dcr | Massachusetts Department of Conservation and Recreation

Silviculture Prescription
Bristol Lot

Massachusetts Department of Conservation and Recreation
Bureau of Forestry

Southeast District
F. Gilbert Hills State Forest
Wrentham, MA

Prepared by:

Paul Gregory – Management Forester – Southeast District
Massachusetts Department of Conservation and Recreation
194 Cranberry Rd. – P.O. Box 66, South Carver, MA 02366
paul.gregory@state.ma.us – 508–866-2580 ext. 121

August 22, 2017

Approved by:

Management Forestry
Program Supervisor _____ Date:_____
William N. Hill, CF

Background

The general area of the F. Gilbert Hills State Forest was used by colonial settlers mainly for firewood, timber, the manufacture of charcoal, and pastureland. These land uses supported a minimal forest cover into the mid to late 1800s. Brush fires were common in the late 1800s and early 1900s. The State Forest Commission, established in 1914, bought burned or cut-over lands for reforestation and forest improvement.

Foxboro State Forest began in 1926 with the purchase of 381 acres. The Civilian Conservation Corps (CCC) was active in the early years with a camp located near the present site of the forest headquarters. The CCC planted hundreds of thousands of trees in the state forest, but most were destroyed in subsequent wildfires. Water holes throughout the state forest were created by the CCC and are still in use today. The forest was renamed F. Gilbert Hills State Forest in 1969 after a dedicated state Forester. In the 1930s he produced a series of illustrative maps of many of the Department's properties.

The state forest consists of a variety of forest types including: mixed oak, northern red oak, white pine–oak, white pine–hardwoods, white pine, oak–hardwoods, and shrub swamp. Currently the State Forest is approximately 1,037 acres.

Site Data

Geology and Landforms

The project area, like most of the state forest, consists mainly of glacial till with pockets of shallow bedrock and rock outcrops. The project area is flat to rolling terrain with moderate slopes in the southwestern part of the project area.

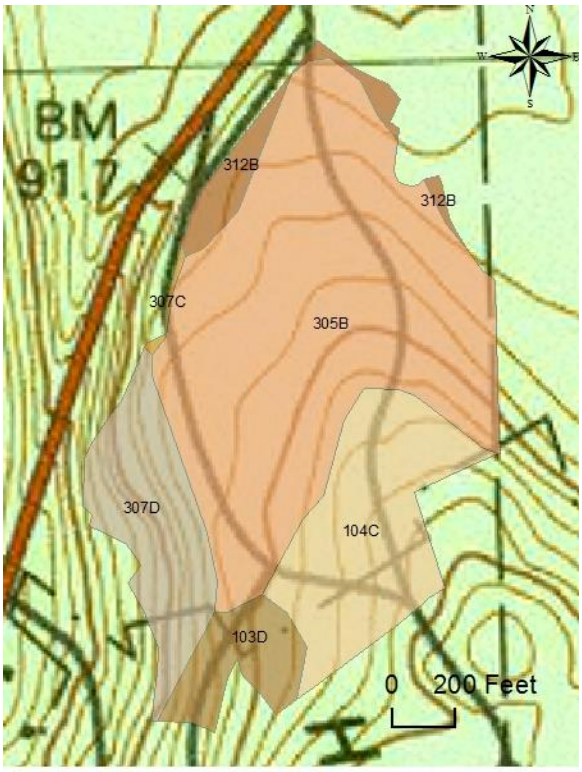
The F. Gilbert Hills State Forest is located in the Southern New England Coastal Plains and Hills ecoregion. The landforms of the ecoregion are irregular plains with low hills and some open high hills with relief of about 100 to 400 feet. Bedrock types are mostly granites, schist and gneiss. Historically, forests were dominated by a mix of oaks, American chestnut, hickories, other hardwoods, and some hemlock and white pine. Forests today are mainly central hardwoods with some transition hardwoods and some elm-ash-red maple and red and white pine. Many major rivers drain this area. (Swain and Kearsley 2011, Griffith et. al., 2009).

Climate

The yearly precipitation average from 1954 to 2016 for Foxborough is 48.0 inches. Monthly precipitation averages range from 3.5 inches in July to 4.6 inches in December. The average January temperature is 27°F, and the average July temperature is 72.5°F. 2016 was a dry year with only 35.5 inches of precipitation, 26% below average. There were 67 hurricanes in New England that occurred from 1620 to 1997, averaging one storm every 6 years.

Soils

The primary soil types comprising the project area are: 305B-Paxton fine sandy loam (58%); 104C-Hollis-Rock outcrop-Charlton complex (19%); 307D-Paxton fine sandy loam-extremely stony (13%), and 103D-Charlton-Hollis-Rock outcrop complex (6%). All are somewhat excessively drained to well drained soils derived from glacial till. All soil types are sandy loams ranging from fine to gravelly, and all have no frequency of flooding or ponding. As referenced in the names of the soil types, rock outcrops and stoniness are present in the project area (NRCS 2017).



Hydrology and watershed

The project area, and the state forest, falls in the Taunton River watershed. The state forest has many intermittent streams and scattered wooded and shrub swamps. The only water body in the State Forest is Sunset Lake located in the most eastern part of the state forest. A wooded swamp and vernal pools are not within, but lie adjacent to the project area. They will be treated at or above the minimum standards set forth in "Massachusetts Forestry Best Management Practices Manual".

Potential Vegetation

The project area consists mainly of sawlog and pole size red oak and mixed oak forest types. Red oak is more prevalent on the eastern side of the project area. Throughout the project area the dominate tree species are northern red oak (*Quercus rubra*), black oak (*Quercus velutina*), hickory (*Carya* sp.), red maple (*Acer rubrum*), and Eastern white pine (*Pinus strobus*). Black birch (*Betula lenta*), and white oak (*Quercus alba*), were also present to a lesser degree. The understory consists of low amounts of white pine, sassafras (*Sassafras albidum*), red maple, oak, black cherry (*Prunus serotina*), and hickory, and just a few highly scattered black gum (*Nyssa sylvatica*), dogwood (*Benthamidia florida*), and muscle wood (*Carpinus caroliniana*).

The project area was most likely used as a pasture due to the lack of small stones in the stone walls, small pits and mounds, and eastern red cedar (*Juniperus virginiana*) in the understory. A Home Fuelwood program occurred in the fall and winter of 2016. 4 lots were sold along the north side of High Rock Road. These lots extended 100 feet back from High Rock Road.

Site Productivity

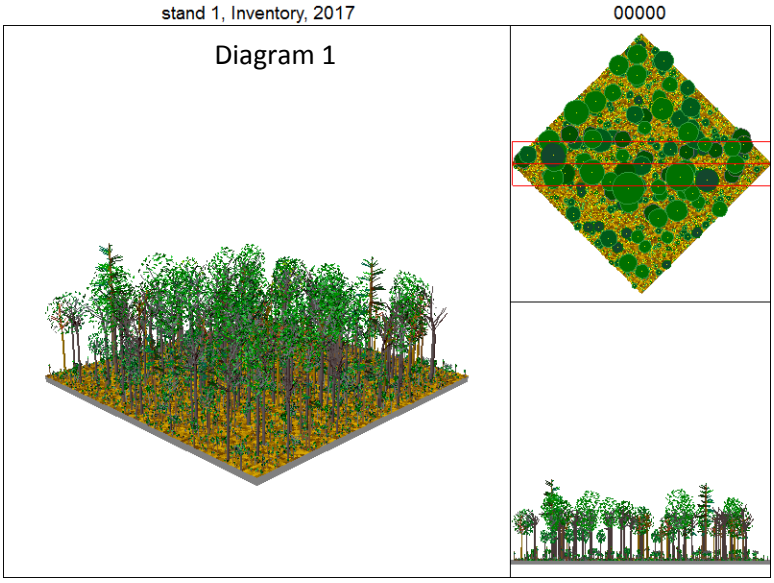
An analysis was conducted across all properties managed by the Bureau of Forestry to assess site productivity and complexity using Geographic Information System (GIS) data layers of Prime Forest Soils, Potential Vegetation Complexity, Late Successional potential, Forest Diversity, Early Successional potential, CFI Site Index, and CFI Stand Structure (Goodwin and Hill, 2012). An analysis of the Bristol Lot suggests a medium to medium-high level of complexity. This implies that the site is suited for both even-aged management and uneven-aged management. With the site being comprised of mostly oak species, which tend to be intolerant of shade during the regeneration phase, an even-age regeneration method, shelterwood, was selected.

Cultural and Archeological Analysis

Stone walls are found throughout the project area. Where possible, pre-existing bar-ways will be used to cross the stone walls. If a portion of a stonewall needs to be dismantled, it will be rebuilt at the conclusion of the sale to presale conditions. Trees will be felled away from stonewalls in order to prevent damage. No known or significant historic or archaeological resources exist in the project area as reviewed by DCR's archeologist.

Stand Data

Forest Stand Attributes



The project area consists of 42 acres of upland forest comprised mainly of northern red and black oak (Table 1 and Figure 1). The project area is approximately 85 to 100 years old with 105 trees per acre. The project area has a relative density of 71. Relative density is defined as the number of trees actually in a stand divided by the maximum number of trees of that average size that could exist (Smith, et al., 1997). As relative density increases, competition between trees increases, leading to mortality of some trees as the growing space is occupied by fewer trees typically of larger size. The total basal area is 89 ft^2/acre. The median overstory tree diameter is 15.2 inches. White pine, hickory, white oak, red maple, and black birch occur to a lesser degree. A few individuals of chestnut oak are also present. The understory is comprised mainly of white pine, sassafras, and red maple with most stems less than 4.5 feet tall (Table 2). Oaks regeneration is present to a lesser degree, but none are greater than 1" in diameter. The ground cover includes both woody and herbaceous species

(Table 3), most of which are less than 5% in cover. A representation of the current stand derived from the stand exam inventory is seen in Diagram 1.

Table 1 – Stocking Diagnostics

Species	Total trees/acre	Total BA/acre	% BA/acre by species	Relative density	% AGS
White pine	28.0	9.3	10%	4.4	44%
Red maple	13.0	9.3	10%	7.6	28%
White ash	0.4	0.4	0%	0	0%
Black birch	6.7	4.1	5%	3.4	73%
Red oak	22.3	34.8	39%	30.3	91%
White oak	4.4	4.1	5%	3.4	73%
Chestnut oak	0.4	0.4	0%	0	100%
Black oak	14.4	18.9	21%	15.0	76%
Hickory	14.7	7.4	8%	6.7	90%
Black gum	0.4	0.4	0%	0	0%
Total	104.8	88.9	100%	71	74%

Figure 1. Stand Species Composition

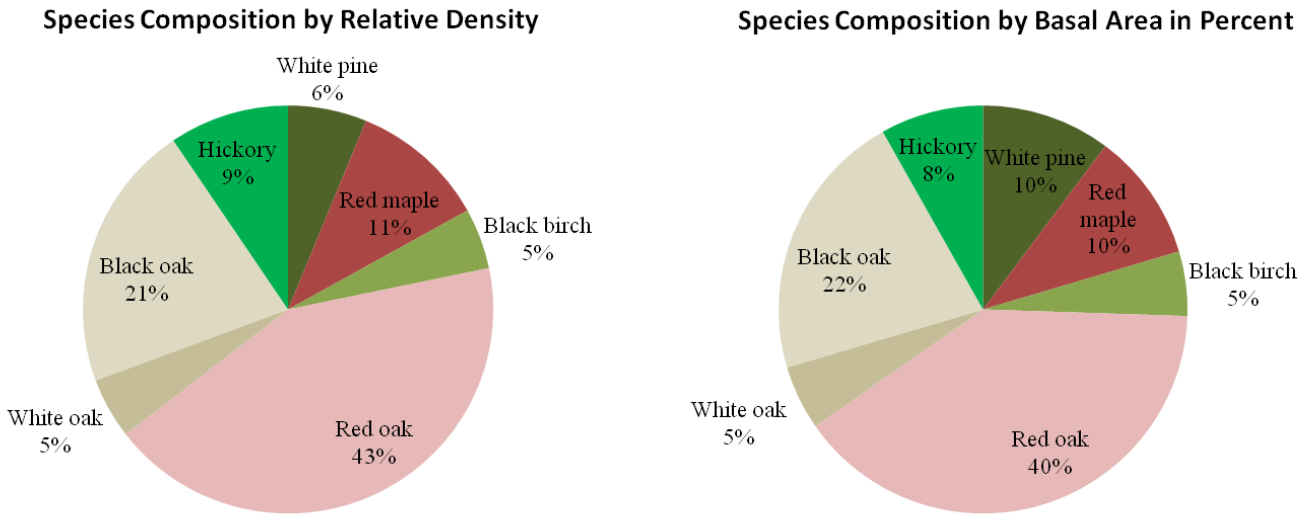


Table 2 – Stand Advanced Regeneration (stems per acre)

Species	< 1.0	1.0 - 4.5	4.5 - 1" dbh	>1" dbh	total
eastern white pine	445	456	44	89	1,034
sassafras	501	512	11	0	1,023
red maple	445	378	33	67	923
white oak	156	211	11	0	378
northern red oak	334	0	0	0	334
black cherry	100	133	11	0	245
hickory	78	11	11	22	122
black oak	111	0	0	0	111
black gum	33	33	0	11	78
black birch	44	0	0	11	56
chestnut oak	11	22	0	0	33
total	2,258	1,757	122	200	4,338

Table 3 – Ground cover (percent cover)

Species	Percent cover
American witchhazel	9
beaked hazelnut	6
bellwort	5
black huckleberry	7
bristly dewberry	1
Canada mayflower	4
clubmoss	7
common winterberry	1
eastern poison ivy	1
glossy buckthorn	2
grape	1
greenbrier	1
highbush blueberry	2
huckleberry	1
lowbush blueberry	7

Species	Percent cover
maleberry	2
mapleleaf viburnum	15
partridgeberry	7
Pennsylvania sedge	2
serviceberry	2
smooth Solomon's seal	1
arrowwood	1
starflower	1
striped prince's pine	2
unidentified fern	9
unidentified Forb	<1
unidentified grass	4
Virginia creeper	1
wild sarsaparilla	5
wintergreen	1

Wildlife Habitat Conditions

Tree tops will be left on site creating fine and coarse woody material which is beneficial to a variety of insects and for nutrient cycling. Songbirds may take advantage of the canopy openings to forage for insects and other foods. Over time, production of acorns and other mast for wildlife will likely increase on retained legacy trees within the project area.

The Massachusetts Department of Fisheries and Wildlife (DFW) conducted a deer browse survey of the state forest in 2016. The general level of forest health and impacts from deer browsing were classified as moderately impacted with some areas showing little or no impact.

The Landscape Designations for DCR Parks & Forests: Selection Criteria and Management Guidelines propose maintaining a minimum of a least 256 cubic feet of down coarse woody material. There is an estimated 316 cubic feet of coarse woody material per acre existing on the ground. This material is greater than three inches in diameter and three feet in length. Down woody material decomposes slowly, making it a long-term source of nutrients. Large pieces of down woody material, dead logs, serve as a seed bed for tree and plant species (Evans & Kelty 2010). Dead down woody material provides essential hiding and foraging habitat for at least 50 vertebrate species in New England (DeGraaf et al. 2006). Examples include: many salamanders, snakes, voles, shrews, and mice.

The hardwoods prevalent in the project area provide hard mast (acorns, hickory nuts), nesting structures, and snags required by wildlife species such as squirrels, blue jays (*Cyanocitta cristata*) and owls. Mast and fruits are high energy foods required by many wildlife species, including many species of migrating songbirds where high energy sources are of key importance during fall migration. Shrub cover provides essential breeding and feeding cover for species that utilize this vertical layer of habitat, including many songbirds and small mammals, such as Eastern Towhees, Deer mice (*Peromyscus maniculatus*), and Ruffed grouse.

Throughout the stand there is an average of 42 snags per acre, with the majority being oak species. Snags help maintain populations of wildlife that require cavities. Snags grow lichen, mosses, and fungi which many small mammals forage. Slash from the project provides low canopy hiding and nesting cover for songbirds and small mammals, such as hermit thrushes (*Catharus guttatus*) and rabbits. Slash also protects seedlings from browsing damage by deer when deer density exceeds levels where damage occurs.

The project area is not within priority habitats of rare species as those published in the current 14th Edition of the Massachusetts Natural Heritage Atlas.

Water Resources

No wetland resources occur in the project area. A forested wetland and two potential vernal pools exist just to the northeast of the project area. A potential vernal pool exists just to the west of the project area. These vernal pools will be protected to filter strip standards of the "Massachusetts Forestry Best Management Practices Manual" as needed. The proposed timber harvest area is not within 100 feet of a certified vernal pool according to the Natural Heritage & Endangered Species Program (NHESP) datalayer downloaded August 11, 2017 available from MassGIS.

Recreational and Aesthetic Resources

Cross-country skiing, geocaching, hiking, horseback riding, hunting, mountain biking, seasonal motorcycle riding, and snowmobiling, occur in F. Gilbert Hills State Forest. There are 23 miles of trails. A portion of the Warner Trail runs through the state forest. The Warner Trail is a long-distance trail starting in Sharon Massachusetts and travels more than 30 miles southwest to Cumberland, Rhode Island.

The State Forest is supported by the State Forests Advisory Council. The council's mission statement is to assist the State Forest staff to maximize the recreational uses of the F. Gilbert Hills, Franklin and Wrentham State Forests.

A paved road and two forest roads are located within the proposed project area (see logging plan). The proposed forest management project will reduce the number of dead and dying trees that could potentially impact safe travel on High Rock Road and the adjacent forest roads. There will be minimum impact to recreational activities within the state forest. In the final report of the Technical Steering Committee of the Forest Futures Visioning Process, scenic roads in Woodlands were recommended to have management guidelines to protect their integrity and scenic quality. High Rock Road is not a designated scenic road.

Forest Protection Concerns

The 2016 and 2017 Gypsy moth (*Lymantria dispar*) larvae feeding seasons were heavier than in previous years, and along with Winter moth (*Operophtera brumata*) the oak species within the project area and the state forest have had major defoliation. Winter moth and Gypsy moth are non-native species.


Jon Yuschock, Bugwood.org

Tree species diversity, age class distribution, and overall health and vigor of forests and trees are affected by gypsy moth defoliation. During outbreaks, gypsy moth caterpillars often completely consume host tree foliage, causing trees to expend energy reserves to produce new leaves. Repeated defoliations in subsequent years weaken trees, leading to extensive areas of dieback and mortality, which permit other tree and plant species (including invasive plants) to grow and change the overall characteristics of the affected area. Oak species are the most highly favored hosts of the gypsy moth, and the impacts of gypsy moth outbreaks and defoliation on forest condition are

particularly dramatic in oak-dominated forests (Fajvan and Gottschalk, 2012). Mortality, growth decline, and reduction in wood quality are occurring in the project area.

Evaluation of Data and Projected Results

Objectives

Due to the recent gypsy moth outbreaks, and along with stress from last year's drought, many of the large diameter oak trees have died. Approximately 28% of the sawlog quality oak trees have died since last summer. As a result, snags per acre went from 16.9 trees per acre in 2016, to 45.2 trees per acre in 2017 (Table 4). All new snags were oak species. These standing dead trees pose a hazard to public safety along High Rock Road and the two forest roads travelling through the project area. This portion of the state forest was impacted more than other parts of the state forest. As a result of the sawlog quality trees dying from gypsy moth, many will have to be salvaged as firewood instead of providing sawlogs. Gypsy moths will most likely continue to impact the project area, and the state forest, on some level in the next few years, further impacting the oaks. Many of the oaks still alive have reduced crowns and dead limbs.

Table 4 - snags

Species	Snags/acre
black oak	15.6
eastern white pine	0.8
northern red oak	26.2
Red cedar	1.3
white oak	1.3
total	45.2

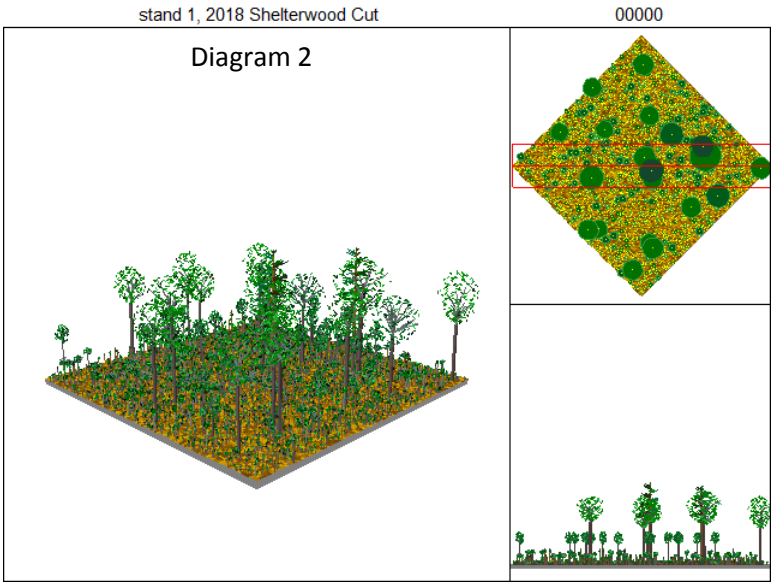
The primary silvicultural goal is to establish oak regeneration. Very little oak regeneration is occurring in the project area. The vast majority of overstory oak trees are red and black oak, but no regeneration of these two species is progressing past the seedling stage (Table 2). A secondary goal is to increase the structural diversity of the forest. The understory is lacking for all species. A third goal is the demonstration of a shelterwood with reserves system. The project area will be managed for oaks species in a two-aged class structure. The majority of the large oak trees will be harvested. A mixture of small, medium, and large trees of various other species will be harvested. Scarification will occur to encourage germination and survival of oak seedlings.

Silvicultural Prescription

The forest in the project area is even aged consisting mostly of oak species and lesser amounts of hickory, eastern white pine, red maple and black birch. The project area will be managed to favor the development of the more vigorous oak trees through their release from competition. Many oak trees that remain alive have poor crown development and are at a high risk of dying. These trees have had multiple gypsy moth infestations, have had to refoliate several years in a row, and have low levels of reserved carbohydrates. The dead trees pose a safety hazard along High Rock Road and the two forest roads and will be removed. Trees that are leaning or within 12 feet of High Rock Road will also be removed to increase public safety and allow for maintenance along the road shoulder. Due to the uneven mortality of the oak species, due to the gypsy moth, large gaps will occur between retained trees. Tree species located within the project area will be selected for cutting due to their potential to reduce competition, increase growth on larger trees, increase mast production and to increase public safety. Trees that are suppressed, of poor vigor, showing signs of decay or disease, and have smaller crowns will be targets to favor remaining canopy trees with large crowns and better form. The silvicultural operation will take the project area down to a total stand level of approximately 40 ft^2 /acre. All slash will be disposed of according to the Massachusetts Slash Law. The project area will be thinned in between openings. Large tree distribution will be for the most part a dispersed distribution where individual trees are scattered across the stand area. An aggregate distribution may occur in areas with unique features, i.e. areas with large diameter trees, rocky outcrops, or patch of snags. Scarification will occur through the normal process of log skidding to encourage acorns to grow. Removing existing competition from large living oak trees that have healthy crowns will help increase production of acorns for a variety of animals and lessen stress to increase vigor to help combat any future insect infestations.

Leaving the high number of dead trees would pose a safety hazard to firefighters responding to a wildfire within the project area, as well as having an increased fuel load. At least 5 snags/acre will be retained, which is the standard per the DCR Management Guidelines (2012).

The shelterwood with reserves silvicultural system is an even-aged (two-age) regeneration method where some trees are left to provide sufficient shade (shelter), provide seed, and to produce a new age class in a moderated environment. The long term development of the stand differs from a traditional shelterwood in that a set of mature trees (reserves) are retained for a substantial period while the new age class grows up around them. The set of mature trees retained will be well formed, dominant trees with large crowns. Hickory will be favored due to its wildlife benefits. A representation of what the project area may look like upon completion of the prescribed harvest is shown in diagram 2.



The silvicultural treatment fits many of the directives of the DCR Management Guidelines (2012) for Woodlands by: providing locally grown forest products to the local economy; creating a more diverse forest structure that is resilient to disturbance; sequesters carbon in retained overstory trees, permanent forest products produced from the harvest, and in the vigorous regenerating forest; and provides the conditions for early seral or regenerating forest that will support diverse species.

Desired and Expected Results

The long term desired condition of the stand is having the young oak trees approach the height of the reserve trees. By applying the shelterwood with reserves system aspects of a mature forest are maintained while still providing for timber production. The retention of a subset of mature trees will retain habitat elements of the mature forest (e.g. mast production, vertical structural diversity), lessen the visual impact of the shift in complete removal of overstory trees, and will retain trees to produce large diameter older trees. The retention of legacy trees will also serve as future late-successional structure as they are left to grow, develop into snags, fall over and become large downed logs (D'Amato and Catanzaro 2009). The shelterwood with reserves approach can provide beneficial habitat for various wildlife species of conservation concern in this region that benefit from even-aged regeneration harvesting such as whip-poor-will, Eastern towhee, brown thrasher, Eastern hognose snake, and Eastern rat snake (see Table 4-13 on pg. 163 of the Massachusetts State Wildlife Action Plan).

If oak seedlings are being overtopped by other hardwood species, e. g. red maple and/or black birch, a prescribed burn will be conducted to release the oak from competition. A separate

prescribed fire plan will be written. Vigorous oak advance reproduction can develop under shelterwoods when managed with periodic fires (Dey, 2014). In a shelterwood with reserves system one or more removal cuts could follow this establishment cut. For example, when thinning the younger age class it may be possible to harvest the reserve trees in the openings created without substantial injury to the stand. The long term desired condition of the project area is the presence of healthy stems with large crowns providing mast for wildlife and a source for regeneration. With the uncertainty of future gypsy moth impacts, as well as an existing vulnerability to other pests and pathogens, the oak species may still decline and die.

Logging System Requirements

The harvesting of this project area can be accomplished with a variety of logging equipment safely, efficiently and effectively. Both mechanized and conventional felling systems will be allowed. Timber harvesting equipment will be restricted to its ability to process up to 4" tops. There will be no whole tree harvesting. Skidding will be permitted to provide scarification for oak regeneration. Hand felling of trees will be permitted provided proper directional felling techniques are used to protect residual trees and any cultural resources.

A skidder will be permitted to move product from the stump to the landing. Skidding length of stems and weight of forwarder loads can be restricted based on equipment size as well as operator ability to protect residual trees and roads/trails.

Preliminary landings have been located (see logging plan). Prior to leaving the sale, all landings will be smoothed, logging residue will be moved into the woods, and the landings will be seeded. Access to the proposed project area will be from State Route 1 (Washington Street) in Wrentham then to High Rock Road. Work will begin in the rear of each section and move towards the landing.

Primary skid trails have been identified (see logging plan). Since no record of harvesting exists, and no previous skid trails were located during the stand exam, the installation of all interior skid trails will be required. Skid trails will be marked prior to the start of harvesting activities, and it is understood that minor changes to the routes may be required during the course of logging operations. All proposed changes will be reviewed on a case-by-case basis by the forester-in-charge and/or Program Supervisor as required. Prior to the leaving the harvest areas all skid trails will have water bars installed, and excess disturbance will be mitigated. Upon completion of all harvesting activity all skid trails will be left in a stable state and water bars will be installed according the "Massachusetts Forestry Best Management Practices".

The sale may allow the installation of a gate and small parking area for recreational use at the eastern most proposed landing on High Rock Road through in-kind services. Signs will be displayed to make the public aware of the sale area during the project. High Rock Road will be closed for the duration of the project.

Prescription Documentation

Timber Marking Guidelines

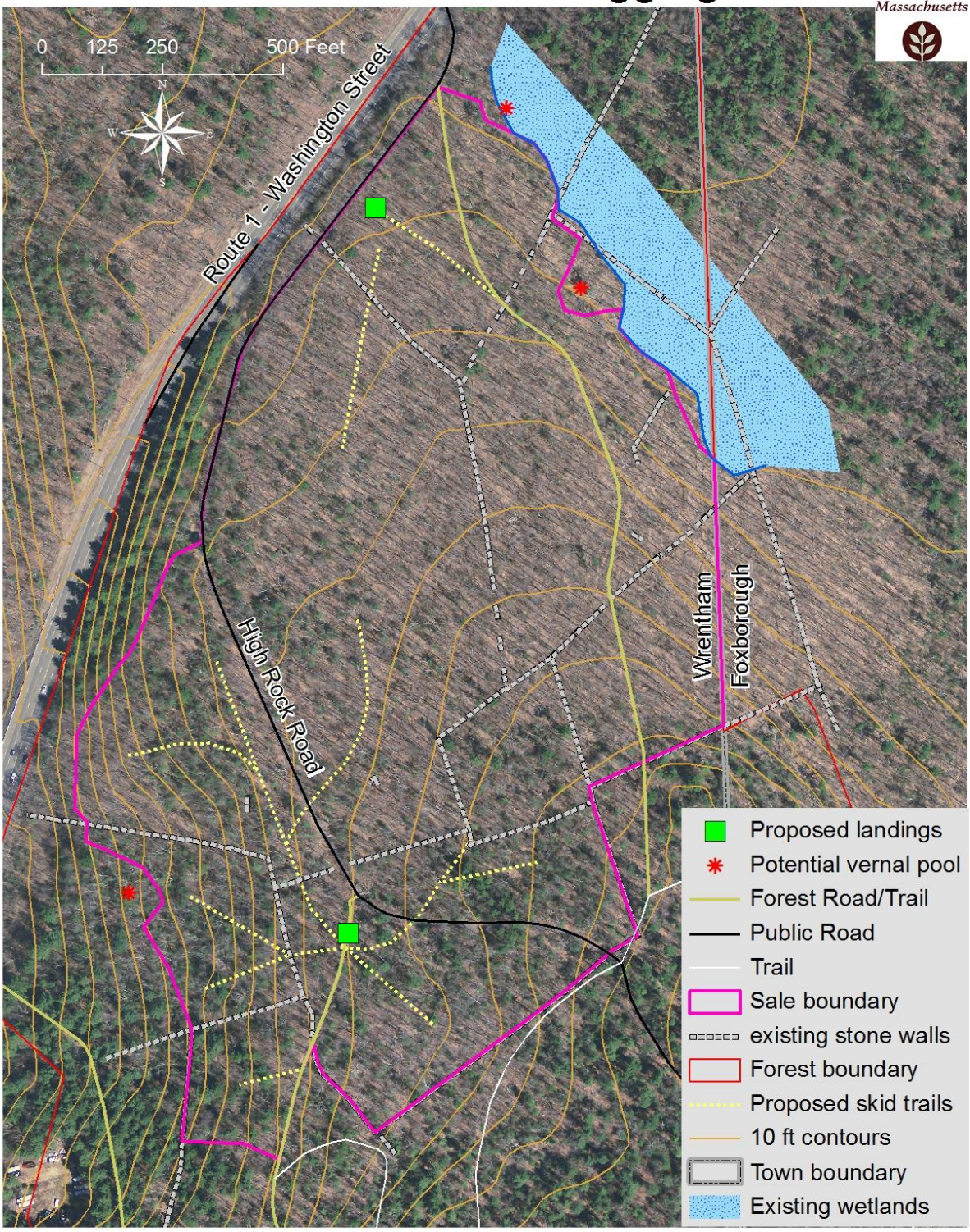
Tree marking is a management tool that allows foresters to achieve multiple benefits, such as maintaining an aesthetic appearance, providing habitat for wildlife, and maintaining and creating structural diversity. Trees will be designated for removal with the "Take Tree" marking method. Trees to be cut and/or removed will be marked/painted at breast height and stump. All other trees will be retained.

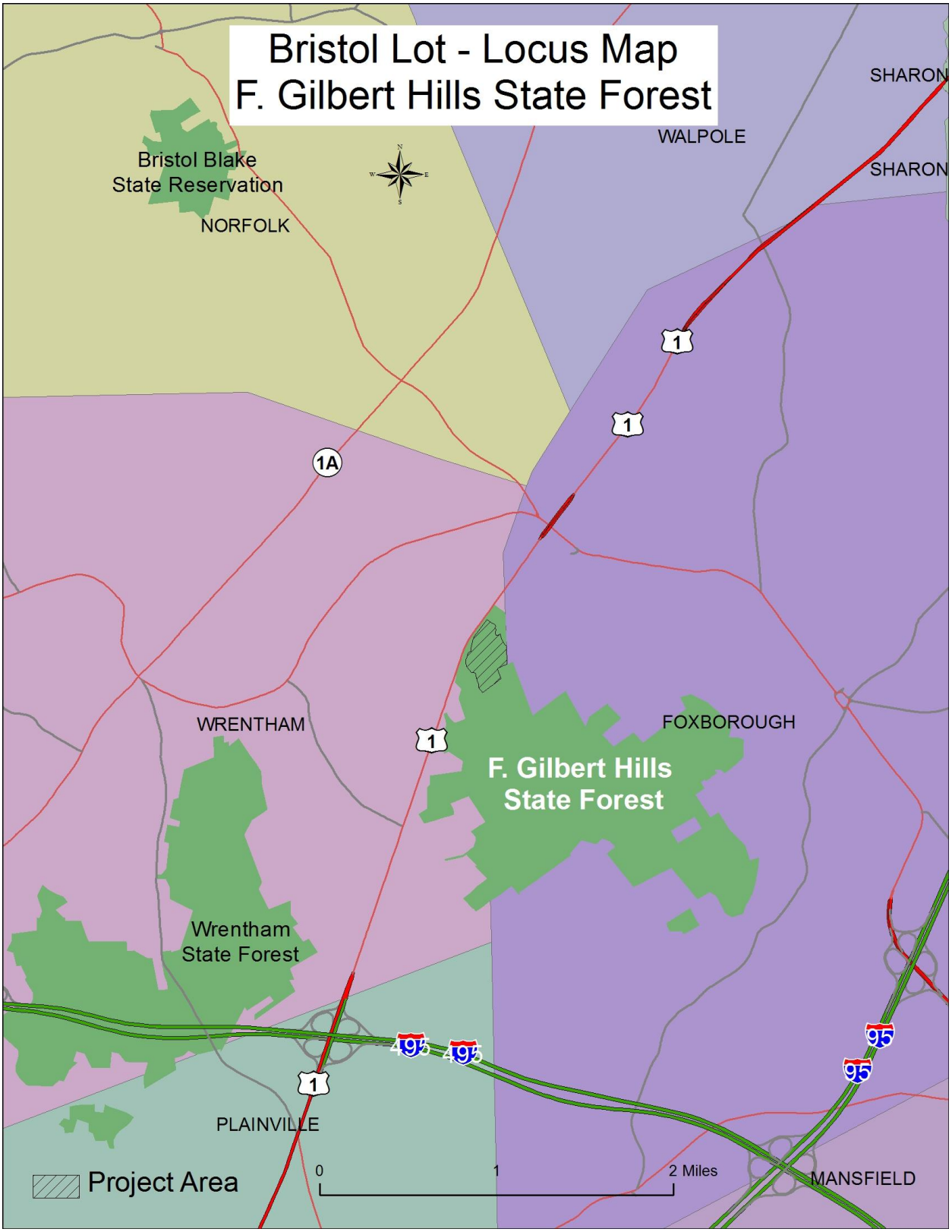
Sawtimber with be marked with a horizontal line around the bole in blue paint. Firewood and pulp will be marked with a vertical line on a least two sides in blue paint. Trees less than 5 inches in diameter at breast height to be cut will be marked with a blue dot. The boundary of the forest management project will be marked by three diagonal stripes in blue paint. Boundary trees will be cut. All trees to be cut will have a stump mark in blue paint. The stump mark is to ensure only marked trees are being cut. Proposed skid trails will be marked with a vertical line in red paint and red flagging, signifying the centerline of the skid trail. Bumper trees will be marked with a "B" in red paint. Trees to be saved for wildlife will be marked with a "W" with white paint to unsure their protection throughout harvesting operations. Pink "Wetland Delineation" flagging defines the wetland just outside the project area.

Reduce basal area to approximately 40 ft^2 /acre based on existing conditions, including tree health, crown class, form and vigor. Residual density may remain higher in areas with acceptable growing stock and lower in areas with high snag density. Well formed mature dominant oak species with large crowns will be retained as a seed source and a subset will serve as reserve trees in future operations. Healthy hickory will be favored for its wildlife value and being less preferred by gypsy moth. Non-oak and non-hickory species directly competing will be favored for cutting. Unacceptable red maple, black birch, and white pine will be favored for cutting. Oak species with poor crowns will be cut. All trees leaning or within 12 feet of High Rock Road will be cut for public safety. Standing dead trees within a tree length of High Rock Road and the two forest roads will be removed. Retain large diameter snags for their wildlife value as cavity and den trees as safe operating conditions will allow. Standing dead trees will be cut to reduce fire danger. Retain at least 5 snags/acre. Protect tree species of low occurrence including dogwood, muclewood, and hop-horn beam.

Bristol Lot Timber Harvest Logging Plan

dcr Massachusetts




Bristol Lot - Locus Map
F. Gilbert Hills State Forest
Bristol Blake
State Reservation
NORFOLK
WALPOLE
SHARON
SHARON
1
1
1A
WRENTHAM
1
FOXBOROUGH
F. Gilbert Hills
State Forest
Wrentham
State Forest
95
95
95
95
1
PLAINVILLE
MANSFIELD
Project Area
0
1
2 Miles

References

D'Amato, A.W. and P.F. Catanzaro. 2009. *A Forest Manager's Guide to Restoring Late-Successional Forest Structure*. UMass Extension publication. Amherst, MA.

DeGraaf, R.M., Yamasaki, M., Leak, W.B., Lester, A.M. 2006. *Technical Guide to Forest Wildlife Habitat Management in New England*. Burlington, Vermont. University of Vermont Press.

Dey, D.C. 2014. *Sustaining Oak Forests in Eastern North America: Regeneration an Recruitment, the Pillars of Sustainability*. Forest Science, 60(5):926-942.

Evans, A.M. & Kelty, M.J. 2010. *Ecology of Dead Wood in the Northeast.* The Forest Guild, Santa Fe, NM.

Fajvan, M. A. & Gottschalk, K.W. 2012. *The Effects of Silvicultural Thinning and Lymantria dispar L. Defoliation on Wood Volume Growth of Quercus spp*. American Journal of Plant Sciences, 3, 276-282.

Forest Guild Biomass Working Group. 2010. *Forest Biomass Retention and Harvesting Guidelines for the Northeast.* The Forest Guild, Santa Fe, NM.

Goodwin, D.W. and W.N. Hill. 2012. Forest Productivity and Stand Complexity Model [A GIS Grid Analysis using ArcGIS®]. Massachusetts Department of Conservation and Recreation, Amherst, MA.

Griffith, G.E., Omernik, J.M., Bryce, S.A., Royte, J., Hoar, W.D., Homer, J.W., Keirstead, D., Metzler, K.J., and Hellyer, G., 2009, Ecoregions of New England (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,325,000).

Smith, D.M., Larson, B.C., Kelty, M.J., Ashton, P.M.S. 1997. *The Practice of Silviculture Applied Forest Ecology Ninth Edition*. John Wiley & Sons. New York, New York.

Web Soil Survey, Natural Resources Conservation Service, United States Department of Agriculture. Available online at http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspxv . Accessed [8/2017].

Swain, P.C. and J.B. Kearsley. 2011. *Classification of the Natural Communities of Massachusetts. Version 1.4.* Natural Heritage & Endangered Species Program, Massachusetts Division of Fisheries and Wildlife. Westborough, MA.

Massachusetts Department of Conservation and Recreation. 2012. *Landscape Designations for DCR Parks & Forests: Selection Criteria and Management Guidelines*. Massachusetts Department of Conservation and Recreation, Boston, MA.