fire Operations

A. Legal and Regulatory Issues

Chapter 227-L (Woodland Fire Control) of New Hampshire Title XIX-A (Forestry Laws) provides for granting of permits for open burning with the approval of the fire warden of the town where burning will take place (New Hampshire Division of Forests and Lands 2005). While there are no specified requirements in the law for notification, the forest ranger has recommended that neighbors be notified at least one week before the burn (Bob Boyd, personal communication). Notification of the Ossipee Valley Mutual Aid and the Green Mountain Fire Tower (if it is staffed) prior to ignition will also be necessary (Bob Boyd, personal communication).

Permits are issued by the forest ranger and the fire warden (following a review of available resources). Chapter ENV A-1000 of the New Hampshire Code of Administrative Rules specifies the approval by the New Hampshire Department of Environmental Services is not required for open burning. A commercial permit is required for burns between 9:00 AM and 5:00 PM local time, unless it is raining, in which case a regular permit is required. A regular permit is required for burns after 5:00 PM. Both types of permits may be necessary if burns are to start before 9:00 AM and continue past 5:00 PM. Mop-up must be complete so that is nothing burning or smoking, unless the burn will be attended. If sufficient crew and equipment are available, some residual smoldering may be permitted. The permittee is responsible for damages and suppression costs should the prescribed burn become a wildfire (New Hampshire Division of Forests and Lands 2005; Bob Boyd, personal communication).

The Nature Conservancy Fire Management Manual (Heumann 2012) provides standard operating procedures, guidelines and requirements for planning and implementing prescribed burns, including the requirements for burn plans, crew qualifications and experience, and equipment and are incorporated into this document and all burn plans. For the Ossipee Pine Barrens, The Nature Conservancy will be implementing prescribed burns on land it owns or on partner lands. Permission for burninng on other's lands, as well as permission to access TNC lands through other lands will need to be gained before any prescribed burns take place. Agreements may also be needed for cooperation with local fire departments.

There may be additional local permits for impacts in wetlands, and all local, state, and federal laws will be complied with.

B. Planning and Managing Prescribed Burns

1. Components of a Prescribed Burn Plan

Each burn must have a Prescribed Burn Unit Plan, approved by The Nature Conservancy fire manager, to ensure that burns meet the ecological goals and objectives for fire management while assuring safety and the protection of life and property as outlined in TNC's Fire Management Manual.

Burn plans will be developed for each management unit with a discussion of specific conditions (fuels, smoke management, etc.) for individual treatment units. This will reduce the number of plans required and allow for improved contingency planning.

2. Fire Complexity

The Nature Conservancy requires a complexity analysis for all prescribed burns. Proper preparation of the unit, mechanical fuel reduction, limiting unit size, training, and clear lines of authority can reduce the complexity of fire management operations.

C. Fire Environment

1. Fuels

Patterson (2001) described fuel characteristics within sections of the Ossipee Pine Barrens in detail and developed several custom fuel models for the site. The remaining areas were mapped by The Nature Conservancy (Lougee 2005). Some cultural land uses, such as residential development with highly flammable pine barrens vegetation between houses and roads, create hazardous conditions. Others may contain little or no fuels, such as some of the recently cleared mined and logged areas or densely developed areas.

Based on interviews with fire practitioners (see Section IX A), a review of previous studies and reports and management history, analyses of field data collected by The Nature Conservancy in 2013, custom models developed by Patterson (2001) and the Fire Behavior Prediction System (Rothermel 1972, Albini 1976), fuel types were assigned to management regimes as shown in Table 5 below. These types are briefly described in Appendix I.

Table 5. Recommended potential fuel models for the Ossipee Pine Barrens

Source: Batcher 2014

Treatment	Fuel Types	Other Potential Types
Mechanical (harvested but not mowed)	TU2, TU3, TL6, SH3, SH6	CFM 60, 61, 63 MFCSF Pitch pine-scrub oak control, SFM5, SFM6, SH5
Mechanical (mowed)	TU2, TU3, TL6, SH3, SH6	MFCSF scrub oak mow/burn 1 &2 MFCSF scrub oak mow/burn 2 &3 SB
Burned	TL6, TL9, SH1, SH6, TU1, TU3	SB
Burned/Mowed	TL2,TL6, TU2, TU3, SH6, SB2	MFCSF scrub oak mow/burn 1 &2 MFCSF scrub oak mow/burn 2 &3 SB
Untreated Pitch Pine-Scrub Oak Barrens	CFM 60, 61, 63, TL6, TU2, TU4, SH3, SH6, SH8	MFCSF Pitch pine-scrub oak control
Untreated Hardwood Forests	TL2, TL6,	SFM 8
Untreated Oak Forest (litter)	TL2, TL6	MFCSF Oak Forest Untreated, SFM9
Untreated Oak Forests with shrub understory	TL2, TL6, SH5, SH6?	SFM9, TU3, TU5
Untreated White Pine	TL1, TL6, TU2, SH6	SFM 8
Untreated Hemlock	TL2	SFM 8

2. Fire and Seasons

In the northeastern and north central United States, the fire season ranges from March or April when snow cover is gone to late November or early December when snows return. Summer is usually more humid with more rain and vegetation has high live fuel moisture so fire spread is limited. Drought or low humidity levels may allow for summer fire, but lower relative

humidity levels and large scale curing of vegetation are needed for any significant fires to occur. Fall again brings drying fuels and weather conditions, increasing fire hazard. However, relative humidity levels increase after dark, and shorter days limit the amount of time for fuels to dry and be pre-heated by the sun.

During the spring and early summer, lengthening days and the movement of frontal systems bring warmer conditions to the area with alternating periods of precipitation and drying as systems move across the continent. Relative humidity can range as low as 20-30% during days when high pressure systems dominate to 100% with precipitation or as temperatures drop at night (Table 6). The lowest humidity levels occur in March through May, and levels increase in the growing season.

Leaf litter, standing live or dead stems and shrubs, fine herbaceous and gramanoid vegetation, and downed woody debris are the primary fuels. Large woody debris may form localized fuel accumulations, and create problems during mop up as such areas will burn for long periods, as can standing dead trees. However, large woody fuels generally do not affect intensity and rates of spread over wide areas. Mechanical treatments alter the distribution of fine and coarse fuels, and prescribed burning reduces fuel created from mechanical treatments.

Fire intensity is highest when live fuel moisture is low, which is primarily during the dormant season. The spring is also the time of lowest relative humidity, resulting in fires of high intensity and rates of spread. As plants leaf out, live fuel moistures increase and the potential for high intensity fires decreases. Some shrubs contain volatile oils, including ericaceous species and scrub oak, and can burn with green leaves, though intensity and rates of spread will be much lower in the growing season due to higher moisture in the leaves and stems.

Sandy soils can dry quickly and create conditions ripe for severe fires during dry periods in the summer and fall. Drought conditions in the summer can reduce live fuel moisture and reduce moisture in soil and duff layers so that the potential for severe fires increases. In such cases, litter and other fuels can smolder for long periods of time. In severe droughts, these ground fires can smolder for days or longer.

Weather conditions and flammability of fuel types will determine outcomes for fire behavior calculations . For example, scrub oak during the dormant season can behave as a fuel model 4, but will burn with significantly lower intensity and rates of spread during the growing season. While many pine barrens species will burn during the growing season, with high live fuel moistures, fire intensity and rates of spread are lower than in the dormant season (Joel Carlson, William Patterson, Tim Simmons, personal communication).

Table 6 summarizes climatic conditions for Ossipee from a number of sources. The Tamworth 4, a cooperative weather observation station, is within five miles of Ossipee and has recorded station normal temperature and precipitation records for the period 1981 to 2010 (NOAA 2013). FireFamily Plus (version 4.1) was used to acquire data from 2010 to 2014 for White Mountain National Forest (Station 270301) to calculate ranges of relative humidity. The

U.S. Naval Observatory provides data on day length by locations chosen by entering coordinates.

Table 6. Summary statistics of relative humidity, temperature and day length

Sources for temperature: NOAA 2013; Day length from U.S. Naval Observatory for 2014; RH from White Mountain NF using FireFamily

Month	Recorded Max RH	Recorded Min RH	Mean Max RH	Mean Min RH	Normal Max T	Normal Min T	Mean # Days Max>=90	Mean # Days Min<=32	Mean Day Length (hours)
March	100.0	8.0	89.8	31.7	41.6	18.4	0	29.7	12.0
April	100.0	9.0	89.9	27.9	54.3	30.6	0.1	19.6	13.0
May	100.0	8.0	95.5	37.8	66.5	41.0	0.3	3.8	14.7
June	100.0	18.0	96.6	41.7	74.8	50.4	0.7	0	14.9
July	100.0	20.0	96.4	40.7	79.3	55.4	1.5	0	15.1
August	100.0	23.0	98.6	41.1	77.8	52.9	1.2	0	13.9
September	100.0	28.0	97.4	45.6	70.0	43.9	0.2	2.6	12.1
October	100.0	14.0	95.9	44.8	57.4	34.0	0	15.3	11.0
November	100.0	7.0	91.2	37.5	46.3	26.0	0	23.9	9.4

The potential for fire is highest during periods of low precipitation and humidity when fine fuels can ignite readily. Wildfires occurring during these periods can create sparks or embers carried aloft in the rising hot air above the fire. When the relative humidity falls below 35% and fine fuels dry, these embers or sparks may ignite spot fires downwind of the main fire. In high winds, these may fall hundreds or thousands of feet from the main fire and cross barriers such as roads, wetlands, water bodies, and fire breaks.

3. Fire Behavior, Wind and Topography

Records from the University of New Hampshire AIRMAP site at Castle Springs from 2002 through 2008, indicate that winds are generally from southwest to northwest. This is likely true during periods when high-pressure systems that bring dry weather dominate weather patterns. Easterly winds generally are associated with storm systems that bring in precipitation and high humidity (Keim 2004, Zielinski and Keim 2003). Less than two percent of winds blow at greater than 17 knots or 19.5 mph (Figure 1). Figures 2, 3 and 4 provide wind roses for spring, summer and fall and show the same trends primarily westerly winds.

Topographic changes are relatively minor in most of the Ossipee Pine Barrens except for areas along the base of Jackman Ridge. This is a factor that should be considered in fire management planning (see Section V).

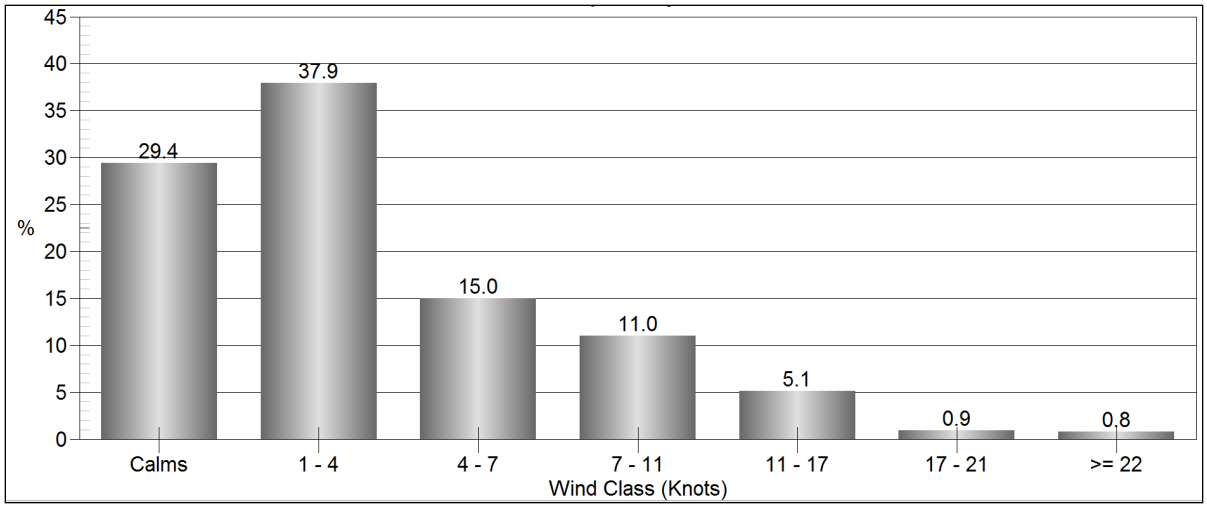


Figure 1. Wind speed distribution at Castle Springs AIRMAP site from 2002 through 2008. Source: University of New Hampshire 2014 from data from Castle Spring in Moltonborough, NH 2002-2008.

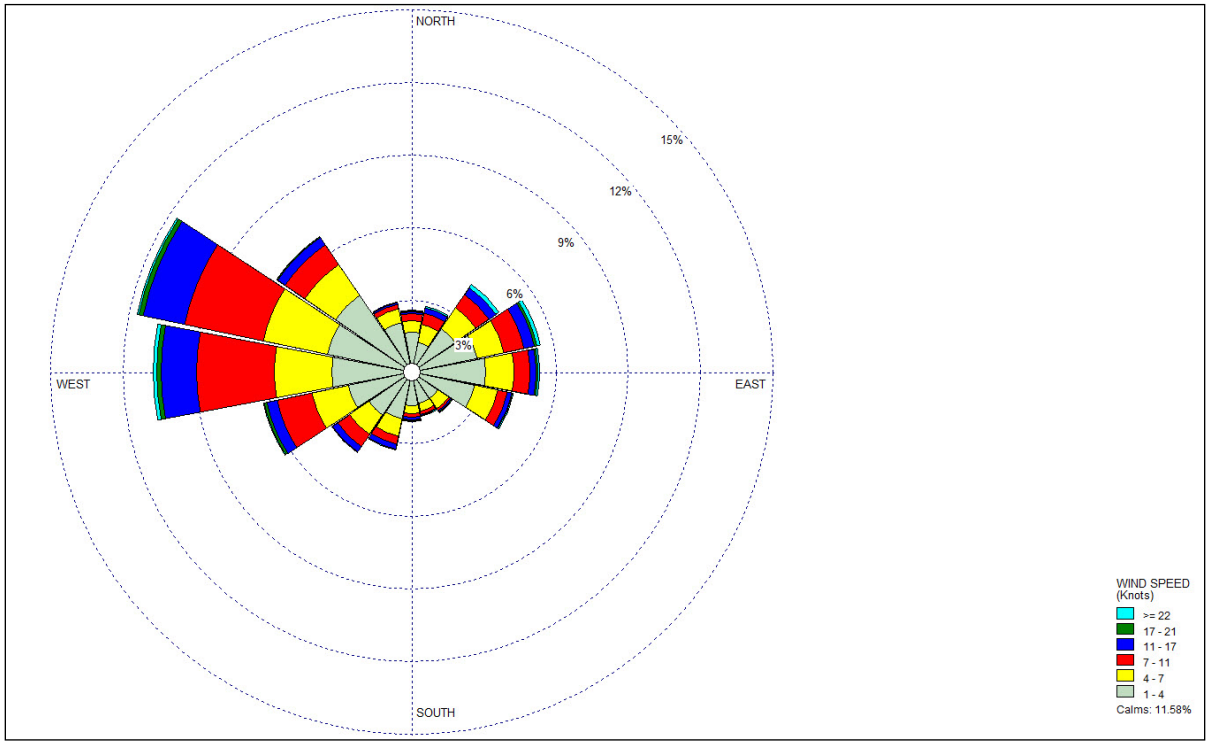


Figure 2. Wind direction and average speed for spring, March 1 through May 31. Source: University of New Hampshire 2014 from data from Castle Spring in Moltonborough, NH 2002-2008.

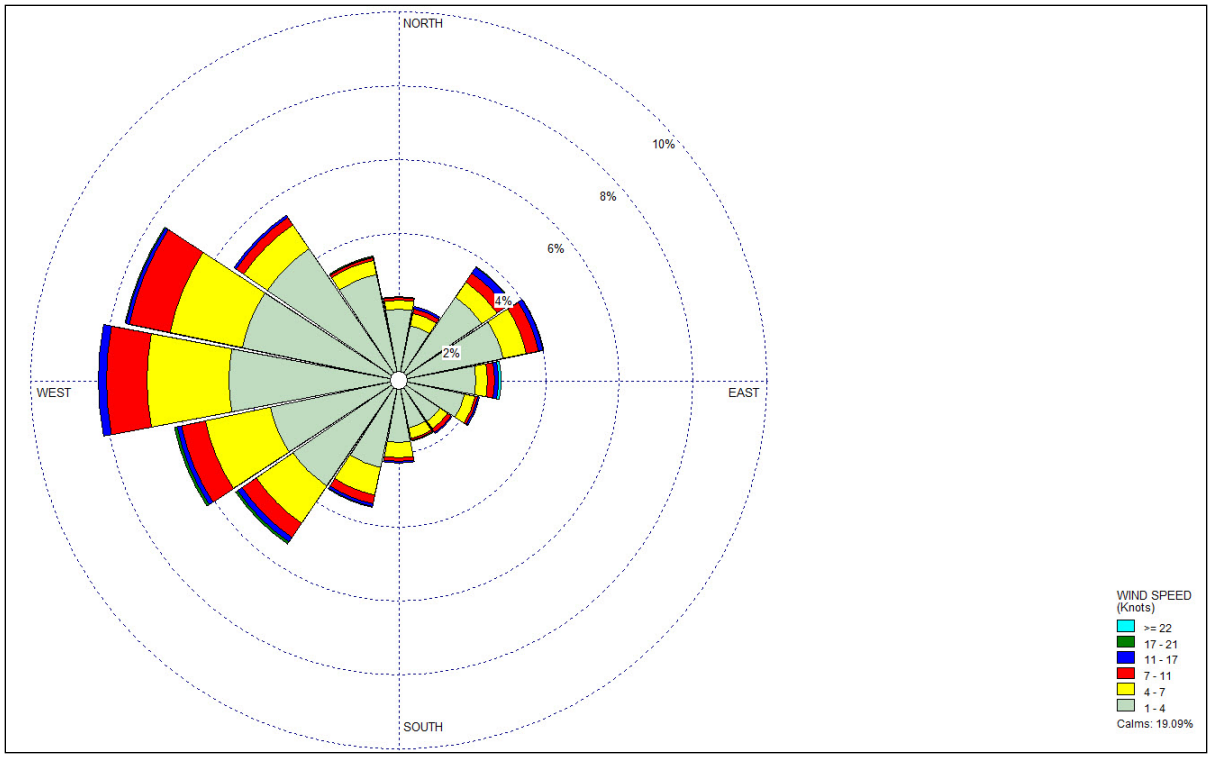


Figure 3. Wind direction and average speed for summer, June 1 through August 31. Source: University of New Hampshire 2014 from data from Castle Spring in Moltonborough, NH 2002-2008.

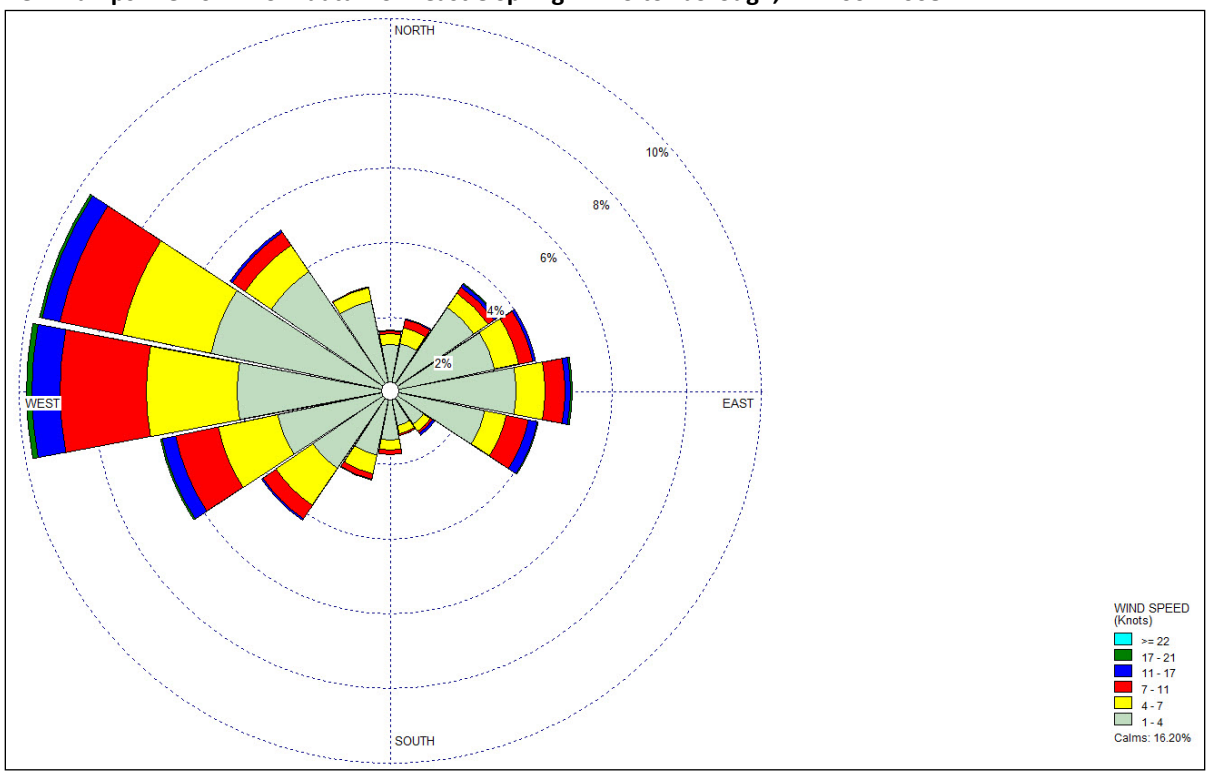


Figure 4. Wind direction and average speed for fall, September 1 through November 30. Source: University of New Hampshire 2014 from data from Castle Spring in Moltonborough, NH 2002-2008.

4. Potential Fire Behavior

Fire behavior in treated vs. untreated fuels can be very different. Fuel models for treated fuels have not been developed, but Patterson (reference) has shown dramatically reduced fire behavior in treated vs. untreated fuels. Fire behavior predictions for fuels at the Ossipee Pine Barrens are based on the data from FireFamily 4.1 taken from the WMNF Saco Ranger District RAWS station. These data are reflected in the value shown in Table 7.

Table 7. Fire behavior prediction assumptions

Parameter	Growing Season	Dormant Season
One-hour fuel moistures (%):	4, 6, 8, 10, 12, 14, 16, 18	4, 6, 8, 10, 12, 14, 16, 18
Ten-hour fuel moisture	12	12
100-hour fuel moisture: 17% growing; 19% dormant	17	19
Live herbaceous fuel moisture (%)	180	30
Live woody fuel moisture (%)	160	50
Temperature	70^0 F	60^0 F
Fuel shading (%)	50	50
20-foot windspeeds (mph)	0, 5, 10,15, 20, 25, 30	0,5,10,15, 20, 25, 30
Wind adjustment factor	0.4	0.4
Tree height: 50 ft.	50 ft.	50 ft.
Torching tree	*Pinus serotina*	*Pinus serotina*

BehavePlus does not include pitch pine for torching and spot fire prediction, but *Pinus serotina* or pond pine is a very similar species. Behave runs were then performed for each of the fuel types shown in Table 5. The results for both growing season and dormant season fires are shown in Tables 8 and 9 below.

BehavePlus has been shown to predict greater fire intensity and rates of spread for fuels in northeastern pine - oak forests for dormant season fires and lower intensity and rates of spread for summer fires where the standard (Anderson 1982) models have been used (Dell'Orfano 1996).

Table 8 shows predicted fire behavior during the growing season (May through September) and Table 9 shows predicted fire behavior during the dormant season (March, April, November). As can be seen, the Patterson models result in potentially extreme fire behavior in untreated fuels, with head fire flame lengths from up to 18 feet in the growing season and 26 feet in the dormant season depending on wind, topography and fuel moisture.

At least one after action report[6] for Ossipee indicated that the custom models 60 and 61 might over predict fire behavior in some situations. A mixture of fuel models 5 and 11 that consist of short, live scrub oak during the growing season and slash from mowing was used to predict behavior post-mechanical treatment. After action reports from Ossipee indicate that this model adequately predicts fire behavior in scrub oak after mowing. Additional monitoring

[6] Jeff Lougee maintains AARs for most burns.

of site weather and fire behavior will be needed to determine how closely predicted fire behavior aligns with conditions experienced in the field. The mixed SB2/SH5 appears to have more extreme fire behavior than would be expected in mechanically treated fuels.

The potential for torching trees is high for all but SFM8 and TL2 as scorch heights reach substantially into the canopy of pitch pine at Ossipee. Therefore, the potential exists for canopy fires and spotting if wind speeds are sufficient. Spotting distance from trees was predicted at 0.0 to 0.4 miles in all instances as the distance a tree will send an ember is independent of fuel type. It would seem that spotting pitch pine would likely send embers further than 0.4 miles depending on wind and relative humidity.

Table 8. Predicted growing season fire behavior

	Headfire				Backing Fire		
Fuel Model	Rate of Spread (fpm)	Flame Length (ft)	Spotting distance from surface (miles)	Scorch Height (ft)	Rate of Spread (fpm)	Flame Length (ft)	Scorch Height (ft)
CFM 60	1 to 86	1 to 18	0 to 0.7	3 to 152	0 to 1	1 to 3	0 to 15
CFM 61	1 to 73	1 to 18	0 to 0.6	4 to 143	0 to 1	1 to 3	0 to 14
CFM 63	1 to 88	1 to 19	0 to 0.7	4 to 169	0 to 2	1 to 3	0 to 16
MFCSF PPSO Control	1 to 94	3 to 21	0 to 0.8	12 to 204	1 to 2	2 to 4	1 to 21
MFCSF PPSO Thin/Mow	0 to 1	0	0	0	0	0	0
MFCSF SO Control	1 to 68	3 to 19	0 to 0.7	12 to 162	1 to 2	2 to 4	1 to 18
MFCSF SO Mow	0 to 8	0 to 2	0 to 0.1	1 to 2	0	0	0 to 1
SH8	0 to 31	1 to 10	0 to 0.4	2 to 43	0 to 1	1 to 2	0 to 6
SH6	1 to 46	2 to 12	0 to 0.5	5 to 67	1	1 to 2	0 to 7
SH5	0 to 113	0 to 18	0 to 0.7	0 to 148	0 to 2	0 to 3	0 to 12
SH3	0 to 8	0 to 3	0 to 0.1	1 to 3	0	0	0 to 1
TU5	1 to 20	2 to 10	0 to 0.4	6 to 44	0 to 1	1 to 2	0 to 9
TU4	0 to 40	0 to 9	0 to 0.4	0 to 40	0 to 1	0 to 2	0 to 6
TU3	0 to33	0 to 6	0 to 0.3	1 to 17	0 to 3	0 to 1	0 to 3
TU2	0 to 39	1 to 6	0 to 0.2	2 to 14	0 to 1	1	0 to 3
SB2	1 to 67	1 to 12	0 to 0.5	4 to 66	0 to 2	1 to 2	0 to 9
SB2/SH5	0 to 96	1 to 18	0 to 0.7	4 to 148	0 to 2	1 to 3	4 to 11
SFM11/SFM5	0 to 23	0 to 6	0 to 0.2	0 to 12	1 to 2	1 to 3	0 to 12
TL9	1 to 37	1 to 9	0 to 0.4	4 to 38	0 to 1	1	0 to 8
TL6	0 to 27	1 to 5	0 to 0.2	1 to 11	0 to 1	0 to 1	0 to 3
TL2	0 to 3	0 to 18	0	0	0	0	0
SFM9	0 to 48	1 to 7	0 to 0.3	2 to 17	0 to 1	0 to 1	0 to 3
SFM8	0 to 7	0 to 2	0 to 0.1	0 to 1	0	0	0 to 1

Table 9. Predicted dormant season fire behavior

	Headfire				Backing Fire		
Fuel Model	Rate of Spread (fpm)	Flame Length (ft)	Spotting distance from surface (miles)	Scorch Height (ft)	Rate of Spread (fpm)	Flame Length (ft)	Scorch Height (ft)
CFM 60	2 to 167	2 to 26	0 to 0.9	8 to 244	1 to 4	2 to 4	1 to 21
CFM 61	2 to 161	3 to 27	0 to 0.9	12 to 262	1 to 4	3 to 5	1 to 23
CFM 63	2 to 196	3 to 29	0 to 1.0	13 to 305	2 to 4	3 to 5	2 to 25
MFCSF PPSO Control	2 to 148	3 to 26	0 to 0.9	14 to 258	1 to 4	3 to 5	2 to 26
MFCSF PPSO Thin/Mow	0 to 1	0	0	0	0	0	0
MFCSF SO Control	2 to 128	4 to 26	0 to 0.9	16 to 253	1 to 4	3 to 5	2 to 26
MFCSF SO Mow	0 to 11	0 to 3	0 to 0.1	1 to 2	0	0	0 to 1
SH8	2 to 117	3 to 22	0 to 0.8	13 to 184	2	3 to 4	2 to 16
SH6	1 to 108	2 to 19	0 to 0.7	8 to 139	1 to 2	2 to 3	1 to 13
SH5	0 to 288	0 to 29	0 to 1.0	0 to 299	0 to 6	0 to 5	0 to 23
SH3	0 to 19	1 to 5	0 to 0.2	1 to 7	0	1	0 to 2
TU5	1 to 38	2 to 14	0 to 0.5	8 to 84	0 to 1	1 to 3	0 to 13
TU4	0 to 78	0 to 13	0 to 0.5	0 to 75	0 to 2	0 to 2	0 to 9
TU3	2 to 159	2 to 17	0 to 0.6	6 to 118	1 to 3	2 to 3	1 to 10
TU2	1 to 58	1 to 7	0 to 0.3	2 to 19	0 to 1	1	0 to 3
SB2	1 to 67	1 to 12	0 to 0.5	4 to 58	0 to 2	1 to 2	0 to 8
SB2/SH5	0 to 184	1 to 29	0 to 1.0	4 to 299	0 to 4	1 to 5	0 to 26
SFM11/SFM5	0 to 90	0 to 15	0 to 0.6	0 to 91	0 to 2	0 to 2	0 to 8
TL9	1 to 37	1 to 9	0 to 0.4	3 to 34	0 to 1	1 to 2	0 to 7
TL6	0 to 27	1 to 5	0 to 0.1	1 to 10	0 to 1	0 to 1	0 to 3
TL2	0 to 3	0 to 15	0	0 to 1	0	0	0 to 1
SFM9	0 to 48	1 to 7	0 to 0.3	1 to 15	0 to 1	0 to 1	0 to 3
SFM8	0 to 7	0 to 2	0 to 0.1	0 to 1	0	0	0 to 1

D. Application of Fire

1. Potential Fire Behavior

Table 10 provides guidance for fire behavior prescription parameters. Tactics for how fire will be applied in a given treatment unit will be described in the Burn Unit Management Plan.

Table 10. Prescription parameters for fire behavior in major fuel types at the Ossipee Pine Barrens

Fire Behavior	Untreated Pitch Pine-Scrub Oak	Treated Pitch Pine-Scrub Oak	Oak Forests	Other Hardwood Forests
Headfire Flame Length	3 to 6 feet within 20-50 feet of line 5 to 20 feet within unit beyond 20-50 feet of line	3 to 6 feet within 20 feet of line 5 to 20 feet within unit beyond 20-50 feet of line	3-6 feet within 20 feet of line 5-20 feet within unit beyond 20-50 feet of line	3 to 6 feet within 20 feet of line 5 to 30 feet within unit beyond 20-50 feet of line
Backing Fire Flame Length	1-3 ft.	1-3 ft.	Up to 1 ft likely	Up to 1 ft likely
Headfire Rate of Spread[7]	5- to 70 fpm	5-70 fpm	5-50 fpm.	1-20 fpm
BF Rate of Spread	<1-2 fpm	<1-2 fpm	<1-2 fpm	<1-2 fpm
Scorch Height	Scorch height should be limited in pitch pine to 1/3 canopy height to avoid torching if the objective is to maintain canopy pitch pine.		Scorch height can be unlimited for hardwoods or white pine that are to be reduced in abundance. For oaks, mortality can be reduced by avoiding burns after buds have broken in the spring (William Patterson III, personal communication).	
Fire Severity	Reduction of litter and duff will be minimal in dormant season burns, but more significant in growing season burns. Growing season burns may also result in mineral soil exposure. Fires should smolder as long as possible given smoke considerations and resource availability to achieve objectives (see Section II). Patchy burns will provide refugia as well as structural diversity, and burns should be managed to allow for unburned patches.			

Table 11 provides guidance parameters for weather and fuel moisture for the fire behavior needed to achieve ecological and fuel management goals and assure containment. These should guide planners in developing prescriptions for individual management units, and those prescriptions should address and provide specific justification for burning outside these guidance parameters.

[7] A person walking at two miles per hour will be moving approximately 176 feet per minute. Fire behavior should be carefully monitored to provide safety for both line crew and interior igniters and to reduce smoke and spotting potential.

Table 11. Prescription parameters for weather and fuel moisture

Prescription Parameters		Maximum	Minimum	Preferred
Wind Direction		Wind direction will depend on the location of the specific unit and smoke sensitive areas. At Ossipee, a variety of wind directions can be used.		
Mid-flame Windspeed		10	2[8]	2-7
Transport Winds		> 5	5	>=10
Atmospheric Mixing Height[9]		Unlimited	2,500 feet above ground level	Greater than the minimum
Air Temperature[10]		90	35	40-85
Relative Humidity		60	30	30-55
Days Since Last Rain[11]	Growing Season	10	1	Minimum of 2
	Dormant Season	5	1	Minimum of 2
Keetch Byram Drought Index		400	None	100-300
1 Hr. Fuel Moisture		16	6	
10 Hr. Fuel Moisture		25	10	
100 Hr. Fuel Moisture		None	10	
Live Fuel Moisture[12]		300	30	

Conditions that could result in the maximum in fire intensity and rates of spread should be avoided, such as effective winds near 10 mph and low relative humidity and fuel moisture levels. In addition, high KBDI or a high number of days since rain combined with low relative humidity could lead to excessive smoldering in heavier fuels as well as snags.

2. Prescribed Fire Crew Qualifications, Organization, and Responsibilities

All burns will be conducted by a qualified Conservancy burn boss (RxB2) and staffed by crew who meet at least the minimum National Wildfire Coordinating Group (NWCG) standards (see Heumann 2012). Specific crew requirements will be stated and approved in the Prescribed Burn Unit Plan. Contractors hired by The Nature Conservancy will be approved by the State Fire Manager, and must provide appropriately trained crew, and equipment as specified in the burn plan.

[8] Light and variable winds can result in unpredictable fire movement. However, minimum mid-flame windspeed may be less than 2 mph, provided there are adequate fuel breaks and equipment or fuels have been mechanically treated.

[9] Mixing heights give an estimate of how high smoke will rise, though this is also dependent on the amount of heat released by the fire, wind and other conditions.

[10] Temperature ranges are for crew safety and equipment operations. Below freezing, water in pumps may freeze. In colder temperatures, nomex provides little warmth. Above 90^0 F, heat exhaustion is much more likely.

[11] The KBDI may be a more important factor than days since rain, particularly during the growing season.

[12] Will vary greatly between dormant and growing seasons.

Crew will consist primarily of TNC staff and volunteers from the New Hampshire and Maine Chapters of The Nature Conservancy as well as staff from other TNC units who may wish to participate. Partners that have offered to participate include the U.S. Forest Service (White Mountains National Forest), U.S. Fish & Wildlife Service, and the New Hampshire Division of Forest and Lands. Staff from local volunteer fire departments may participate as their time and resources permit. Local volunteer fire department staff have training and experience in wildland fire, but are generally not trained to NWCG standards. Their role should be based on specific agreements between TNC and individual fire departments and on the qualifications, experience and fitness of individual staff. They can provide important local knowledge as well as resources for prescribed burns and would become involved in any escapes.

3. Equipment

Specific equipment, including required engines, hand tools, methods of ignition and communications will be specified in the management unit burn plans. The equipment will be supplied primarily by the New Hampshire and Maine Chapters of The Nature Conservancy and partner organizations. All fire crew will meet Conservancy standards for personal protective equipment (PPE). There will be at least two phones on site for emergency communications.

4. Unit Preparation

The following information is provided as guidance for planning purposes. Detailed descriptions of unit preparation will be included in individual burn unit plans.

Where possible, units should utilize existing human (such as roads) and natural firebreaks (lakes, wetlands, streams, low or no fuel, etc.) to contain the fire. Fuel reduction, through mechanical treatments, should be completed in areas where these breaks are either insufficient or do not exist.

In units completely contained within pitch pine - scrub oak barrens, firebreaks will be prepared 5-10 feet wide and allow for access by Type 6 or Type 7 engines. Scrub oak should be mowed to less than two feet in height within 25 feet of either side of this break. Where topography or other conditions prevent access by an engine or ATV with water, the same standards would apply, but a hose lay can be used. Pitch pine within this area should be treated using a variety of techniques to reduce the potential for torching or canopy fire including thinning the stand, limbing, reducing height of shrubs below the stand, and burning with relatively low intensity backing fires, depending on the potential for fire to reach the canopy.

Within the 5-10 ft. firebreak, debris should be removed. Fine litter will be removed prior to the burn, within a width of at least three feet along the line. Exposure to mineral soil is not necessary, and undue disturbance to the soil should be avoided. During ignition, the line and adjacent vegetation may be wet down as operations progress.

Wet lines and blacklining may also be used, and will be described in prescribed burn unit

plans. Wetlands and streams can also be used as fire breaks provided they would provide a break of at least 20-50 feet in width. This width may be reduced in cases where fuels across from the unit are limited or would produce low intensity fires if spotting were to occur. Where wetland shrubs or graminoid species could carry fire, these natural breaks should be enhanced through mowing or black lining as necessary. Additional crew may be needed to patrol across these if direct access from the unit is not available.

Depending on the size of the unit and the shrub layer, lines may be mowed within the unit as "soft breaks." These could be used by igniters or other crew traversing the unit or as lines to be used for control if the burn is shut down for any reason. These lines should be 5-10 feet in width.

Where pitch pine - scrub oak barrens transition to hardwood forests, breaks should be located within those forests at least 20 feet from the transitional edge of the pitch pine - scrub oak community. These breaks should be wide enough for crew to walk and fine fuels removed prior to the burn.

If multiple units are to be burned, units can be burned in a sequence so that those burned early in the burn window are downwind of those burned later to provide areas of reduced fuel, in case of escape.

5. Season

Burns can be carried out any time of the year if prescription parameters and objectives can be met. However, with days shortening in October and November, burns after mid-October may not be effective as daylight operating periods are limited and relative humidity may not reach acceptable levels until noon or later and rise quickly after 3:00 PM. Freezing temperatures can cause pumps to malfunction. March burns are unlikely due to snow cover. However, some black lining or limited dormant season burns in March may be possible. Some snow cover could be beneficial to prohibit fire spread in some areas. Generally, the best periods for burning at Ossipee are April through mid-May and August through mid-October.

6. Burning Slash and Debris

Slash and debris from mechanical treatment may be piled and burned in the winter, when snow cover would prevent fire from escaping the burn pile. Crew and equipment on hand should meet the requirements for plans for non-broadcast burns approved by the State Fire Manager.

E. Smoke Management

Both particulate matter and other substance in smoke can negatively impact the health of those exposed, including crew. In addition, smoke can impair visibility, particularly when the

relative humidity and fuel moisture levels are high or when light winds or a stable atmosphere limit dispersal. For a complete review of the impacts of smoke see Hardy et al. (2001).

Map 5 shows a five-mile smoke screening area. This area is primarily within portions of the Towns of Tamworth, Ossipee, Freedom and Madison. The estimated combined population of these three towns in 2013 was approximately 11,294 people (New Hampshire Office of Energy and Planning 2014). The major cover type within this nearly 80,000-acre area is forest. Approximately three percent is developed and the remainder is agriculture and water from the many lakes in the area. Smoke sensitive areas including hamlet centers. A resort and school are also located within this area. Major roads include Routes 16, 25, 41, 113 and 153 (J. Lougee, personal communication). Smoke from prescribed burns at Ossipee has been observed in Conway and the Maine border. Therefore, the Maine Forest Service is now being notified of prescribed burn operations. Unit burn plans will address smoke sensitive areas and smoke mitigation. In general, there are several methods for controlling smoke:

Burn During Appropriate Atmospheric Conditions: A key strategy to reduce smoke is to burn when atmospheric conditions are unstable and smoke will rise and disperse above smoke sensitive areas. Prescribed burning operations should also be scheduled when winds will transport smoke away from smoke sensitive areas. The conditions in Table 11 should provide for good smoke lift and dispersal away from sensitive areas.

Reduce Fuel Loads By Mechanical Removal: Reduced fuel loads will produce less smoke. Burning slash piles will reduce fuels, and these burns can be scheduled for the dormant season when surrounding fuels are wet or covered by snow. Slash piles would need to be covered so they could be burned.

Burn When Fuel Moisture in Large Woody Fuels, Litter and Duff is High: Burning when fuel moistures in 100 and 1000 hour fuels and when litter and duff are moist (low KBDI) will limit smoldering (Hardy et al. 2001). Table 11 provides parameters that should allow for good combustion with limited smoldering.

Mosaic Burning: Vegetation and fuels vary across a site. In a wildfire, the amount that burns will vary with microsite conditions, such as moisture and amount and type of fuel. Portions of units can be left unburned to mimic these conditions, either by creating soft breaks or by ignition patterns that do not result in complete burning of the entire unit (Nancy Sferra, personal communication; Hardy et al. 2001). This is also important for maintaining refugia for lepidoptera.

Limit Management Unit Size: The size of units can be limited so that burns are completed within a short period of time (3-5 hours) and the amount of fuel consumed is reduced.

Mop Up: Mop up can be complete so that there are few or no sources of residual smoke that might create problems after the burn or overnight.

The Nature Conservancy

Protecting nature. Preserving life.®

0 2 Miles

- 5 Mile Smoke Screening Area
- Smoke Sensitive Feature
- Pitch pine areas (transparent)
- Ossipee Pine Barrens Preserve
- Other Conservation Lands

NH DOT Roads

- State Road
- Local Road
- Town Boundaries

5-Mile Smoke Screening Area

Ossipee Pine Barrens Fire Management Plan

Data Sources and Notes:

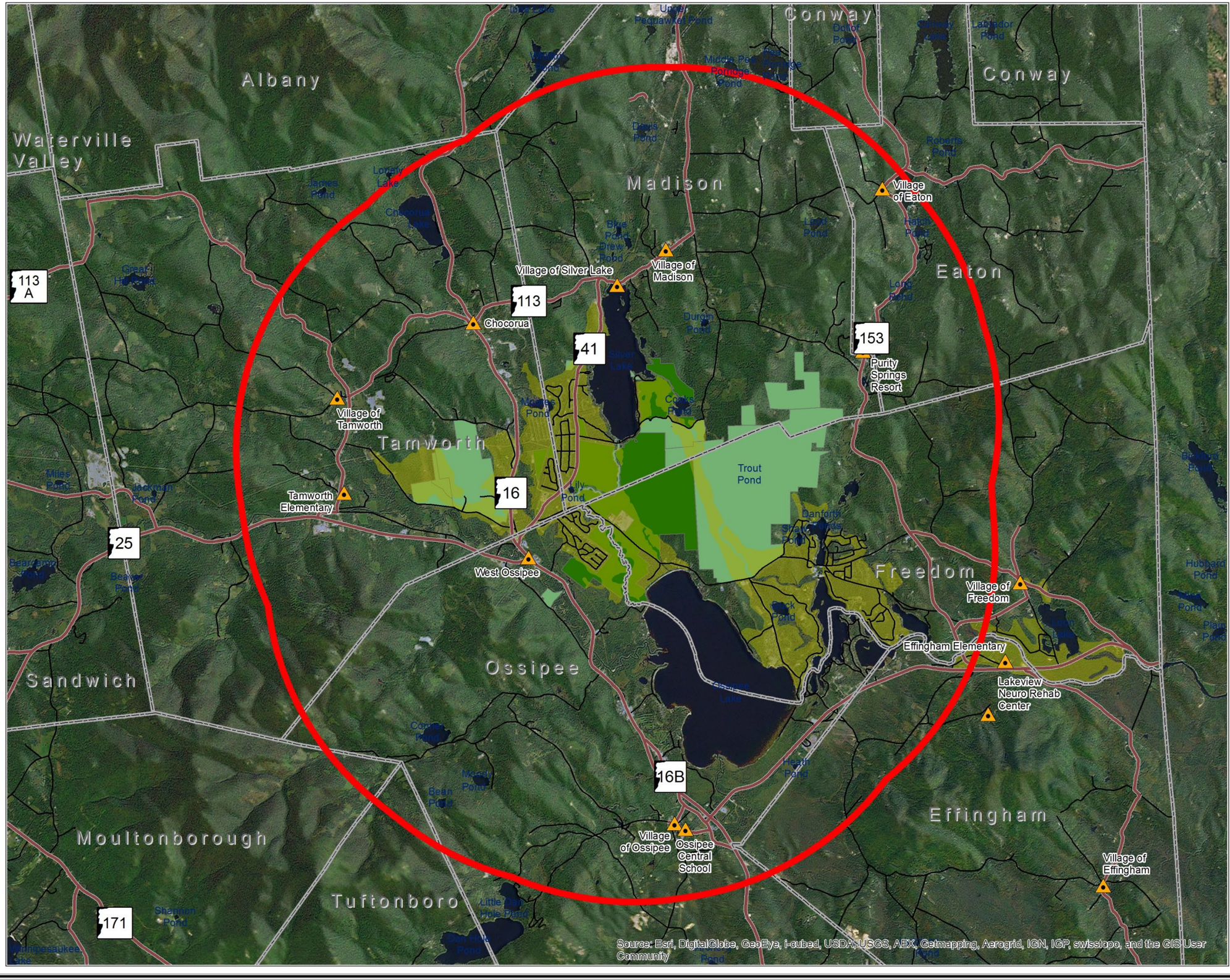
All data, except that noted below, are available from Complex Systems Research Center, Durham, NH
www.granit.sr.unh.edu

Smoke Sensitive Features, The Nature Conservancy New Hampshire Chapter, updated 2015

Major smoke sensitve features are highlighted on this map, but any developed areas (residences, roads, public places) are smoke sensitive features.

Scale 1:100,000

Map prepared on 3/27/15 by TNC



Control the Rate of Ignition: If heavy smoke is a problem, the rate of ignition can be adjusted by reducing the amount of area being ignited and the timing between strip head and flanking fires (Nancy Sferra, personal communication).

F. Combining Mechanical and Fire Treatments

1. Mechanical Treatments

Mechanical and other treatments will be needed to reduce the fuel bed depth for shrub fuels and to reduce pitch pine canopy cover in pitch pine - scrub oak woodland and forest structural types. Fire alone will not be effective in altering structure to achieve ecological and fuel reduction goals. Mowing can be used to reduce the height of the shrub layer by 80-90%, thereby greatly reducing the potential for high intensity, fast moving fires (Patterson and Crary 2004). Fire can then be used to reduce residual fuels and to maintain structural types and species habitat.

Mowing can be done at large scales (greater than one-acre) using tractor-pulled brush-hogs, Davco rotary brush-mowers mounted on rubber-tracked vehicles or other heavy mowing equipment to cut shrubs and saplings, with some equipment capable of removing vegetation with diameters up to six inches. At smaller scales, such as along control lines or around individual pitch pine trees, mowing can be accomplished using a Gravely or DR walk-behind mower or chain saws, power brush-saws or brush-cutters.

Growing season mowing, when reserves in the roots are low, can reduce the overall cover of scrub oak and other shrubs by reducing nutrients available for storage in roots. Several cuts within a growing season can be effective (William Patterson III, personal communication). Burning following mowing in the growing season can dramatically reduce scrub oak and increase herbaceous cover (Neil Gifford, personal communication). Scrub oak and other combustible shrubs should be mowed to maintain a height of less than two feet in areas near development or where shrubs create ladder fuels to ignite canopy fires.

Forestry operations have been used at Ossipee to reduce the density of pitch pine thereby reducing the risk of canopy fires. Forestry operations have also been used to reduce and eliminate less fire tolerant species that have become established, white pine and several hardwoods species.

2. Use of Herbicides

Herbicides are an option for controlling hardwoods such as red maple, and may be used where necessary.

3. Use of Prescribed Burning

Mowing can leave extensive amounts of organic debris on the ground, which can burn as slash and which may alter nutrient cycles. Removal of canopy trees will also increase slash and may increase shrub cover as sunlight is increased, thereby increasing fire hazard. Prescribed burning will be necessary to reduce fine fuels and to reduce slash from mowing, particularly smaller diameter slash (10-hour fuels) that can affect fire intensity and rates of spread more significantly than 100 and 1000-hour fuels.

Prescribed burns in untreated fuels will have higher intensity and rates of spread and will leave standing dead scrub oak (10-hour fuels). Follow-up burns may be extremely intense through these standing dead fuels if fuel moistures are low. An alternative is to mow through the standing dead scrub oak during the growing season, thereby also reducing nutrients for resprouting scrub oak. (William Patterson III, Tim Simmons, personal communication).

G. Wildfire and Prescribed Fire Escapes

The Nature Conservancy has completed a wildfire response plan and has shared it with local fire departments (Lougee 2010), which is incorporated by reference here. That plan contains the following elements:

- Introduction and Site Location
- Site Description including topography, fuels and fire sensitive areas described and mapped
- Wildfire Response Narrative addressing how both wildfires and prescribed fire escapes will be addressed and a map of local first responder locations.
- Notifications and Communications with contact information for TNC, state and local officials including radio channels
- Firefighting Resources Available at The Nature Conservancy
- Media Response Plan
- Fire Fighting Resources on the Preserve and Surrounding Areas including descriptions of access points, fire breaks, staging areas, safety zones and water resources
- Hazard Areas
- Crown Fire Hazard Map

Applicable sections should be incorporated into burn plans and burn bosses should be familiar with the wildfire response plan.

H. Potential Impacts of Prescribed Fire Operations

1. Cultural Resources

There appear to be no significant cultural resources at Ossipee Pine Barrens. Historic or cultural resources in developed areas are part of the WUI and will be protected through fuel reduction and other strategies.

2. Impacts on Neighbors

The public will be informed of planning and management through information meetings, field walks, implementation of WUI actions and pre-burn or management notifications. Neighbors who may be affected by smoke should be individually notified of the beginning and end dates of the prescribed fire season. Robert Boyd, Forest Ranger for the NH Division of Forest and Lands, has recommended that neighbors be notified at least one week prior to any burns. Information may also be provided in the local newspapers and on radio and television. Neighbors who so request should be notified the day of the burn, particularly if they have health conditions that may be aggravated by smoke or are involved in some activity that could be negatively affected by smoke (e.g., house or outdoor maintenance such as painting).

In addition to smoke, impacts may include noise from vegetation management, creation or enhancement of firebreaks, and fire operations.

3. Recreational Uses

During wildfires, prescribed burns, and mechanical treatments, recreational visitors will have to be notified via signage and excluded from areas where operations are occurring. Clearly, hikers may be in danger from machinery operating either during mechanical treatment or prescribed burn operations. They will also be in danger in the event of wildfire or potential escapes from prescribed burns. They may also be subjected to smoke from burns. Access points will be closed and appropriate signage displayed to inform visitors about the purpose and duration of closure. Specific burn crew personnel (information staff, smoke spotters) should be assigned to direct visitors who might wander into the area, away to safety.

VI. Program Evaluation

This section outlines methods for monitoring conservation targets, management effectiveness and program evaluation.

A. Biological Monitoring of Conservation Targets

1. Monitoring the Pitch Pine - Scrub Oak Communities

Monitoring of treatment effectiveness should be linked to management objectives for management units and treatment units and for both the goals and desired condition described in Section IV. Bushell (2011) has developed methods to monitor exposed mineral soil, scrub oak height, scrub oak cover, fire-intolerant tree mortality (red maple, white pine, red oak, American beech, aspen), and sapling abundance (pitch pine, white pine, red maple, red oak,

American beech and aspen). In 2014, the monitoring protocols developed by Bushnell were adjusted with input from UNH faculty. Two changes were made. The sampling design has been changed from random to systematic. And presence/absence data is being collected for pitch pine regeneration (seedlings). Appendix IV provides preliminary summaries of post-treatment monitoring data collected from 2011 – 2014. Further analysis of this data is planned for 2015, and will be written up in a separate report. The results of this analysis will be used to further refine priority setting for the site, especially with respect to determining those treatment units requiring additional management to meet the established objectives.

2. Fuels and Fire Behavior

Patterson (2001) collected and analyzed fuel data using methods to inventory downed woody fuel, stand data (similar to Dacey 2003), litter accumulation by harvesting, drying and weighing fine fuels, scrub oak stem density by size class. This provides information on live and dead fuels, with shrub fuels estimated using allometric equations. These kinds of data could be collected if either the custom fuel models developed by Dr. Patterson or the models described in Anderson (1982) or Scott and Burgan (2005) do not adequately predict fire behavior.

Fire behavior should be measured through observations of flame length and rates of spread collected during prescribed burns and collated by time, observed weather conditions (wind, relative humidity, and sunlight) and fuel types. Markers of a known height and spaced a known distance apart within units can aid in estimating rates of spread and flame length. Flame length can be recorded at intervals and these observations tabulated to provide a range, mean and other statistics. Video recorders can also be used to film fire behavior. A crew member should be assigned as a Fire Effects Monitor (FEMO) to take and record both weather and fire behavior observations. It would be relatively easy to summarize these for each burn on a spreadsheet to allow for improved fire planning.

Within a one month of the burn, an assessment should be made of the percentage of the unit burned, change in litter depth, affects on vegetation such as scorch height and shrub cover consumed, and other variables. This would be a quick assessment and would not substitute for more quantitative data.

For pitch pine dominated communities, measurements of crown bulk density could be collected using methods described in Duveneck (2005). Again, where these results can be correlated with canopy cover estimates from aerial photographs, a broader picture of the potential for canopy fire can be attained.

3. Monitoring Early Successional and Shrubland Birds

Citizen scientists should be recruited to assist with monitoring early successional and shrubland birds. There are two options for monitoring.

a. Annual or Biennial Bird Presence/Absence Surveys

Using methods similar to those used in breeding bird atlas surveys, observers could walk the perimeters of treatment units and list birds observed using the same codes for singing, pairs, nesting behavior, observed fledglings etc. used in the atlas surveys. This would require at least two visits in a breeding season and would result in a list of possible and probably breeding bird species in the treatment units. Visits would need to occur at different time of day to capture both crepuscular and nocturnal species. Christmas bird surveys could also be completed to determine what species overwinter. The timing of these surveys would depend on the treatment schedule, but units should be visited prior to treatment and then 2, 4 and 6 years post treatment.

b. Biennial Breeding Bird Surveys

For more quantitative information these surveys should be undertaken using point counts within management areas and units. The timing would depend on the treatment schedule, but units should be visited prior to treatment and then 2, 4 and 6 years post treatment. This is done by completing ten-minute counts of birds observed both within and beyond 50-meter radius circles at points established within the habitat. This is a standard method developed by Faccio et al. (2013) and described in materials created by the Vermont Center for Ecostudies (2012). Birds are identified visually or by song or call within a 50-meter circular plot. Bird locations and movement are also mapped during a 10-minute period. Birds identified visually or by sound beyond the 50-meter circle are also entered on the data sheet.

Distance sampling, or recording bird observations and the distance to the bird within the 50-meter circular plots can be undertaken to measure of density. Of these, distance sampling may be the most useful in providing a measure of abundance within habitat types and could be done within the 50-meter circular plots. Kart (2002) has also recommended using taped calls to census whip-poor-will using methods being developed by New Hampshire Audubon.

Data on the presence/absence of target and other species would be tabulated to determine trends. There will probably not be enough points within any management unit to allow statistical analyses, but one could determine the number of points at which individual species are identified and note trends in other species, particularly those that may prey on nests.

4. Monitoring Lepidoptera

Lepidoptera can be monitored using blacklights and bait. Both backlight traps and sheets can be used to collect lepidoptera (Kart 2002). Sampling must be done several times during the year as different species fly at different times. Sampling should be done within each management unit, depending on the treatment schedule, every 3-5 years. Sampling locations could be located in locations where vegetation monitoring is occurring.

5. Other Fauna

Other fauna, such as the Smooth Green Snake and odonates should be the subject of periodic surveys to determine if they are still present. Natural heritage program survey methods and data forms can be used for these.

6. Other Natural Communities

The other communities beyond the pitch pine - scrub oak woodland are primarily wetland communities. Periodic surveys using natural heritage program methods could be used to map and document the status of these communities and to determine if invasive species or other threats exist.

B. Program Monitoring

It will be important to track program progress. This can be done annually by assessing completion of research, inventory and monitoring, ecological management, neighbor relations, activities and training with partners and summarizing the results of monitoring. In addition, resource use in terms of staff time for ecological management, particularly prescribed burns, should be tracked.

For each burn, a prescription will be prepared. Following the burn, an after action report should also be prepared summarizing the objectives, actual methods of ignition and holding, timing of various events, any changes in the prescription by the burn boss, actual equipment and crew (list) on the burn, problems with equipment, and recommendations for changes.

VII. Further Planning Needs

A. Ecological Model

Using Dacey's (2003) transitions as a starting point, an ecological model should be developed to help in predicting potential changes between pitch pine - scrub oak barrens types and other natural communities, with and without management. Ecological models help summarize knowledge of processes that determine species composition and abundance. In the northeastern pine barrens, ecological modeling efforts have been developed at Waterboro Barrens in Maine (Young 1993), the Long Island pine barrens (Jordan et al. 2003), the New Jersey pine barrens (Whittaker 1979, Windisch 1993), the Shawangunks (Batcher 2000) and at both the Pocono and serpentine barrens sites in Pennsylvania (R. Latham personal communication). These models and extensive ecological studies of natural community associations (Motzkin et al. 1996) all indicate the importance of disturbance from periodic fire, land use (agriculture, logging, etc.), and of variations in substrate, in maintaining barrens and associated communities.

For Ossipee, the Waterboro model has the most application for predicting community change. However, Finton's study (1998) indicates that site conditions, fire and disturbance history and current vegetation structure and composition operate in such complex ways, that transferring knowledge and lessons learned from one to another is limited. Therefore, it would be important to begin to develop an Ossipee model to help in predicting evaluating management outcomes.

B. Inventory, Information and Research Needs

As stated in Section II, there are other potential community, bird and lepidopteran targets at Ossipee Pine Barrens. Monitoring for the current targets will provide inventory information for other potential targets.

Further information is needed on the ecological requirements of the pitch pine - heath swamp on the Mustapha parcel. A literature search of the Fire Effects Information System for species found within the pine - heath swamp would be good places to start as would the bibliography on fire effects in wetlands at the Northern Prairie Research Center (Kirby et al. 1988) and Wildland Fire in Ecosystems: Effects of Fire on Flora (Brown et al. 2000).

VIII. Resource Needs and Time Frame for Implementation

Table 12 provides a time frame for implementation and time estimates for completing actions described in this plan. The Nature Conservancy has closely tracked expenses related to ecological management at Ossipee over the past several years. This financial data provides a summary of average costs for implementing prescribed burns and mechanical treatments.

Table 12. Program implementation

Program Area	Action	Location	Time Frame	Resource Needs
Outreach and Education	Maintain database of members of the public and agencies requiring notification	Site-wide	Ongoing	Minimal staff time to update annually
Outreach and Education	Provide public information and outreach including contacts with neighboring landowners	Site-wide	Ongoing	2-3 days staff time annually
Research, Inventory and Monitoring	Continue to collect vegetation data following modified methods from Bushell (2011)	Treatment Units	Annually, 1, 3, and 5 Years post-burn	2-3 weeks staff time annually
Research, Inventory and Monitoring	Establish breeding bird survey points and collect data	Management Units	2015-2016	1 week staff time and volunteer, student, intern or partner support
Research, Inventory and Monitoring	Complete draft ecological model and submit for review by pine barrens experts. Revise as necessary	Site	2015-2016	2-3 weeks staff time
Research, Inventory and Monitoring	Light trap, bait and inventory for invertebrates	Treatment units	Every other year from 2016 through 2025	1 week staff time and volunteer, student or intern support for each monitoring interval
Research, Inventory and Monitoring	Early successional and shrubland bird surveys	Management units	Every other year from 2016 through 2015	1 week staff time and volunteer, student, intern or partner support for each monitoring interval
Research, Inventory and Monitoring	Complete literature and expert review of ecological processes for the pitch pine-heath swamp	Mustapha and Soaring Heights	2016	Intern or student project
Fuel Reduction and Wildland Urban Interface Actions	Manage established WUI buffers	Treatment Units	Generally 5-year rotations	Staff time and burn crew annually; varies depending on priorities
Fire Management Planning	Update Wildfire Response Plan and share with local fire departments	Site-wide	2015	1-2 weeks staff time
Fire Management	Revise treatment unit burn plans as necessary and get any necessary permits and approvals	Treatment Units	Ongoing	3-5 days staff time annually, or use of a contractor
Fire Management	Identify qualified burn bosses and line bosses Gain commitments for staff time and equipment availability from partners	For units given treatment schedule	Ongoing as needed	Staff time annually; varies depending on priorities

Program Area	Action	Location	Time Frame	Resource Needs
Fire Management	Prepare treatment units based on schedule	See Map 4	See Map 4	Staff time and contract for mechanical treatment; staff time varies depending on priorities
Fire Management	Complete Tier 1 Units	See Map 4	2015 to 2017	Staff time and burn crew
Fire Management	Complete Tier 2 Units	See Map 4	2018 to 2019	Staff time and burn crew
Management Planning	Evaluate Progress and Revise Fire Management Plan and Wildfire Response Plan as necessary	Fire mapping area with priority for management units	2020	3-6 months of staff time

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Provided data layers of management units, fuel types, access points, water sources, fuel breaks, and conserved lands used in Maps 1, 2, and 3 and smoke sensitive areas for Map 5.

Map 4 was developed based on analyses of those data layers.

Orthophotograph images were from the USDA Geospatial Data Gateway available via: http://datagateway.nrcs.usda.gov/

Town boundaries and transportation routes were from NH GRANIT available via: http://www.granit.unh.edu/

Appendix I. Description of non-pine barrens exemplary natural communities

Red maple floodplain forest (S2S3). This is an A-ranked exemplary natural community found along the West Branch south of Ossipee Lake Road (Nichols et. al. 2000) and is surrounded by pitch pine - scrub oak communities. On low terraces, within one to two feet of normal river elevation, *Acer rubrum* (red maple) is dominant with *Alnus incana* ssp. *rugosa* (speckled alder), *Osmunda cinnamomea* (cinnamon fern), and *Carex stricta* (tussock sedge) common. Associated species include *Calamagrostis canadensis* (bluejoint), *Symphyotrichum racemosum* (small headed white aster), and *Toxicodendron radicans* (climbing poison ivy). On terraces that are greater than two feet above normal river levels, *Pinus strobus* (white pine) and *Quercus rubra* (red oak) are more abundant, with *Pinus rigida* (pitch pine) common in some areas. Proximate to where the West Branch enters Ossipee Lake, this low floodplain forest varies considerably with location, but generally has a tall shrub layer of *Alnus incana* ssp. *rugosa* and *Cornus amomum* (southeastern silky dogwood) and a dense herbaceous layer of *Calamagrostis canadensis* (bluejoint), *Carex stricta* (tussock sedge), and *Osmunda regalis* var. *spectabilis* (royal fern). There is a backchannel swamp north of the mouth dominated by red maple and pitch pine in the overstory, a moderate cover tall shrubs and short shrubs, including speckled alder and *Lyonia ligustrina* (male berry), and a dense understory of cinnamon fern and peat moss. An accumulation of charcoal infused organic matter in the soil indicates fire periodically burns through the area. The use of fire in this community needs to be carefully investigated, but this community may be used as a natural firebreak depending on season and moisture content.

Hudsonia inland beach strand community (S1). This community occurs only on Ossipee Lake where berms have formed on the lakeshore as a result of ice and wave action. The community contains several rare plants including *Hudsonia tomentosa* (hairy Hudsonia G5 S2), listed as Threatened in New Hampshire, *Hudsonia ericoides* (golden heather G4 S1), listed as Endangered in New Hampshire and *Euthamia caroliniana* (grassleaf goldenrod G5 S2), listed as Threatened in New Hampshire as well as a unique assemblage of common species such as *Quercus ilicifolia*, *Prunus pumila* var *susquehanae* (dwarf cherry), *Vaccinium macrocarpon* (large cranberry), *Gaylussacia baccata* (black huckleberry), and several grasses such as *Panicum virgatum* (switch grass) and *Danthonia spicata* (poverty oak-grass). This community will be protected from fire, to avoid negative impacts on the rare plants.

Kettle-hole bog ecosystem: Located on the east side of Silver Lake, this system is made up of several natural communities. The dominant community is the Sphagnum rubellum/small cranberry dwarf heath moss lawn dominated by *Sphagnum rubellum* (sphagnum moss) and *Cladopodiella fluitans* (liverwort). Shrub species include *Vaccinium oxycoccos* (small cranberry) and there are “islands” of *Chamaedaphne calyculata* (leatherleaf) and *Andromeda glaucophylla* (bog rosemary). Herbaceous species include *Utricularia cornuta* (horned bladderwort), *Rhynchospora alba* (white beak-rush), *Xyris montana* (northern yellow-eyed grass), *Calopogon tuberosus* (grass-pink), *Sarracenia purpurea* (pitcher-plant), and *Eriophorum virginicum* (tawny cotton-grass). The community grades into a dwarf shrub peatland dominated by leatherleaf,

Kalmia angustifolia (sheep laurel), *Kalmia polifolia* (bog laurel), and scattered *Larix laricina* (larch).

Medium level fen ecosystem: One occurrence, located at the north end of Ossipee Lake, east of West Branch inlet, was not well documented and consists of a grass and sedge-dominated community with *Vaccinium macrocarpon* (large cranberry), *Rhododendron canadense* (Rhodora), *Lyonia ligustrina* (male berry) and *Chamaedaphne calyculata*. The second, a B-ranked occurrence at Cooks Pond inlet, includes four communities including: 1) Deep emergent marsh with several species of *Pontedaria* (pondweed), *Sagittaria latifolia* (common arrowhead), *Nymphaea odorata* ssp. *odorata* (white waterlily), *Nuphar variegata* (variegated yellow pondlily), and *Utricularia macrorhiza* (common bladderwort); 2) Hairy-fruited sedge - sweet gale fen with *Carex lasiocarpa* (hairy-fruited sedge) and scattered shrubs; 3) a Sweet gale - meadowsweet - tussock sedge fen dominated by *Chamaedaphne calyculata* (leatherleaf), *Myrica gale* (sweet gale), and *Carex utriculata* (bottle-shaped sedge); and 4) S*peckled* alder wooded fen with *Alnus incana* ssp. *rugosa* (speckled alder), *Myrica gale* (sweet gale), *Vaccinium corymbosum* (highbush blueberry), and several herbaceous species.

Sandy Pond Shore ecosystem: NHB reports that this occurrence, on the north end of Ossipee Lake, needs further documentation. Plant species include *Hudsonia tomentosa*, *Hudsonia ericoides*, *Helianthemum bicknellii* (Bicknell's frostweed), *Asclepias amplexicaulis* (blunt-leaved milkweed) (G5 S2), *Gratiola aurea* (golden pert) and *Prunus pumila* var *susquehanae* (sand cherry). The Hudsonias and the blunt leaved milkweed are state listed species. Sperduto and Nichols (2011) describe this system as created by wave and ice action and consisting of a 1) Twig-rush sandy turf pond shore (S1) described as structurally diverse with *Cladium mariscoides* (twig-rush), *Carex stricta* (tussock sedge), *Carex lasiocarpa* (wire sedge), *Euthamia caroliniana* (grass-leaved goldenrods) and *Calamagrostis canadensis* (bluejoint) on sandy, organic mats found between shrublands and open water or sandy beach and 2) a Bulblet umbrella-sedge open sandy pond shore (S2): a sparsely vegetated community on sandy soils with *Cyperus dentatus* (bulblet umbrella-sedge), *Viola lanceolata* (lance-leaved violet), *Juncus pelocarpus* (mud rush) and *Bidens frondosa* (common beggar-ticks as characteristic species).

Pitch pine - heath swamp (S1S2). This community consists primarily of pitch pine with a shrub layer of *Rhododendron canadense* (Rhodora) and other bog shrubs, growing on peat (*Sphagnum* sp.). There is some literature suggesting this community type is fire dependent (Thompson and Sorenson 2000).

Appendix II. Fuel Models

Standard 13 Models. Source: Anderson 1982	
Model	Description
SFM4	Fast spreading fire, continuous overstory, flammable foliage and dead woody material, deep litter layer can inhibit suppression
SFM5	Low intensity fires, young, green shrubs with little dead material, fuels consist of litter from understory
SFM6	Broad range of shrubs, fire requires moderate winds to maintain flame at shrub height, or will drop to the ground with low winds
SFM7	Foliage highly flammable, allowing fire to reach shrub strata levels, shrubs generally 2 to 6 feet high
SFM8	Slow, ground burning fires, closed canopy stands with short needle conifers or hardwoods, litter consist mainly of needles and leaves, with little undergrowth, occasional flares with concentrated fuels
SFM9	Longer flames, quicker surface fires, closed canopy stands of long-needles or hardwoods, rolling leaves in fall can cause spotting, dead-down material can cause occasional crowning
SFM11	Fairly active fire, fuels consist of slash and herbaceous materials, slash originates from light partial cuts or thinning projects, fire is limited by spacing of fuel load and shade from overstory

Scott and Burgan 40 Models. Source: Scott and Burgan 2005	
Model	Description
SH1	Low load dry climate shrub, woody shrubs and shrub litter, fuel bed depth about 1 foot, may be some grass; spread rate and flame low
SH3	Moderate Load, Humid Climate Shrub: woody shrubs and shrub litter, possible pine overstory, fuel bed depth 2-3 feet; spread rate and flame low
SH5	High Load, Humid Climate Grass-Shrub Combined: heavy load with depth greater than 2 feet; spread rate and flame very high; moisture of extinction is high
SH6	Low Load, Humid Climate Shrub: woody shrubs and shrub litter, dense shrubs, little or no herbaceous fuel, depth about 2 feet; spread rate and flame high
SH8	High Load, Humid Climate Shrub: woody shrubs and shrub litter, dense shrubs, little or no herbaceous fuel, depth about 3 feet; spread rate and flame high
TU1	Low Load Dry Climate Timber Grass Shrub: low load of grass and/or shrub with litter; spread rate and flame low
TU2	Moderate Load, Humid Climate Timber-Shrub: moderate litter load with some shrub; spread rate moderate and flame low
TU3	Moderate Load, Humid Climate Timber Grass Shrub: moderate forest litter with some grass and shrub; spread rate high and flame moderate
TL1	Low Load Compact Conifer Litter: compact forest litter, light to moderate load, 1-2 inches deep, possibly representing a recent burn; spread rate and flame low

Scott and Burgan 40 Models. Source: Scott and Burgan 2005	
Model	Description
TL2	Low Load Broadleaf Litter: broadleaf, hardwood litter; spread rate and flame low
TL3	Moderate Load Conifer Litter: moderate load conifer litter, light load of coarse fuels; spread rate and flame low
TL6	Moderate load broadleaf litter, spread rate and flame moderate
TL9	Very High Load Broadleaf Litter: may be heavy needle drape; spread rate and flame moderate
SB2	Moderate Load Activity Fuel Or Low Load Blowdown: 7-12 t/ac, 0-3 inch diameter class, depth about 1 foot, blowdown scattered with many still standing; spread rate and flame low

Northeastern Pine Barrens Custom Fuel Models	
CFM 60	Pitch pine-scrub oak forest (Hobbs)
CFM 61	Pitch pine-scrub oak forest (West Branch)
CFM 63	Pitch pine-scrub oak thicket
MFCSF/PPSO	Pitch pine-scrub oak untreated (Manuel F. Cornelius State Forest, Martha's Vineyard)
MFCS/SO1-2	Scrub oak mow and burn, years 1 and 2 (Manuel F. Cornelius State Forest, Martha's Vineyard)
MFCS/SO2-3	Scrub oak mow and burn, years 2 and 3 (Manuel F. Cornelius State Forest, Martha's Vineyard)

Appendix III. Wildland-Urban Interface Actions

The wildland-urban interface is that area where homes, businesses and other forms of development are constructed among flammable vegetation. Within Ossipee Pine Barrens, there are several areas, including Camp Calumet, East Shore Drive, Carved in Bark near the West Branch Preserve, portions of Windsock Village, Soaring Heights and Chocorua Beach and Ski north of the Triangles. Wildfires may spread into these areas from pitch pine - scrub oak barrens and forests or humans within these developed areas may start fires that spread to open lands.

For existing buildings, vegetation management is critical. The National Fire Protection Association and Firewise recommend (NFPA 2008):

- Using noncombustible materials in roofing material and building exterior
- Appropriately locating buildings
- Provide defensible space around homes and buildings, water supplies and utilities through vegetation management to reduce fuels in the Home Ignition Zone, which extends up to 200 feet around the buildings and homes and all attachments by:
- Locating combustibles such as fuel, wood piles, and storage buildings at least 30 feet away from the home, especially during fire season.
- Keeping trees and shrubs pruned six to ten feet from the ground to avoid ladder fuels.
- Removing overhanging branches from roof.
- Removing debris, such as leaves, pine needles and downed branches from gutters, roof and along foundation.
- Replacing flammable plants, such as holly and pine, with fire-resistant vegetation.
- Keeping landscaping and lawn well watered.
- Providing adequate water supplies for structure protection

The following three zones can be thought of as ranging from high to low priority in terms of managing potential fuels near structures:

Zone 1: An area within 30 feet of a building within which flammable vegetation could allow a wildfire to directly contact the building. Within this area, vegetation should be managed so that no type of wildfire could be supported. The best option for these areas would be low, maintained lawn. Plants should be free of resins, oils and waxes the burn easily. Leaves or other dead vegetation should be removed from under any decks or other overhangs and away from the building. Firewood stacks and propane tanks should not be located within this zone. Patio materials should be fire-resistant.

Zone 2: An area within 30 to 100 feet of a building where flames, radiant heat, and embers could ignite a structure. Topography is important, as this area would extend further down slope than upslope, as fire intensity is dramatically greater when moving upslope than down

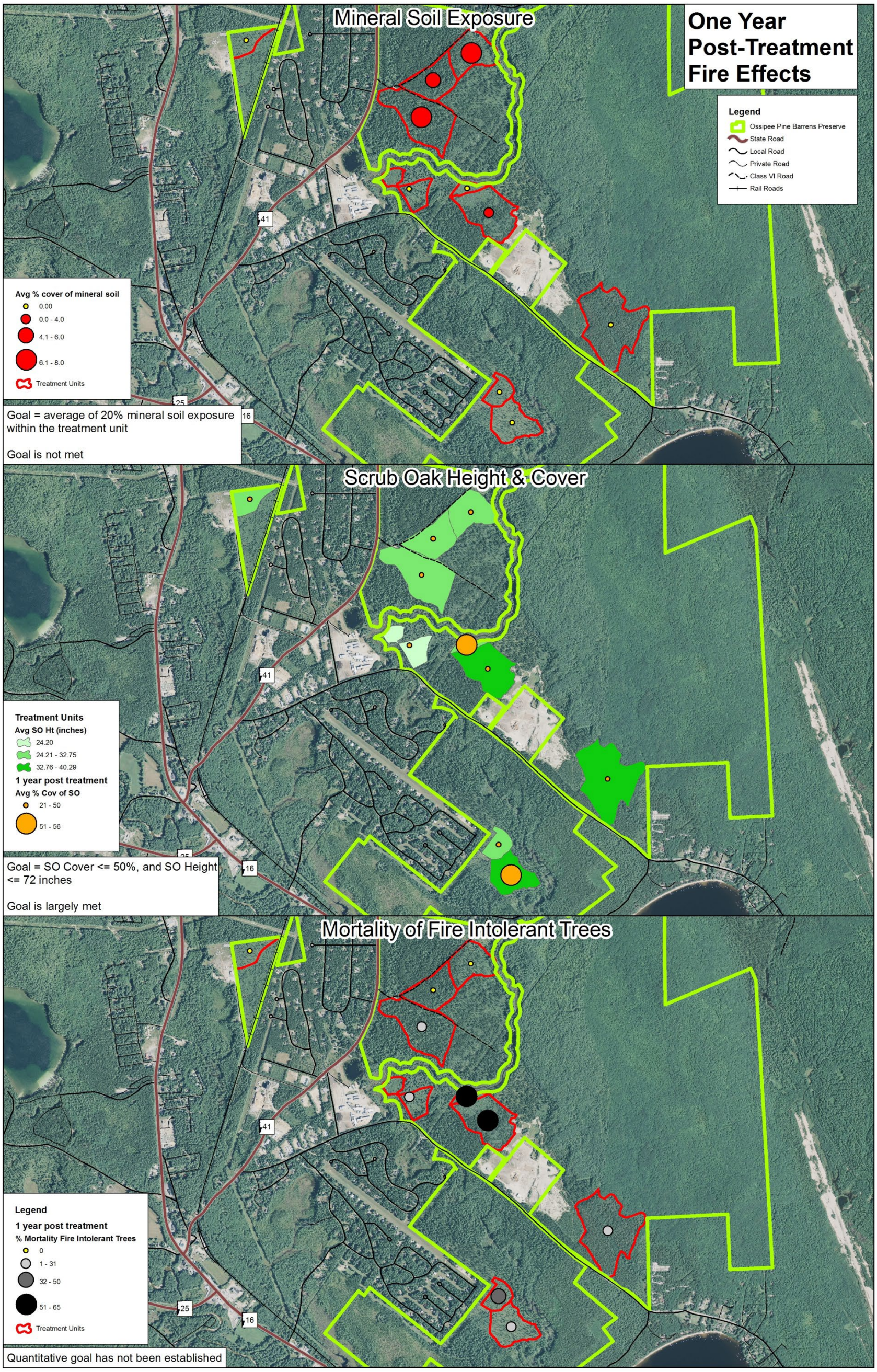
slope. Vegetation should be managed to limit fire to low intensity and rates of spread. Where feasible, fuel breaks including walking paths and driveways can break up fuels.

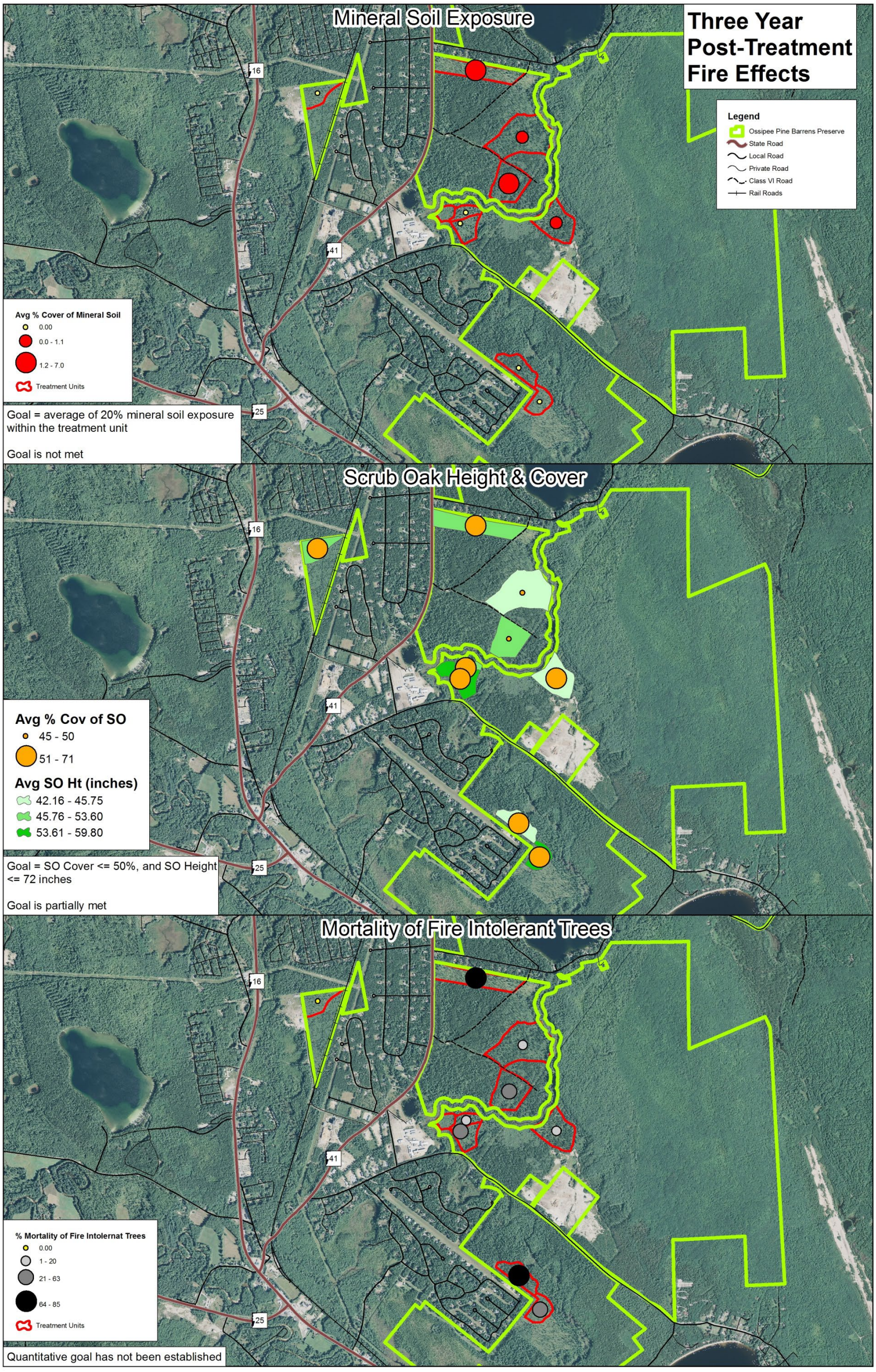
Zone 3: An area 100 to 200 feet of a building within which structures are threatened by embers from crown fires. Vegetation should be managed to prevent high intensity and rapidly moving surface fires that could also generate embers. Heavy accumulations of fuels as well as fine fuels such as tall grasses should be removed or broken up so they are not continuous.

Methods of vegetation management include mechanical treatment to thin the canopy and reduce shrub fuels followed in appropriate places by prescribed burning to reduce fine fuels. Long term management could involve planting of alternative vegetation that would be less combustible than that found within pitch pine - scrub oak barrens at Ossipee. The latter would include low cut lawns within the Priority Zone 1 and deciduous hardwoods (sugar maple, birch, red oak) within Priority Zones 2 and 3.

Appendix IV. Post Treatment Monitoring Data Summaries (2011 – 2014)

	Treatment Unit Info.						Burn Data			Mineral Soil Exposure				Scrub Oak Height and Cover						Fire Intolerant Tree Species Mortality				Seedling Regenerations		
Unit	Data Year	Sample Pts	Year of Burn	Mowed	Harvested	Years Post Burn	Avg. RH of Burn (%)	Avg. Temp of Burn (F)	Days Since Rain	# pts with mineral soil ≥ 20%	% pts with mineral soil ≥ 20%	Avg % cover of mineral soil for points with a value	Avg % cover of mineral soil	# of pts with SO cov < 50%	% of pts with SO cov < 50%	Avg % cov of SO	# of pts with SO ht < 72"	% of pts with SO ht < 72"	Avg SO ht (inches)	# of pts with fire intol tree	# of pts where stem is dead	% mortality	Avg DBH of stems	Sample pts with pitch pine seedlings	Sample pts with fire intolerant seedlings	Most abundant fire intolerant species
Thicket 7-1	2011	28	2010	No	No	1	38	72	4	0	0%	7%	1%	17	61%	43%	28	100%	40	17	11	65%	11			
Thicket 7-2	2011	15	2010	No	No	1	43	72	4	0	0%	-	0%	6	40%	56%	15	100%	30	8	5	63%	10			
West Branch 11	2011	29	2010	No	No	1	47	73	6	3	10%	56%	8%	25	86%	21%	29	100%	31	10	3	30%	12			
West Branch 4-1	2011	30	2010	No	No	1	55	79	5	2	7%	41%	7%	24	80%	25%	30	100%	33	7	0	0%	11			
West Branch 4-2	2011	30	2010	No	Yes ('10)	1	61	74	5	4	13%	29%	6%	26	87%	25%	30	100%	33	1	0	0%	9			
East Shore Drive Buffer - 1	2011	30	2009	Yes ('09)	Yes ('05)	2	34	73	4	0	0%	23%	1%	20	67%	34%	30	100%	49	6	1	17%	15			
East Shore Drive Buffer - 2	2011	25	2008	Yes ('07)	Yes ('05)	3	43	80	14	3	12%	60%	7%	10	40%	56%	23	92%	54	13	11	85%	18			
West Branch 5-1	2011	28	2008	No	No	3	46	87	15	4	14%	35%	7%	13	46%	49%	26	93%	51	19	12	63%	10			
West Branch 1-1	2011	27	2007	Yes ('07)	No	4	65	73	5	0	0%	-	0%	8	30%	62%	25	93%	51	26	9	35%	9			
Thicket West - 2	2012	30	2011	Yes ('11)	No	1	60	81	2	0	0%	-	0%	27	90%	25%	30	100%	24	29	9	31%	12			
Windsock Village 1-1	2012	30	2011	Yes ('09)	Yes ('04)	1	54	81	3	0	0%	-	0%	24	80%	30%	30	100%	33	24	12	50%	6			
Thicket 8	2012	31	2009	No	No	3	42	75	4	1	3%	18%	1%	10	32%	58%	30	97%	42	28	3	11%	11			
Thicket West - 1	2012	30	2009	Yes ('09)	No	3	56	69	5	0	0%	-	0%	6	20%	71%	28	93%	52	29	4	14%	13			
West Branch 8	2012	30	2009	No	Yes ('10)	3	49	81	9	1	3%	12%	1%	19	63%	45%	30	100%	45	10	2	20%	8			
South Jackman Ridge 2	2012	30	2008	No	No	4	64	80	16	0	0%	-	0%	15	50%	57%	23	77%	51	22	6	27%	8			
Triangle 1	2012	30	No burn	Yes ('11)	Yes ('05)		-	-	-	0	0%	-	0%	20	67%	43%	30	100%	31	6	0	0%	11			
South Jackman Ridge 7	2014	30	2013	No	No	1	37	76	11	0	0%	-	0%	8	27%	35%	28	93%	35	27	2	7%	9	0	8	RM (7)
Windsock Village 2	2014	29	2013	Yes ('12 Nov)	Yes ('04)	1	47	78	5	0	0%	-	0%	11	38%	52%	29	100%	37	24	1	4%	10	0	17	RM (16)
Thicket West - 2	2014	20	2011	Yes ('11)	No	3	60	81	2	0	0%	-	0%	5	25%	69%	19	95%	58	20	12	60%	13	3	5	RM (4)
Windsock Village 1-1	2014	30	2011	Yes ('09)	Yes ('04)	3	54	81	3	0	0%	-	0%	12	40%	58%	24	80%	60	17	8	47%	9			
Windsock Village 1-2	2014	30	2011	No	Yes ('10)	3	53	79	6	0	0%	-	0%	15	50%	51%	30	100%	46	7	5	71%	9	30	6	WP (4)
East Shore Drive Buffer - 1	2014	30	2009	Yes ('09 & "13)	Yes ('05)	5	34	73	4	0	0%	14%	1%	23	77%	29%	30	100%	30	9	0	0%	17	20	1	RM
Thicket 8	2014	30	2009	No	No	5	42	75	4	0	0%	10%	0%	20	67%	41%	30	100%	34	27	4	15%	14	0	4	WP/RO (2 each)
Thicket West - 1	2014	15	2009	Yes ('09)	No	5	56	69	5	0	0%	-	0%	1	7%	95%	4	27%	68	15	2	13%	15	0	6	RM (5)
West Branch 8	2014	30	2009	No	Yes ('10)	5	49	81	9	1	3%	15%	1%	4	13%	73%	21	70%	59	3	0	0%	8	4	32	WP (31)
Triangle 1	2014	20	No burn	Yes ('11)	Yes ('05)					0	0%	-	0%	7	35%	62%	20	100%	50	10	0	0%	9	2	9	WP (8)


Mineral Soil Exposure
One Year Post-Treatment Fire Effects
Legend
Ossipee Pine Barrens Preserve
State Road
Local Road
Private Road
Class VI Road
Rail Roads
Avg % cover of mineral soil
0.00
0.0 - 4.0
4.1 - 6.0
6.1 - 8.0
Treatment Units
Goal = average of 20% mineral soil exposure within the treatment unit
Goal is not met
Scrub Oak Height & Cover
Treatment Units
Avg SO Ht (inches)
24.20
24.21 - 32.75
32.76 - 40.29
1 year post treatment
Avg % Cov of SO
21 - 50
51 - 56
Goal = SO Cover <= 50%, and SO Height <= 72 inches
Goal is largely met
Mortality of Fire Intolerant Trees
Legend
1 year post treatment
% Mortality Fire Intolerant Trees
0
1 - 31
32 - 50
51 - 65
Treatment Units
Quantitative goal has not been established
41
25
16


Mineral Soil Exposure
Three Year Post-Treatment Fire Effects
Legend
Ossipee Pine Barrens Preserve
State Road
Local Road
Private Road
Class VI Road
Rail Roads
Avg % Cover of Mineral Soil
0.00
0.0 - 1.1
1.2 - 7.0
Treatment Units
Goal = average of 20% mineral soil exposure within the treatment unit
Goal is not met
Scrub Oak Height & Cover
Avg % Cov of SO
45 - 50
51 - 71
Avg SO Ht (inches)
42.16 - 45.75
45.76 - 53.60
53.61 - 59.80
Goal = SO Cover <= 50%, and SO Height <= 72 inches
Goal is partially met
Mortality of Fire Intolerant Trees
% Mortality of Fire Intolernat Trees
0.00
1 - 20
21 - 63
64 - 85
Treatment Units
Quantitative goal has not been established
16
41
25