dcr
Massachusetts

Massachusetts Department of Conservation and Recreation
Vegetation Survey Report
Blue Hills Reservation
March 2016

Background

The Blue Hills Reservation was established in 1893 by the Metropolitan Park Commission and offers opportunities for natural recreation in the largest protected open space, approximately 6,161 acres, in metropolitan Boston. The Blue Hills is physically large and is characterized by a range of East-West oriented hills. The tallest of these, Great Blue Hill, is the highest point in the metropolitan Boston area. Granite and other volcanic cliffs and ridge tops provide recreational opportunities for visitors and habitat for plants and wildlife. The reservation's soils vary with topography and location. Shallow, rocky, nutrient-poor soils are found on hilltops and steep slopes. Deeper, richer soils are common to the gentle slopes, valleys, and depressions among the hills. They are also common in level sections of the reservation. Much of the Blue Hills is within the Weir River Watershed and serves as a recharge area for Great Pond Reservoir; the water supply for the towns of Braintree, Holbrook, and Randolph. Portions of the Blue Hills have been designated as Outstanding Resource Waters.

Approximately 770 species of plants have been recorded on the Blue Hills Reservation and adjacent areas in recent decades. Three plants and 17 animal species are currently protected under the Massachusetts Endangered Species Act (MESA). Over 75% of the Blue Hills Reservation has been designated Priority Habitat. Twenty natural communities, 11 terrestrial and nine palustrine (i.e., non-tidal freshwater), have been identified, 5 of which are of statewide or global significance and are tracked by the Natural Heritage Endangered Species Program (NHESP). The five priority Natural Communities that have been mapped in the Reservation are Acidic Rocky Summit/Rock Outcrop Community, Acidic Talus Forest/Woodland, Atlantic White Cedar Bog, Level Bog, and Ridgetop Pitch Pine-Scrub Oak Community. The majority of the Blue Hills, approximately 89%, is forested uplands. This forest is a mosaic of forest types, characterized by a variety of oaks in combination with variable mixtures of eastern white pine, hickory, or hemlock. Wetlands account for 11% of the Blue Hills' land cover. Forested wetlands (8% of land cover) are dominated by either Atlantic white cedar or red maple communities. Non-forested wetlands (3% of land cover) are dominated by shrubs or herbaceous vegetation. There are approximately 65 Certified Vernal Pools and many more potential vernal pools in the Reservation. Cultural grasslands account for 5% of land cover. MassWildlife has identified four blocks of interior forest, totaling approximately 738 acres. These blocks are areas where forest cover is relatively unfragmented by human development. An old European larch plantation exists on Buck Hill. Remnants of red pine plantations are present on the southern slopes of Chickatawbut, Fenno, and Kitchamakin hills. Most of these pines are dead or senescent.

The Ponkapoag Pond, the immediate area surrounding the pond, and the Little Blue Hill area are part of the Fowl Meadow and Ponkapoag Bog Area of Critical Environmentally Concern. It was designated in 1992. Areas of Critical Environmental Concern (ACECs) are places in Massachusetts that receive special recognition because of the quality, uniqueness and significance of their natural and cultural resources.

A Resource Management Plan (RMP) was adopted by the DCR Stewardship Council on April 1, 2011, and included the Blue Hills Reservation and the Ponkapoag Golf Course. One of the high priority recommendations in the RMP was the Massachusetts Department of Conservation and Recreation "work with the Massachusetts Division of Fisheries and Wildlife (DFW) to conduct a study of white-tailed deer populations within the Blue Hills Reservation and to ascertain the extent of their impacts on the Reservation's natural resources." On October 14, 2015 DCR and the Massachusetts Division of Fisheries and Wildlife (DFW) approved a deer management plan for the Blue Hills Reservation. This vegetation survey report endeavors to determine the impact white-tailed deer are having on the Reservation's natural resources.

Purpose

The objective of this vegetation survey was to report on the current status of the regeneration occurring in the upland portions of the Blue Hills Reservation to gain insight into the species diversity and abundance for the forest's upland ground layer.

Past/Comparable Studies

In 1974 a woodland examination was conducted in the Blue Hills Reservation by The New England Forestry Foundation. It discusses the different forest types and size classes in the Reservation and proposes thinning operations in a few sections of the Reservation. Other recommendations include timber stand improvement, wildlife plantings, and educational programs funded through the thinning operations. No mention of the ground cover was given.

In 1984 and 1985 a vegetation inventory was conducted in the Blue Hills Reservation (Eck, 1985). In 1984 a Reservations and Historic Sites Unit was formed, among other goals, to provide active management of the natural and cultural resources of the Reservations, in order to improve their appearance and value and preserve them for future generations.

The Blue Hills Reservation was compartmentalized into forest stands with specific stand information on fuel load, understory, ground cover, overstory and snags. General site location collected included tree size class, forest type, slope, aspect, drainage class, potential stand management objective, and stand health class. The study divided the Reservation into 7 compartments with a range of 200 acres to 1300 acres, with an average of 800 acres. Aerial photographs and a stereoscope were used to stratify compartments into various forest cover types. 1 nested plot for every 10 acres was used for the sampling intensity, with stands less than 50 acres receiving 5 nested plots. The nested plot included one fuel load plot, one understory plot, two ground plots,

one overstory plot, and one 20th acre plot (snag plot). At the end of the second field season over 600 nested plots (over 3,600 different plots) were completed. Both uplands and wetlands were sampled.

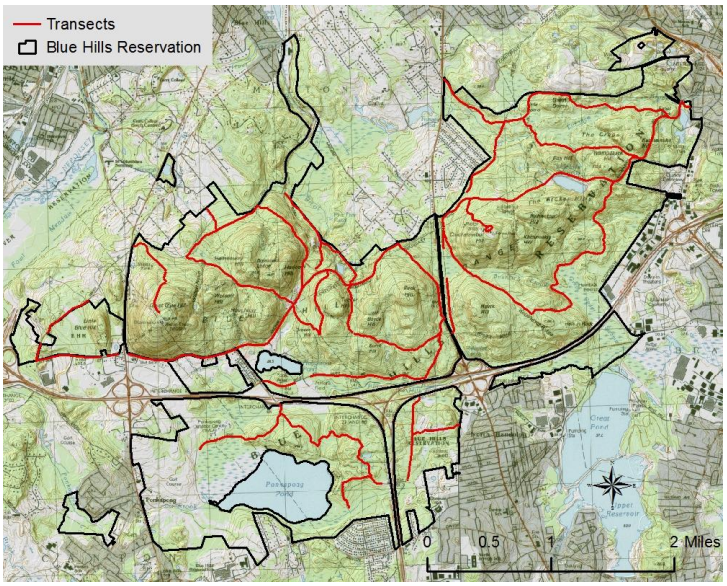
In 1989 a study was conducted on the Quabbin Reservoir (Kyker-Snowman, 1989) to assess the adequacy of forest regeneration given large areas were heavily browsed by white-tailed deer. Data was collected from 796 1/1000th acre plots. Data collected at each plot included: distance from legal hunting, overstory composition an size, disturbance type (if any) and age, total number of stems less than one foot in height, species and height class (1' to 4.5' or 4.6' to 1" diameter at breast height (dbh)) for all other stems one foot in height to one inch in dbh.

Location

The Blue Hills Reservation is located in the towns of Braintree, Canton, Milton, and Randolph, and the city of Quincy.

Methods

The vegetation sampling involved four hundred 1/1000th acre ground cover plots (3.72' radius). Sampling transects (roads and trails of the Reservation) were aligned with the transects used by DFW in their Estimating White-tailed Deer Abundance at the Blue Hills Reservation using Distance Sampling technical report, November 2013.



Plots were established randomly up to 300 feet perpendicular from the edge of DFW transects to correspond to DFWs sampling distance from their transects. Distances between starting points along transects were random from 0 feet to 750 feet. Starting points were established in GIS and located in the field using GPS. Plots were established from the starting points using a compass and tape. Plot were randomly choose to go left or right off of DFW transects to cover more area than by sampling on both sides from the same starting point. If a plot contained a portion of a trail, a new random distance was taken. We did not sample along DFW transects that went through wetlands, fields, or golf course as we were concerned with sampling in upland forest types. We added a transect northeast of Ponkapoag Bog as we felt this area was underrepresented. In total, the length of transects was 28.3 miles with a total of 400 plots completed. We conducted sampling from July to September 2015.

Data collected within each plot included: Sub-type, size class, stand structure, slope, aspect, basal area, disturbance (if any) and age, total number of tree stems by species and height class (0 to 1', 1' to 2', 2'to 3', and 3' to 4.5', greater than 4.5" up to 1"dbh, 1" dbh to 5" dbh). Herbaceous and shrubs were recorded by percent cover to the nearest 10% coverage class. Herbaceous plants were classified into graminoids (grasses, sedges and rushes); forbs; ferns and fern-allies; vines; and mosses. For the most part, forbs, ferns and fern-allies, and vines were recorded to the species level, whereas due to time constraints graminoids and mosses were not.

Results

Number of tree stems in various classes and by species are summarized in the following graphs and associated tables. They are followed by frequency of occurrence of the regeneration, and various tables relating to stocking, size class, structure, shrubs, and the herbaceous layer.

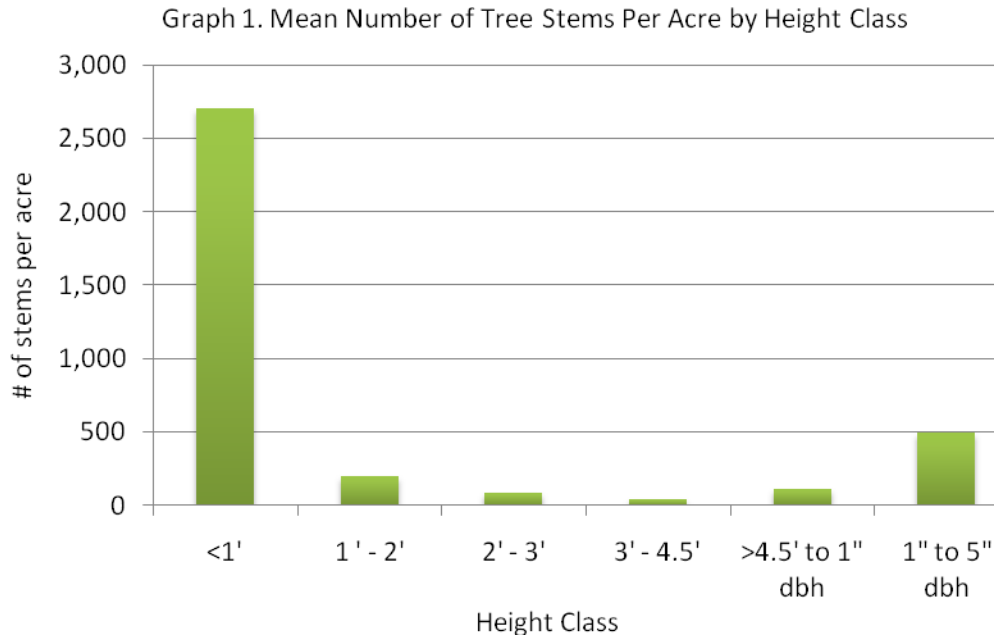


Table 1. Mean Number of Tree Stems per Acre by Height Class.

Height Class	Mean number of stems per acre
<1'	2,705
1' - 2'	197.5
2' - 3'	82.5
3' - 4.5'	40
>4.5' to 1" dbh	112.5
1" to 5" dbh	495

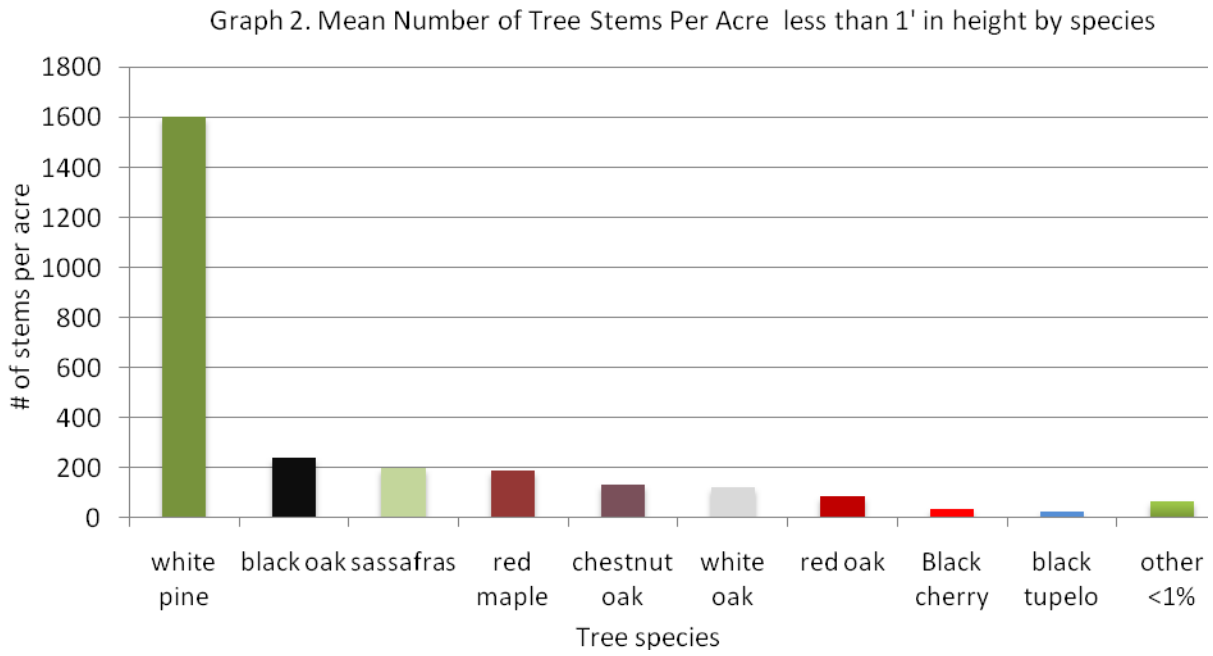


Table 2. Mean Number of Tree Stems per Acre less than 1 foot in height by species.

Tree species	Mean number of stems per acre	% total
white pine	1,605	59%
black oak	240	9%
sassafras	197.5	7%
red maple	187.5	7%
chestnut oak	132.5	5%
white oak	125	5%
red oak	87.5	3%
Black cherry	37.5	1%
black tupelo	27.5	1%
other <1% each	65	2%

Other: black birch, sugar maple, yellow birch, white ash, American chestnut, eastern red cedar, hickory, eastern hemlock, and hop hornbeam.

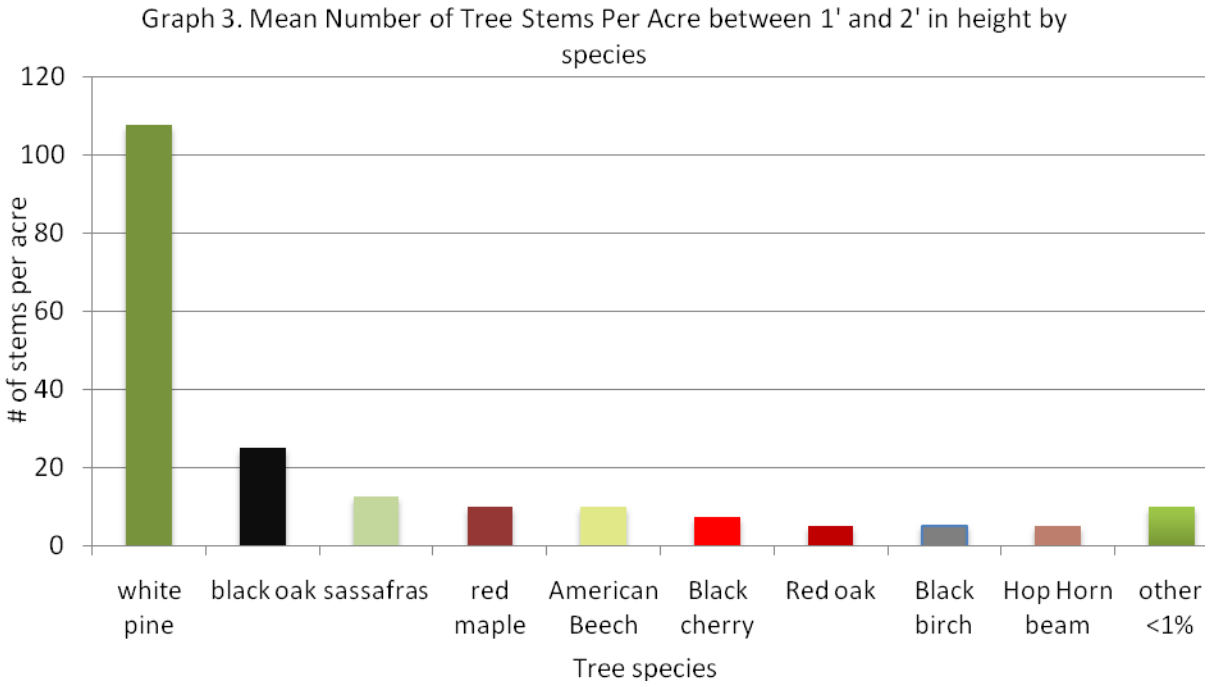


Table 3. Mean number of Tree Stems per Acre between 1 and 2 feet in height by species.

Tree species	Mean number of stems per acre	% total
white pine	107.5	54.43%
black oak	25	12.66%
sassafras	12.5	6.33%
red maple	10	5.06%
American Beech	10	5.06%
Black cherry	7.5	3.80%
Red oak	5	2.53%
Black birch	5	2.53%
Hop Horn beam	5	2.53%
other <1% each	10	5.06%

Other: Chestnut oak, white oak, American chestnut, and big tooth aspen.

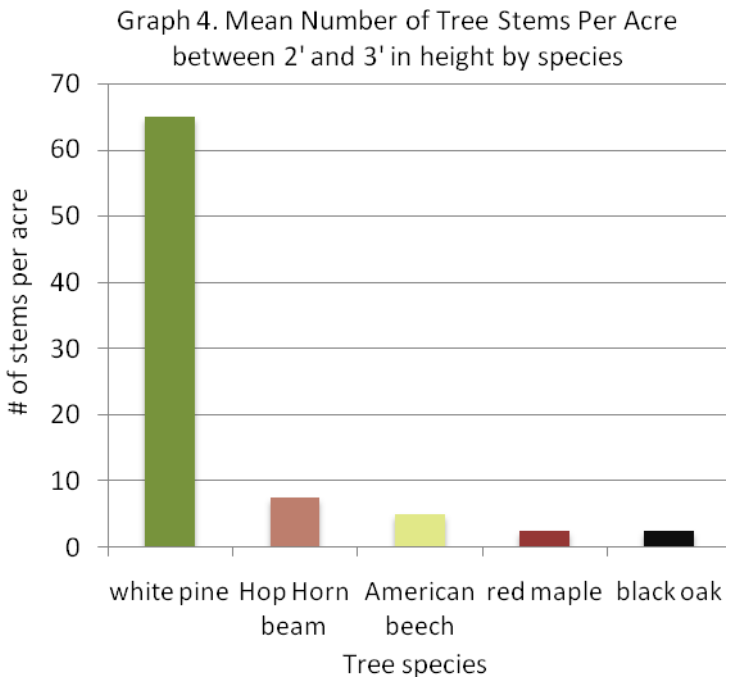


Table 4. Mean number of Tree Stems per Acre between 2 and 3 feet in height by species.

Tree species	Mean number of stems per acre	% total
white pine	65	78.79%
Hop Horn beam	7.5	9.09%
American Beech	5	6.06%
red maple	2.5	3.03%
black oak	2.5	3.03%

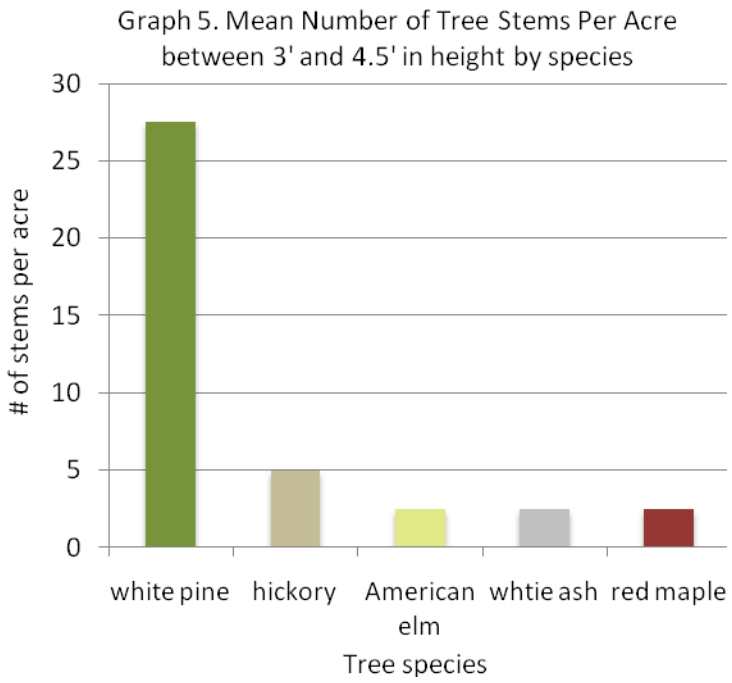


Table 5. Mean number of Tree Stems per Acre between 3 and 4.5 feet in height by species.

Tree species	Mean number of stems per acre	% total
white pine	27.5	68.75%
hickory	5	12.50%
American elm	2.5	6.25%
white ash	2.5	6.25%
red maple	2.5	6.25%

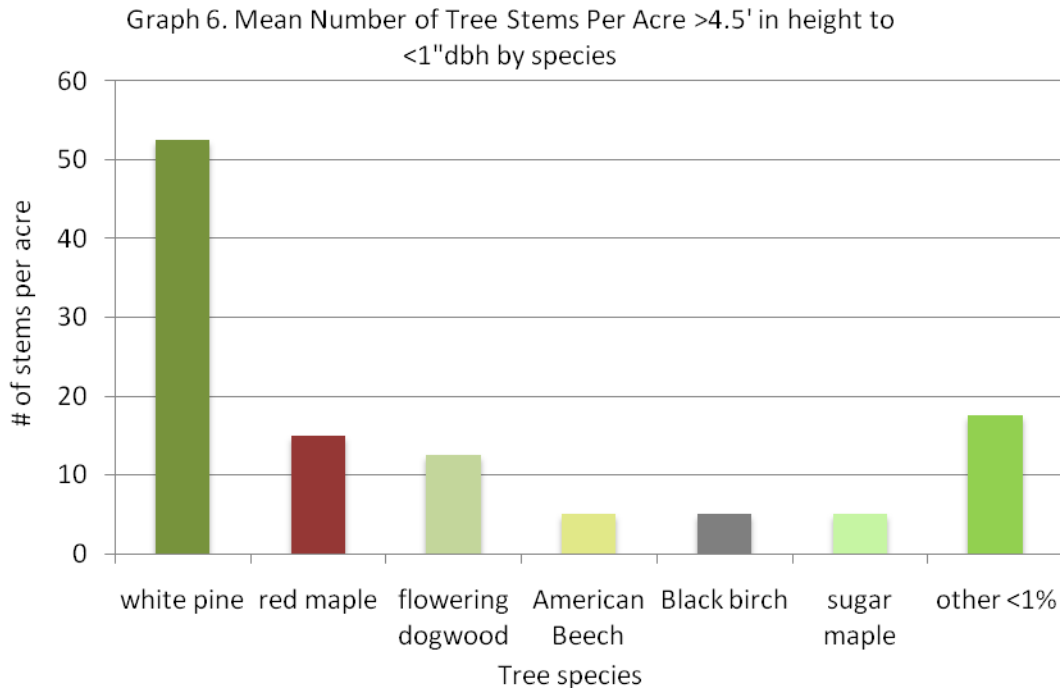


Table 6. Mean number of Tree Stems per Acre greater than 4.5 feet in height to less than 1" dbh by species.

Tree species	Mean number of stems per acre	% total
white pine	52.5	46.67%
red maple	15	13.33%
flowering dogwood	12.5	11.11%
American Beech	5	4.44%
Black birch	5	4.44%
sugar maple	5	4.44%
other <1% each	17.5	15.56%

Other: white oak, black oak, yellow birch, black cherry, hickory, American elm, and hop hornbeam.

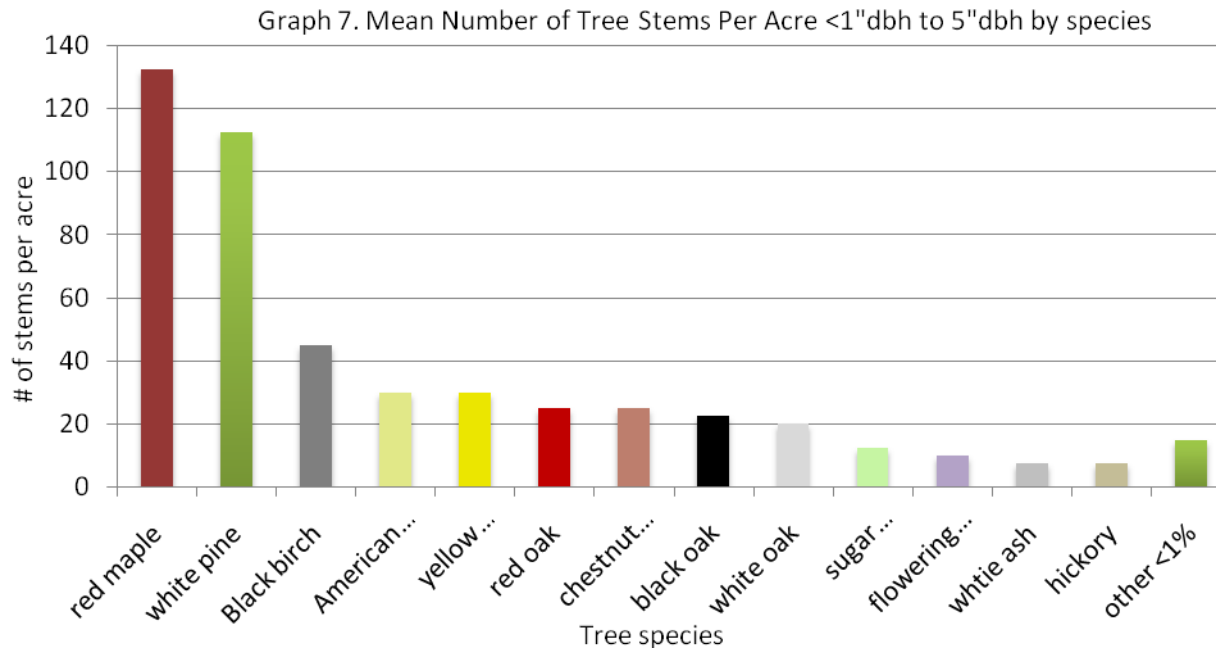


Table 7. Mean number of Tree Stems per Acre between 1” and 5” dbh by species.

Tree species	Mean number of stems per acre	% total
red maple	132.5	26.77%
white pine	112.5	22.73%
Black birch	45	9.09%
American beech	30	6.06%
yellow birch	30	6.06%
red oak	25	5.05%
chestnut oak	25	5.05%
black oak	22.5	4.55%
white oak	20	4.04%
sugar maple	12.5	2.53%
flowering dogwood	10	2.02%
white ash	7.5	1.52%
hickory	7.5	1.52%
other <1% each	15	3.03%

Other: black cherry, American chestnut, Norway spruce, eastern hemlock, American hornbeam, and hop hornbeam.

Table 8. Mean number of Tree Stems per Acre between 1’ and 1” dbh.

Tree species	number of stems per acre	% total
white pine	252.5	58.38%
black oak	30	6.94%
red maple	30	6.94%
American Beech	20	4.62%
Hop Horn beam	15	3.47%
sassafras	12.5	2.89%
flowering dogwood	12.5	2.89%
Black birch	10	2.31%
Black cherry	10	2.31%
hickory	7.5	1.73%
red oak	5	1.16%
white oak	5	1.16%
sugar maple	5	1.16%
American elm	5	1.16%
other <1% each	12.5	2.89%

Other: chestnut oak, yellow birch, white ash, American chestnut, and big tooth aspen.

Table 9. Frequency of Occurrence of Regeneration 1 ft in height to 1” dbh.

# stems/plot	# plots	% of total plots	cumulative %
0	306	76.5%	76.5%
1	65	16.3%	92.8%
2	16	4.0%	96.8%
3	6	1.5%	98.3%
5	2	0.5%	98.8%
6	2	0.5%	99.3%
7	1	0.3%	99.5%
10	1	0.3%	99.8%
19	1	0.3%	100.0%

Table 10. Mean number of Oak Stems per Acre by Height Class

Height class	Oak stems per acre
< 1'	585
1' to 2'	35
2' to 3'	2.5
3' to 4.5'	0
>4.5' to 1" dbh	5
1" dbh to 5" dbh	92.5

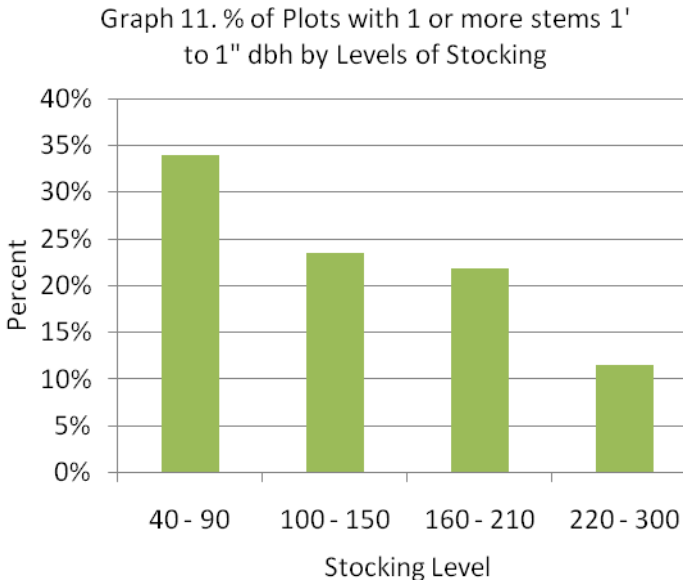


Table 11. Percent of plots on which one or more stems 1 foot to 1" dbh occurred, at different stocking levels.

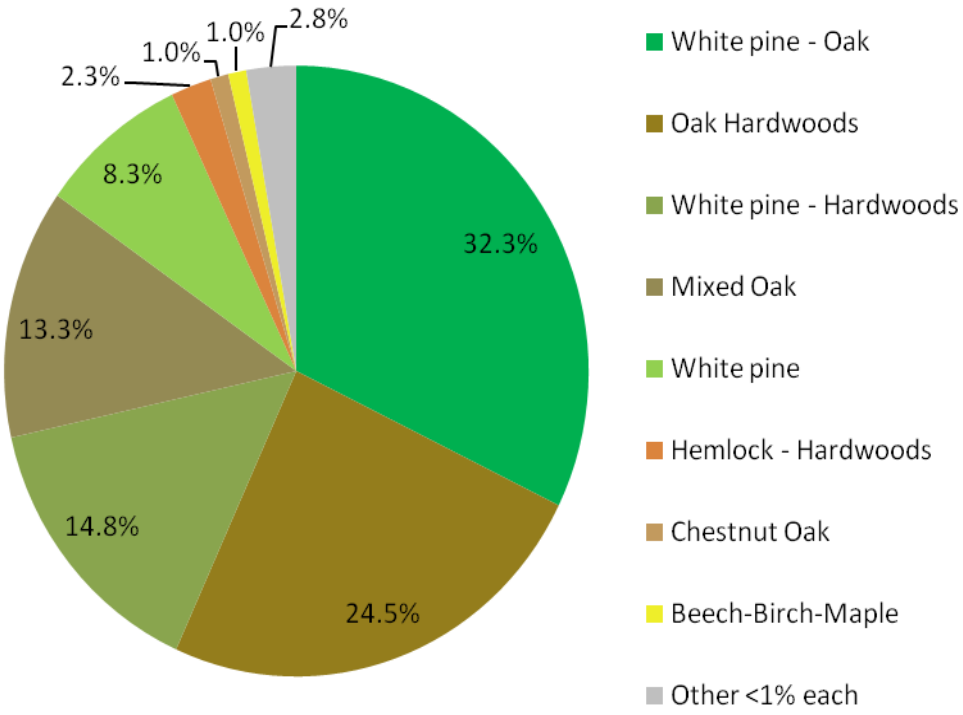
Stocking (BA)	# of plots	% with 1 or more stems
40 - 90	50	34%
100 - 150	196	23%
160 - 210	128	22%
220 - 300	26	12%

BA is basal area; the cross sectional area (in square feet) of tree stems at 4.5 feet (breast height) per acre, a measure of tree density.

Table 12. Percent of plots on which one or more stems 1” to 5” dbh occurred, at different stocking levels.

Stocking (BA)	# of plots	% with 1 or more stems
40 - 90	50	42%
100 - 150	196	32%
160 - 210	128	27%
220 - 300	26	19%

Chart 1. Percent of total plots at different subtypes.



Other: Northern red oak, Norway maple, red maple, American beech, white pine – hemlock, meadow, abandoned orchard

Table 13. Percent of total plots at different subtypes.

Subtype	# plots	% of total plots
White pine - Oak	129	32.3%
Oak Hardwoods	98	24.5%
White pine - Hardwoods	59	14.8%
Mixed Oak	53	13.3%
White pine	33	8.3%
Hemlock - Hardwoods	9	2.3%
Chestnut Oak	4	1.0%
Beech-Birch-Maple	4	1.0%
Other <1% each	11	2.8%

Other: Northern red oak, Norway maple, red maple, American beech, white pine – hemlock, meadow, abandoned orchard

Table 14. Number of plots by size class.

size class	# plots	% of total plots
sawtimber	303	75.8%
pole	87	21.8%
sapling	9	2.3%
not stocked	1	0.3%

Table 15. Number of plots by stand structure.

Stand structure	# plots	% of total plots
even double	182	45.5%
even single	171	42.8%
uneven	43	10.8%
mosaic	3	0.8%
non forested	1	0.3%

Table 16. Number of plots with shrubs and range by species.

Shrub	# of plots	Range (%)
Low bush blueberry	163	10-90%
Black Huckleberry	113	10-80%
Maple-leaf viburnum	59	10-30%
Wintergreen	29	10-20%
Witch hazel	28	10-90%
Glossy Buckthorn	24	10-30%
Sweet pepperbush	22	10-90%
Dangleberry	17	10-80%
Rubus sp.	12	10-80%
Spotted wintergreen	10	10%
Beaked hazelnut	6	10-20%
High bush blueberry	6	10-50%
Arrowwood	5	10%
Euonymus	4	10-90%
Serviceberry	3	10-30%
Multiflora rose	2	20-30%
Scrub oak	2	10-20%
Sweet fern	2	10%
Chokeberry	1	10%
Common buckthorn	1	70%
Fetterbush	1	20%
Hawthorn	1	10%
Maleberry	1	20%
Mountain laurel	1	10%
Pipsissewa	1	10%
Privet	1	70%
Silky dogwood	1	40%
Spicebush	1	10%
Winterberry	1	50%

Table 17. Number of plots with herbaceous plants and range.

Herbaceous Type	# of plots	Range (%)
Graminoids	100	10-90%
Forbs	229	10-50%
Ferns	64	10-90%
Vines	80	10-90%
Mosses	120	10-50%

Table 18. Number of plots with forbs by species.

Forbs	# plots
Canada mayflower	160
bellwort	59
sarsaparilla	55
starflower	26
wood nettle	12
unknown forb	5
lady slipper	3
Indian cucumber	2
goldenrod	2
cinquefoil	1
jack in the pulpit	1
clover	1
yellow hawkweed	1
downy rattlesnake plantain	1
clearweed	1
whorled loosestrife	1

Table 19. Mean Number of Tree Stems per Acre by Height Class at 80% power level, and 10% type 1 error.

Height Class	2015 mean	Re-sample mean	difference	% Change
<1'	2,705	3295	590	22%
1' - 2'	197.5	282	85	43%
2' - 3'	82.5	141	59	71%
3' - 4.5'	40	63	23	58%
>4.5' to 1" dbh	112.5	154	42	37%
1" to 5" dbh	495	596	101	20%

Conclusion

The mean number of trees stems per acre for the 6 height classes (graph 1, table 1), and associated species (graphs 2-7, tables 2-7), show the sharp decline of tree stems from the 1 foot height class. Eastern white pine is the dominant species in all height classes except for the 1" to 5" height class where red maple is the most prevalent. Oak species are low in all height classes despite 72% of the dominant overstory type having an oak component (chart 1, Table 13). The number of tree stems typically decreases with increasing height, mainly due to competition. In this case, however, the number of established stems (1" to 5" dbh height class) was greater than the number of stems in the smaller height classes (1'-2', 2'-3', 3' to 4.5', and >4.5' to 1" dbh). This may be attributable to an increase in deer browse over the last several years. The 1" to 5" dbh height class is above the browse of deer, whereas the lower height classes are not.

In comparison to the 1989 regeneration study in the Quabbin, the 2,705 stems in the <1" height class in the Blue Hills Reservation is considerably lower than 10,870 stems (<1" height class) in the areas not having deer management or any disturbance. Mature forests typically have 5,000 to 12,000 seedlings and saplings per acre (Ward et al., 2013). For all the height classes in the Reservation there were a total of 3,633 stems.

Combining the 1' to 2', 2' to 3', and 3' to 4.5' height classes in the Blue Hills Reservation gives a total of 320 stems per acre from 1' to 4.5', 280 stems in this combined height class were found in the Quabbin. The >4.5' to 1" dbh height class is also comparable between the Blue Hills Reservation and the Quabbin, with the Blue Hills Reservation having an average of 112.5 stems in this height class compared to 30 in the Quabbin study. The mean number of tree stems per acre by species for the combined 1' to 1" dbh height classes (Table 8) is similar to the Quabbin results with the exception of white pine.

In the 1985 Blue Hills Reservation Vegetation Inventory Report the ground cover density was between 2,000 and 28,000 stems per acre for the upland portion of the Reservation with an average of about 11,000 stems/acre. These numbers, however, include all woody stems (e.g. shrubs stems), not just tree stems. Due to the quantity of blueberries, huckleberries, and poison ivy in the 1984/1985 field seasons these woody plants were not individually tallied, but rather visually estimated by percent cover. We did not individually tally woody stems beyond trees stems due to time constraints.

Oak regeneration may be of concern. Some suggest oak regeneration is sufficient if there are more than 434 stems per acre greater than 4.5 in height (Kittredge and Ashton, 1995). Others indicate the greater than 4.5 in height is not necessary and smaller stems can be included (Hibbs and Bentley, 1983). Table 10 shows low number of oaks in all but the smallest height class. With the high number of deer present in the Blue Hills Reservation and oak being a highly preferred food source (Abrams, 1998), oak regeneration may not be sufficient to be a continual source for future canopy oak trees.

In the 1985 Blue Hills Reservation Vegetation Inventory Report, Eastern white pine was the most common overstory tree and was usually found growing with oak species. Although white pine adapts to a wide range of site conditions and is found throughout the Reservation, its abundance is also associated with the history of the Reservation. Thousands of white pine seedlings were planted by the Civilian Conservation Corps, Veterans Conservation Corps, and Metropolitan Parks Commission in the early 1900's. White pine also increased in

abundance by colonizing abandoned farm fields and pastures. The most common forest types, from the 1985 report, were mixed oak followed by white pine - oak.

The frequency of occurrence (Table 9) gives an indication on the scarcity of regeneration occurring in the Blue Hills Reservation. Only 23.5% of the plots had 1 or more tree stems from 1' to 1" dbh. In contract, the Quabbin report details having 46% of disturbed plots in unmanaged areas having 1 or more stems in this height class. Disturbed plots in the Quabbin report were areas which had been treat silviculturally as well as disturbed naturally by wind, heavy insect/disease, or ice. There were only 20 plots in the Blue Hills Reservation that showed some form of disturbance: 13 past fire; 4 Hemlock Wooly Adelgid; 1 red pine scale; 1 ash dieback; 1 cutting.

As the stocking level increased the percent of plots with 1 or more stems in the 1' to 1" dbh range decreased (Graph 11, Table 11). This is consistent with lower stocking levels typically having more favorable growing conditions, e. g. light, growing space, nutrients, than higher stocking levels. The 1" to 5" dbh height class showed similar results (Table 12). The average basal area for all plots was 145 sq. ft. /acre. The average basal area in 1985 was 75 sq. ft. /acre. The number of plots by size class (Table 14) and by stand structure (Table 15) illustrates the lack of structural diversity within the Blue Hills Reservation. The vast majority of the stands were even aged sawtimber.

With respect to the number of shrubs (Table 16), 83 plots had no shrubs present and 156 plots had only one shrub species present. Within the herbaceous layer (Table 17) up to 20 species of forbs (Table 18) were found. Seven species of vines were found: greenbrier, Virginia creeper, oriental bittersweet, poison ivy, partridgeberry, climbing nightshade, and grape. Eight species of ferns were found: hay-scent fern, New York fern, cinnamon fern, bracken fern, interrupted fern, royal fern, marsh fern, and one plot with an unknown fern. The herbaceous layer may be under represented as spring ephemerals were not included as the sampling was done in the summer.

As mentioned by Kittredge and Ashton (1995) sever browsing of regeneration could stop stand development patterns that promote species stratification. In extreme cases forests could resemble open single storied woodlands dominated by relative few tree species with an unpalatable understory. In the Northeastern United States white-tailed deer abundance may impact certain species more than other due to their selective browse preference. Even if the number of deer in the Blue Hills Reservation decreases to the point that preferred species can grow uninhibited, there will be a legacy effect in which it will take time for the density and diversity in the understory to increase (Long et al, 2007). To counteract the impact to deer browse, openings in the canopy may be able to accelerate growth of some seedlings enough to grow beyond the reach of deer (Fredericksen et al., 1998).

Statistical power analysis

A post-hoc statistical power analysis was performed to determine how much larger the regeneration must increase the next time we sample to say the increase observed is actually taking place. Statistical power is the ability to show that a null hypothesis, no change took place in our case, is false when it actually is false. Statistical power is the complement of the missed-change error rate. A missed-change error is one in which a change has taken place but is not detected through the monitoring effort. Power levels are often reported

instead of missed-change error levels as power levels convey the certainty of detecting changes (Elizinga et al., 2001).

As we are concerned about noticing an increase in regeneration due to a reduction in the deer in the Blue Hills Reservation, no change in regeneration may trigger a management action. We want to be sure the missed-changed error is low. Table 19 shows, with an 80% certainty, what the increase in stems per acre must be to say an increase in regeneration took place the next time we sample. For example, the tree stems per acre in the 0-1' height class would have to increase by 590 stems, or 22%, to be 80% certain a change has actually occurred (Table 19).

References

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