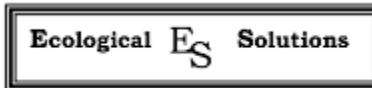


South Mountain Reservation Forest Regeneration Site Evaluation Report

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Native Pinxter Azalea recovering within a site.

This plant will produce beautiful pink flowers that haven't been seen at the Reservation for many years. Outside of the sites, this species doesn't grow more than a couple inches tall before being browsed by deer.

Executive Summary

This report provides results of an evaluation of forest regeneration sites, fenced exclosures planted with native species in 2009, located in the South Mountain Reservation performed from September 24 through October 2, 2014. In 2009, a total of 41 sites were installed across the Reservation. Sites range in size from 0.12 to 0.87 acres – the total area for all sites is 10.9 acres. In addition, the 14-acre “Preserve” exclosure located off Crest Drive was subject to a rapid evaluation. The evaluation included the following:

- 1) Site Structures (condition of fencing, gates and locks),
- 2) Broad Vegetation Cover by Strata (visual estimation of vegetation cover for the herbaceous layer, all woody plants within the deer browse zone, tree seedlings greater than two feet tall, sub-canopy and canopy),
- 3) Restoration Plantings and Natural Recruitment (approximate quantity of each species utilized for restoration plantings was recorded for each exclosure along with quantifying all naturally occurring native herbaceous species, presence of other non-planted native woody shrubs and trees were recorded, but not quantified by the number of individuals present), and
- 4) Invasive Species (cover of each invasive species was recorded separately based upon approximate overall cover within each exclosure).

The key findings of the evaluation include:

- 1) **The majority of sites remain effective in excluding deer**, however, four are severely damaged and non-functional and subject plantings to deer browsing. Five sites require repair and six sites cannot be accessed due to jammed locks from the settling of gates.
- 2) **Native cover was relatively low, but was consistently higher within sites**. This applied to herbaceous and woody species. Non-native cover was more consistent across the exclosure boundary. Non-native cover was somewhat ‘bi-modal’, with some areas having very low cover to other areas with high cover (typically associated with greater light resources).
- 3) **Restoration planting success was mixed**. A total of sixty species were planted. There were no observed individuals for 35% of planted species. Approximately 33% of species were found in > 75% of the sites where they were planted. When present, planted species had fewer individuals than the amount planted with several exceptions (e.g., white wood aster). **There was no evidence of planted species spreading beyond the sites. Natural recruitment of native species within sites was relatively diverse (74 native species recorded)**. Some of these species are found outside of sites and appear to be at least partially deer tolerant (e.g., Beech drops), but most are absent or found in poor condition outside of sites (e.g., White wood aster, Black gum).
- 4) **There were 25 invasive species found within regeneration sites**. A total of ten species are considered to have high control priority (e.g., Oriental photinia). Due to the protection of the sites, overall, the invasive woody shrubs within sites have a slightly greater density than the immediate outside environments.

The fundamental objectives of the regeneration program were to: 1) establish through restoration planting a stable, diverse population of native species to serve as a seed source for regeneration in the Reservation as a whole; and 2) promote a slow migration of these native plants over a 20-plus year period beyond these sites. Based on this study, the first objective, the establishment of native species, has been moderately successful: though there are clear losses of some planted species, there has been some natural recruitment of other native species. There has also been a proliferation of some invasive species in several sites. As for the second objective, there is no evidence that native species have spread beyond the confines of the individual sites. This is in great part due to a population of white tailed deer, despite annual culling, has not been reduced significantly below 20 per square mile, a level twice the density required for regeneration of a forest such as the Reservation with a depleted understory.

In light of these overall objectives and the results of this evaluation, five recommendations with ten associated goals are provided to assure the success of the project (See “Summary of Recommendations and Goals” on the next page).

The key goal of the regeneration site program, *that they serve as seed sources to ultimately restore forest health across the entire Reservation, cannot be met unless the deer population is further reduced.* It is likely that the target deer population density should be 10 per square mile or less. (This recommendation is supported by Dan Bernier, the Union County deer management expert advising Essex County in his annual culling reports. According to those reports, currently the deer density is almost twice that level.) ***However, the guiding principle should not be a target deer density. Rather, the target should be measures of vegetation that reflect continuing improvement and ultimately meeting thresholds that would define a healthy forest.*** Forest health monitoring using the ‘Sentinel Seedling’ and ‘Forest Secchi’ protocols have been performed twice at the Reservation. In 2007/2008, 82% of planted oak seedlings were browsed by deer. In 2012/2013, this number had dropped to 35%. The ultimate goal is 10% browse levels. Improvements were also seen in the cover of native woody plants within the browse zone (2008: 10%; 2013: 30%). The ultimate goal is 70% cover.

Summary of Recommendations and Goals

There are five recommendations and ten associated goals. See report for additional details.

Recommendation #1: Continue to Reduce Deer Herd Population Size

Goal #1-1: Utilize Forest Health Monitoring Program Goals to Set Deer Harvest Goals

- Data collected for this report suggest that the current deer population continues to severely degrade forest health across the Reservation.
- The deer herd size should be reduced until Sentinel Seedling Protocol goals (< 10% browse on planted seedlings) and Forest Secchi Protocol goals (> 70% native woody cover in the browse zone) are met and then annual culling necessary to maintain that reduced herd size.

Recommendation #2: Perform Regular Regeneration Site Fencing Inspection and Repair

Goal #2-1: Repair existing breaches in regeneration sites

- There are currently four ineffective sites with severe fence damage. Five additional sites have moderate damage and six additional sites have access issues due to problems with locks.

Goal #2-2: Implement Inspection and Repair Schedule

- Inspections and repairs should occur bi-annually (spring and fall).

Recommendation #3: Perform Strategic Invasive Species Control

Goal #3-1: Eradicate All Emerging Invasive Species Within and Immediately Adjacent to Sites

- See Table 4 and Appendix A for a list of emerging invasive species and their abundance within sites. Key species include Chinese silvergrass and Callery pear.

Goal #3-2: Selectively Control Widespread Invasive Species Within and Immediately Adjacent to Sites

- See Table 4 and Appendix A for a list of emerging invasive species and their abundance within sites. Key species include Japanese knotweed and Japanese honeysuckle.

Goal #3-3: Develop comprehensive annual program to reduce the most highly threatening invasive species across the entire Reservation

- The most threatening species threaten short- and long-term forest health across the entire Reservation. Key species include Oriental Photinia, Siebold's Viburnum, Linden Viburnum, Winged euonymus and Japanese Aralia.

Recommendation #4: Develop a Plan for Additional Restoration Plantings

Goal #4-1: Install selected herbaceous and shrub species with high likelihood of establishment

- Key species with high potential to survive and spread (following successful implementation of Recommendation #1) include: Maple-leaved viburnum, Spicebush, Bluestem goldenrod, Marginal woodfern, Solomon's seal and False Solomon's seal
- A specific plan should be devised to determine the exact number and location of plantings.

Goal #4-2: Re-install selected native wildflower species that failed to establish during the initial restoration

- Key species include Bloodroot, Wild ginger, Wood geranium, Rue anemone, Bellwort, Jack-in-the-pulpit and violet species
- A specific plan should be devised to determine the exact number and location of plantings.

Recommendation #5: Perform Regular Exclosure Surveys and Reservation-wide Ecological Monitoring

Goal #5-1: Perform regular site plant surveys to track progress

- Repeat surveys every three years for the next nine years (2017, 2020, 2023) using the methods described in this report. Maintenance of sites should not be necessary beyond 2023.

Goal #5-2: Perform regular forest health monitoring throughout the Reservation

- Repeat Sentinel Seedling and Forest Secchi protocols every three years (2016, 2019, 2021 and beyond) to monitor progress of the deer management program.

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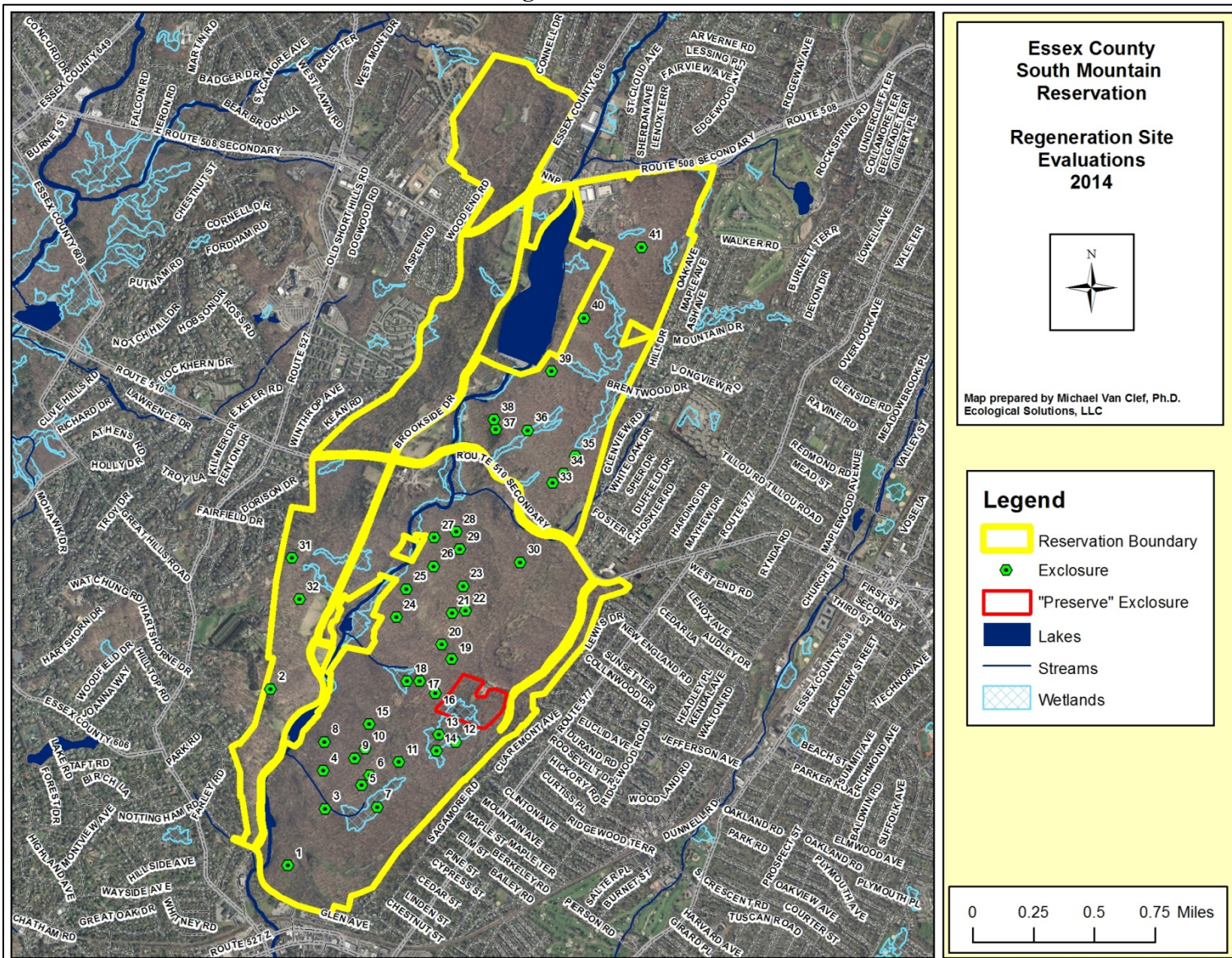
Introduction and Methods

This report provides results of an evaluation of forest regeneration sites, fenced exclosures planted with native species, located in the South Mountain Reservation performed from September 24 through October 2, 2014. In 2009, a total of 41 sites were installed across the Reservation (Figure 1). Sites range in size from 0.12 to 0.87 acres – the total area for all sites is 10.9 acres. In addition, the 14-acre “Preserve” exclosure located off Crest Drive was subject to a rapid evaluation.

The evaluation included the following:

- 1) **Regeneration Site Structures**: The condition of fencing, gates and locks were recorded for each exclosure.
- 2) **Broad Vegetation Cover by Strata**: Broad vegetation cover was visually estimated by forest strata for a) herbaceous layer, b) all woody plants within the deer browse zone (shrubs and trees combined), c) tree seedlings greater than two feet tall, c) sub-canopy and d) canopy. Data was collected both inside each exclosure along with the area immediately surrounding each exclosure to provide direct comparisons. Cover for each stratum was estimated using the following percentage cover categories: 0, < 1%, 1-10%, 11-25%, 26-50%, 51-75% and > 75%. Cover was recorded separately for all native and all non-native vegetation. A list of tree species occupying the sub-canopy and canopy layers was also recorded.
- 3) **Restoration Plantings and Natural Recruitment**: The approximate quantity of each species utilized for restoration plantings was recorded for each exclosure. Quantities were estimated in the following categories: 0, 2-5, 6-10, 11-15, 16-20, 21-25, 26-50, 51-75, 76-100, 101-250 and > 250 individuals. Similarly, all naturally occurring native herbaceous species were also recorded within each exclosure. The presence of other non-planted native woody shrubs and trees was also recorded, but not quantified by the number of individuals present. Species-level cover was not recorded for areas outside of the exclosure (but native cover by strata was recorded as noted in #1 above).
- 4) **Invasive Species**: The cover of each invasive species was recorded separately based upon approximate overall cover within each exclosure. Cover was estimated using the following percentage cover categories: 0, < 1%, 1-10%, 11-25%, 26-50%, 51-75% and > 75%. Species-level cover was not recorded for areas outside of the exclosure (but non-native cover by strata was recorded as noted in #1 above).

Figure 1. Site Locations



Results

1) Regeneration Site Structures

Table 1 provides a summary of sites with issues ranging from minor to severe. The majority of sites (90%) is intact and continues to exclude deer access. Four sites (2, 36, 38, 41) have suffered severe damage from natural tree falls – these no longer provide protection from deer. Minor to moderate damage was noted at five sites. Efforts to repair damage are visible at most/all of these sites (e.g., rope, plastic fence patches), but permanent repairs using the original fencing material would provide longer-lasting results. Six sites have issues with locks (mostly due to setting of gates that precludes lock removal) – entry to these sites currently requires climbing over the gate. The remaining 26 sites are in good condition. The “Preserve” enclosure is also in good condition.

Table 1. Regeneration Site Structure Issues

ID Number	ID Code	Acres	Damage Category	Current Deer Accessibility	Damage Description
2	EL1	0.37	Severe	High	Multiple, large breaches from tree falls
3	SS1	0.12	Lock Only	None	Lock is stuck/wedged
4	LE4	0.27	Minor	None	Repair required in one location (top of fence)
15	LE9	0.12	Moderate	None	Fence damaged in one location
21	LE17	0.98	Lock Only	None	Lock is missing
22	LE16	0.13	Minor	None	Fence damaged at gate
28	BB5	0.12	Lock Only	None	Lock combination does not work
30	OV2	0.48	Lock Only	None	Lock is stuck/wedged
31	EL3	0.12	Moderate	None	Gate held with rope and several repaired breaches
34	LG3	0.65	Lock Only	None	Lock is stuck/wedged
36	HS1	0.32	Severe	High	Multiple, large breaches from tree falls; Gate destroyed
37	LE22	0.30	Minor	None	Existing temporary repairs should be made permanent
38	LE24	0.87	Severe	High	Multiple, large breaches from tree falls
39	RT9	0.35	Lock Only	None	Lock is stuck/wedged
41	TB3	0.36	Severe	High	Single, large breach from tree fall; Lock is stuck/wedged

2) Broad Vegetation Cover by Strata

Broad vegetation cover by strata (native and non-native species recorded separately) is provided in Table 2. The tree canopy within and adjacent to sites was > 75% cover for approximately 50% of the sites. A significant number had much thinner canopy cover (ca. 30% had 51-75% cover and ca. 20% had 26-50% cover). The sub-canopy cover typically ranged from 11-50% for approximately 3/4 of sites with approximately 1/4 of sites having 51-75% cover. Tree species located within the canopy and sub-canopy are provided in Appendix A. Generally, sites with both dense canopy and sub-canopy layers had much less shrub and herb cover. These were typically associated with the presence of American Beech and Sugar Maple as major components to the canopy cover, but more often these species and other shade-tolerant trees were major components of the sub-canopy and suggest a forest transitioning from oak-hickory to beech-maple forest types. Relatively dry areas tended to have thinner canopies / sub-canopies with dominance by oak species and were associated with greater densities of shrubs, tree seedlings and herbaceous species.

Native herbs, shrubs and tree seedlings tended to be sparse within sites (nearly all had less than 50% cover). However, there were striking improvements in native cover within sites relative to immediately adjacent areas (See Figure 2). For example, 49% of enclosed areas had greater than 11% cover of native

herbs as opposed to only 17% with that amount of cover in adjacent open areas (cover was exclusively deer resistant natives outside of the sites, e.g., Pennsylvania sedge). Differences in native woody cover were even more striking – native shrub cover was greater than 11% in over 75% of sites while this was only true in 7% of adjacent open areas. Tree regeneration (as cover of trees > 2 feet tall) was nearly absent outside of sites (the primary exception was beech sprouts), while 2/3 of sites had greater than 11% cover of a variety of tree species not found regenerating outside of sites throughout the Reservation.



Native woody growth differences across enclosure boundary.

Non-native species cover was also responsive to the quantity and species composition of canopy and sub-canopy layers noted above for native species (i.e., shadier spots had less invasive species cover). Generally, non-native herbs (especially Japanese stiltgrass) were more abundant than non-native shrubs and trees. Approximately 30% of sites had greater than 25% cover of non-native herbs. Only 17% of sites had greater than 25% cover of non-native shrubs. Non-native tree regeneration was relatively low within all sites (nearly exclusively represented by Japanese aralia).

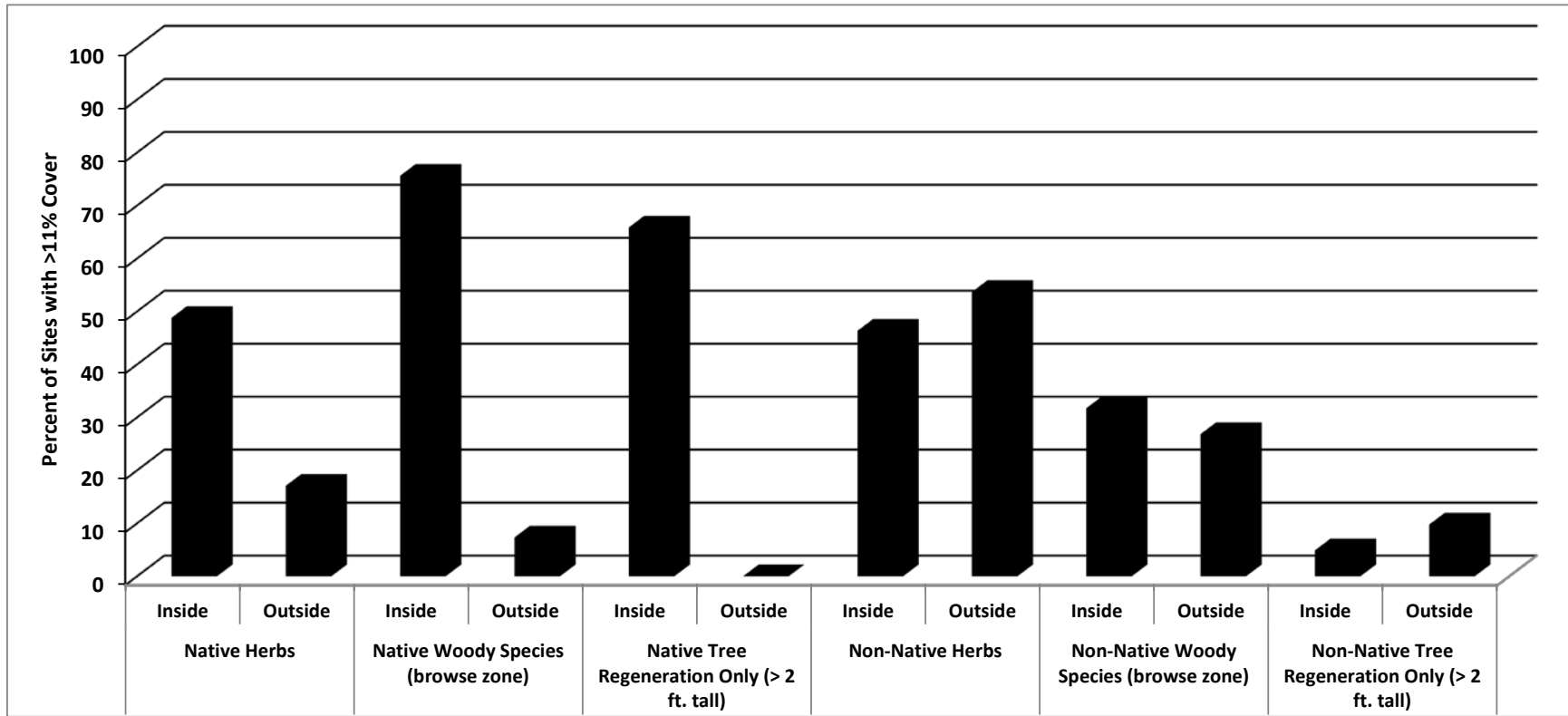
Non-native cover was much less sensitive than native species when comparing areas inside and outside of Sites (Figure 2). Non-native herbs had greater than 11% cover within 46% of sites and 54% of adjacent open areas. Non-native woody species in the browse zone had greater than 11% cover within 32% of sites and 27% of adjacent open areas. Non-native tree seedlings had greater than 11% cover within 5% of sites and 10% of adjacent open areas. Deer impacts appear to slightly impact selected non-native species, but the overall impact is much less significant than those observed on most native species.

Table 2. Results of Vegetative Cover by Forest Strata

Data provided as the percentage of sites for each strata and cover category.
For example, 29% of sites had 51-75% canopy cover inside of exclosed areas.

Strata	Position	Cover Category						
		Absent	< 1%	1-10%	11-25%	26-50%	51-75%	>75%
Canopy	Inside	0	0	0	2	17	29	51
	Outside	0	0	0	2	17	29	51
Sub-Canopy	Inside	0	0	5	37	34	22	2
	Outside	0	0	5	37	34	22	2
Native Herbs	Inside	0	10	41	24	15	5	5
	Outside	0	46	37	2	7	5	2
Native Woody Species (browse zone)	Inside	0	2	22	39	32	5	0
	Outside	2	39	51	5	0	2	0
Native Tree Regeneration Only (> 2 ft. tall)	Inside	2	5	27	41	20	5	0
	Outside	10	41	49	0	0	0	0
Non-Native Herbs	Inside	17	20	17	15	7	12	12
	Outside	15	15	17	15	15	12	12
Non-Native Woody Species (browse zone)	Inside	12	29	27	15	7	10	0
	Outside	17	24	32	12	5	10	0
Non-Native Tree Regeneration Only (> 2 ft. tall)	Inside	54	20	22	5	0	0	0
	Outside	59	17	15	7	2	0	0

Figure 2. Percentage of Regeneration Sites with >11% Cover by Vegetative Strata



3) Restoration Plantings and Natural Recruitment

A total of sixty species were planted within regeneration sites (See Table 3 and Appendix A). This included 33 herbaceous species, 9 shrubs and 18 trees. There were 21 planted species (35%) that did not appear to have any surviving individuals in any of the sites where they were planted. Although there were several species that could not or probably would not be observable in September (i.e., spring ephemerals), this represents a very high percentage of restoration species. Nine species (15% of planted species) had some survival in 25-50% of sites where they were planted. Seven species (12% of planted species) had some survival in 50-75% of sites where they were planted. There were 20 species (33%) that had some surviving individuals in greater than 75% of the sites where they were planted.

Woody species tended to survive at greater rates than herbaceous species. Seventeen of 33 herbaceous species (52%) had zero survival as opposed to only four of 27 woody species (15%) with zero survival. Herbaceous species that survived in greater than 75% of sites included: Christmas fern, Partridge-berry, White wood aster, Pennsylvania sedge, and Zig-zag goldenrod. Woody species with greater than 75% survival included: Sassafras, White ash, Lowbush blueberry, Tuliptree, Spicebush, Ironwood, Witch-hazel, Chestnut oak, White pine, Highbush blueberry, Mountain laurel, Northern red oak, Black haw, Red maple, Sugar maple, and Wild black cherry.

Generally, the number of surviving individuals was less than the number initially planted (Appendix A). Exceptions to this general rule were most often observed for species such as New York fern, Zig-zag goldenrod, White wood aster and Pennsylvania sedge, which showed clonal growth. This was occasionally observed for Solomon's seal and False Solomon's seal.

There was no evidence of planted species spreading to areas immediately outside of the sites.

Species such as Zig-zag goldenrod and White wood aster are strikingly confined to the sites. Additionally, individual White wood asters found across the Reservation are typically browsed by deer, resulting in much shorter plants with fewer flowers and the species cannot form larger clonal colonies as pictured below.



White wood aster plantings – spreading within enclosure but stopping suddenly at the enclosure edge.



Restoration plantings of Solomon's seal (left) and False Solomon's seal (right) are healthy and producing fruit that has the potential to increase their populations across the Reservation.

Natural recruitment of native species within sites was relatively diverse (Table 3 and Appendix A). There were 74 native species naturally growing within the sites. This includes 43 herbaceous species, 13 shrubs and 18 trees. The ten most common species were (in order of increasing frequency of occurrence, all were present in > 25% of sites): Witch-hazel, Allegheny blackberry, Black gum, Beech drops, Black birch, Partridge-berry, Tuliptree, White ash, Wild black cherry, and White wood aster. Some of these species are found outside of sites and appear to be at least partially deer tolerant (e.g., Beech drops), but most are absent or found in poor condition outside of sites (e.g., White wood aster, Black gum). Not surprisingly, the majority of species naturally recruited within sites are woody species (herbaceous species are extremely sparse throughout the Reservation and are less likely to produce seed that could reach sites).

Table 3. Summary of Native Species Restoration Plantings and Naturally Recruited Species within Regeneration Sites

Common Name	Species Code	Growth Form	Number of Planted Exclosures	Number of Exclosures with Survival	Percentage of Exclosures with Survival	Number of Exclosures with Naturally Occurring Individuals	Percent of Exclosures with Naturally Occurring Individuals	Notes
White-snakeroot	AGAL	Herbaceous	22	8	36	7	17	
Hog peanut	AMBR	Herbaceous	0	0	NA	2	5	
Wood Anemone	ANQU	Herbaceous	9	0	0	1	2	
Wild columbine	AQCA	Herbaceous	6	0	0	0	0	
Wild sarsaparilla	ARNU	Herbaceous	14	0	0	0	0	
Jack-in-the-pulpit	ARTR	Herbaceous	25	2	8	0	0	
Wild ginger	ASCA	Herbaceous	7	0	0	0	0	
False nettle	BOCY	Herbaceous	0	0	NA	1	2	
Eastern woodland sedge	CABL	Herbaceous	14	0	0	0	0	
Bluejoint Grass	CACA2	Herbaceous	0	0	NA	2	5	
Pennsylvania sedge	CAPE	Herbaceous	28	26	93	8	20	
Turtlehead	CHGL	Herbaceous	0	0	NA	1	2	
Spotted Wintergreen	CHMA	Herbaceous	1	0	0	6	15	
Enchanter's-nightsshade	CILU	Herbaceous	4	2	50	1	2	
Spring beauty	CLVI	Herbaceous	26	0	0	0	0	If present, species would not be detectable in September.
Hay-scented fern	DEPU	Herbaceous	6	3	50	2	5	
Deer Tongue Grass	DICL	Herbaceous	0	0	NA	1	2	
Dutchman's breeches	DICU	Herbaceous	29	0	0	0	0	If present, species may not have been detectable in September.
Wild yam	DIVI	Herbaceous	0	0	NA	2	5	
Wood Fern species	DRXX	Herbaceous	0	0	NA	1	2	
Virginia wildrye	ELVI	Herbaceous	0	0	NA	3	7	
Beech drops	EPVI	Herbaceous	0	0	NA	13	32	
Yellow trout-lily	ERAM	Herbaceous	18	0	0	0	0	If present, species would not be detectable in September.
White wood aster	EUDI	Herbaceous	19	17	89	11	27	Originally listed as Big-leaf Aster, but all appeared to be White Wood Aster.
Grass-leaved goldenrod	EUGR	Herbaceous	0	0	NA	2	5	
Purple-node Joe Pye	EUPU	Herbaceous	0	0	NA	2	5	
Wild licorice	GACI	Herbaceous	0	0	NA	1	2	
Wintergreen	GAPR	Herbaceous	5	0	0	0	0	
Wood geranium	GEMA	Herbaceous	3	0	0	0	0	
Liverleaf/ Hepatica	HENO	Herbaceous	6	2	33	0	0	
Jewelweed	IMCA	Herbaceous	0	0	NA	1	2	
Cutgrass/White grass	LEVI	Herbaceous	7	5	71	11	27	
Indian-tobacco	LOIN	Herbaceous	0	0	NA	1	2	
Water horehound	LYAM	Herbaceous	0	0	NA	1	2	
Whorled looestribe	LYQU	Herbaceous	0	0	NA	10	24	
Canada mayflower	MACA	Herbaceous	12	2	17	3	7	
False Solomon's Seal	MARA	Herbaceous	19	5	26	2	5	
Partridge-berry	MIRE	Herbaceous	15	12	80	13	32	
Indian Pipe	MOUN	Herbaceous	0	0	NA	5	12	
Sensitive fern	ONSE	Herbaceous	0	0	NA	0	0	Found in "Preserve" only
Cinnamon fern	OSCI	Herbaceous	0	0	NA	3	7	

Table 3. Continued

Common Name	Species Code	Growth Form	Number of Planted Exclosures	Number of Exclosures with Survival	Percentage of Exclosures with Survival	Number of Exclosures with Naturally Occurring Individuals	Percent of Exclosures with Naturally Occurring Individuals	Notes
Jumpseed	PEVI	Herbaceous	0	0	NA	2	5	
Pokeweed	PHAM	Herbaceous	0	0	NA	5	12	
Clearweed	PIPU	Herbaceous	0	0	NA	1	2	
Christmas fern	POAC	Herbaceous	18	14	78	11	27	
Mayapple	POPE1	Herbaceous	19	0	0	0	0	If present, species would not be detectable in September.
Solomon's-seal	POPU	Herbaceous	19	12	63	10	24	
Old-field cinquefoil	POSI	Herbaceous	0	0	NA	5	12	
White Rattlesnake Root	PRAL	Herbaceous	0	0	NA	4	10	
Shinleaf	PYEL	Herbaceous	0	0	NA	6	15	
Bloodroot	SACA	Herbaceous	21	0	0	0	0	
Carrion flower	SMHE	Herbaceous	0	0	NA	1	2	
Bluestem goldenrod	SOCA1	Herbaceous	0	0	NA	6	15	
Canada goldenrod	SOCA2	Herbaceous	0	0	NA	6	15	
Zigzag goldenrod	SOFL	Herbaceous	6	6	100	0	0	
Wrinkle-leaved goldenrod	SORU	Herbaceous	6	4	67	1	2	
Bushy aster	SYDU	Herbaceous	0	0	NA	6	15	
New York fern	THNO	Herbaceous	16	11	69	8	20	
Rue anemone	THTH	Herbaceous	12	0	0	0	0	
Bellwort	UVPE	Herbaceous	5	0	0	0	0	
Sessile Bellwort	UVSE	Herbaceous	5	0	0	0	0	
Long-spurred violet	VIRO	Herbaceous	6	0	0	0	0	
Shadbush	AMCA	Shrub	0	0	NA	0	0	For naturally occurring individuals, includes shrubs > 1' tall only.
Sweet pepperbush	CLAL	Shrub	0	0	NA	0	0	For naturally occurring individuals, includes shrubs > 1' tall only.
Black huckleberry	GABA	Shrub	0	0	NA	1	2	For naturally occurring individuals, includes shrubs > 1' tall only.
Dangleberry	G AFL	Shrub	0	0	NA	1	2	For naturally occurring individuals, includes shrubs > 1' tall only.
Witch-hazel	HAVI	Shrub	23	22	96	25	61	For naturally occurring individuals, includes shrubs > 1' tall only.
Winterberry holly	ILVE	Shrub	0	0	NA	0	0	For naturally occurring individuals, includes shrubs > 1' tall only.
Mountain laurel	KALA	Shrub	7	7	100	3	7	For naturally occurring individuals, includes shrubs > 1' tall only.
Spicebush	LIBE	Shrub	14	12	86	4	10	For naturally occurring individuals, includes shrubs > 1' tall only.
Chokecherry	PRVI	Shrub	2	0	0	0	0	For naturally occurring individuals, includes shrubs > 1' tall only.
Winged sumac	RHCO	Shrub	0	0	NA	0	0	For naturally occurring individuals, includes shrubs > 1' tall only.
Smooth sumac	RHGL	Shrub	0	0	NA	1	2	For naturally occurring individuals, includes shrubs > 1' tall only.
Pinkster-flower	RHPE	Shrub	0	0	NA	1	2	For naturally occurring individuals, includes shrubs > 1' tall only.
Allegheny Blackberry	RUAL	Shrub	0	0	NA	13	32	For naturally occurring individuals, includes shrubs > 1' tall only.
Creeping Dewberry	RUFL	Shrub	0	0	NA	1	2	For naturally occurring individuals, includes shrubs > 1' tall only.
Elderberry	SACA	Shrub	0	0	NA	0	0	For naturally occurring individuals, includes shrubs > 1' tall only.
Catbrier/ Common Greenbrier	SMRO	Shrub	0	0	NA	4	10	For naturally occurring individuals, includes shrubs > 1' tall only.
Highbush blueberry	VACO	Shrub	2	2	100	2	5	For naturally occurring individuals, includes shrubs > 1' tall only.
Lowbush blueberry	VAPA	Shrub	34	27	79	0	0	For naturally occurring individuals, includes shrubs > 1' tall only.
Maple-leaved Viburnum	VIAC	Shrub	7	4	57	2	5	For naturally occurring individuals, includes shrubs > 1' tall only.
Northern arrow-wood	VIDE	Shrub	4	2	50	0	0	For naturally occurring individuals, includes shrubs > 1' tall only.
Black-haw	VIPR	Shrub	3	3	100	3	7	For naturally occurring individuals, includes shrubs > 1' tall only.

Table 3. Continued

Common Name	Species Code	Growth Form	Number of Planted Exclosures	Number of Exclosures with Survival	Percentage of Exclosures with Survival	Number of Exclosures with Naturally Occurring Individuals	Percent of Exclosures with Naturally Occurring Individuals	Notes
Red maple	ACRU	Tree	1	1	100	6	15	For naturally occurring individuals, includes seedlings > 2' tall only.
Sugar maple	ACSA	Tree	2	2	100	6	15	For naturally occurring individuals, includes seedlings > 2' tall only.
Yellow birch	BEAL	Tree	0	0	NA	0	0	For naturally occurring individuals, includes seedlings > 2' tall only.
Black birch	BELE	Tree	0	0	NA	13	32	For naturally occurring individuals, includes seedlings > 2' tall only.
Gray birch	BEPO	Tree	6	2	33	0	0	For naturally occurring individuals, includes seedlings > 2' tall only.
Hornbeam; ironwood	CACA	Tree	9	8	89	0	0	For naturally occurring individuals, includes seedlings > 2' tall only.
Bitternut hickory	CACO	Tree	0	0	NA	1	2	For naturally occurring individuals, includes seedlings > 2' tall only.
Pignut hickory	CAGL	Tree	4	0	0	1	2	For naturally occurring individuals, includes seedlings > 2' tall only.
Shagbark hickory	CAOV	Tree	5	0	0	1	2	For naturally occurring individuals, includes seedlings > 2' tall only.
Flowering dogwood	COFL	Tree	4	2	50	1	2	For naturally occurring individuals, includes seedlings > 2' tall only.
White ash	FRAM	Tree	9	7	78	12	29	For naturally occurring individuals, includes seedlings > 2' tall only.
American holly	ILOP	Tree	0	0	NA	4	10	For naturally occurring individuals, includes seedlings > 2' tall only.
Sweet gum	LIST	Tree	0	0	NA	3	7	For naturally occurring individuals, includes seedlings > 2' tall only.
Tuliptree	LITU	Tree	5	4	80	12	29	For naturally occurring individuals, includes seedlings > 2' tall only.
Black gum	NYSY	Tree	0	0	NA	13	32	For naturally occurring individuals, includes seedlings > 2' tall only.
Hop-hornbeam	OSVI	Tree	5	1	20	0	0	For naturally occurring individuals, includes seedlings > 2' tall only.
Eastern white pine	PIST	Tree	2	2	100	1	2	For naturally occurring individuals, includes seedlings > 2' tall only.
Sycamore	PLOC	Tree	0	0	NA	0	0	For naturally occurring individuals, includes seedlings > 2' tall only.
Wild black cherry	PRSE	Tree	7	7	100	11	27	For naturally occurring individuals, includes seedlings > 2' tall only.
White oak	QUAL	Tree	15	9	60	1	2	For naturally occurring individuals, includes seedlings > 2' tall only.
Swamp white oak	QUBI	Tree	0	0	NA	0	0	For naturally occurring individuals, includes seedlings > 2' tall only.
Chestnut oak	QUMO	Tree	3	3	100	0	0	For naturally occurring individuals, includes seedlings > 2' tall only.
Northern red oak	QURU	Tree	9	9	100	3	7	For naturally occurring individuals, includes seedlings > 2' tall only.
Black oak	QUVE	Tree	1	0	0	0	0	For naturally occurring individuals, includes seedlings > 2' tall only.
Sassafras	SAAL	Tree	4	3	75	9	22	For naturally occurring individuals, includes seedlings > 2' tall only.
American elm	ULAM	Tree	2	1	50	1	2	For naturally occurring individuals, includes seedlings > 2' tall only.

4) Invasive Species

There were 25 invasive species found within sites (Table 4). Additional information on abundance of each species is found in Appendix A, which can be used as a guide for control efforts.

Each species was assigned a “Relative Threat” ranking along with a “Relative Control Priority”. The threat level considers the potential for growing densely (and perpetually) within the site. Therefore, species that may ultimately be out-competed by native species are provided low to moderate rankings, especially if they are already considered to be widespread in New Jersey (e.g., Japanese barberry and Japanese stiltgrass). The control priority is based upon the threat level within the enclosure (i.e., species that may cause severe damage despite the absence of deer browse impacts on native species), along with its current NJ distribution status (i.e., emerging species receive higher priority).

A total of ten species are considered to have high control priority. These include Tree-of-heaven, Japanese aralia, Winged euonymus, English ivy, Toringo crabapple, Chinese Silvergrass, Oriental photinia, Japanese knotweed, Callery pear and Linden viburnum.

Table 4. Summary of Invasive Species found within Regeneration Sites

Common Name	Species Code	Growth Form	Number of Enclosures with Naturally Occurring Individuals	Percent of Enclosures with Naturally Occurring Individuals	Relative Threat	Relative Control Priority	NJ Distribution Status
Garlic-mustard	ALPE	Herbaceous	1	2	Low	Low	Widespread species
Common mugwort	ARVU	Herbaceous	2	5	Low	Low	Widespread species
Narrowleaf bittercress	CAIM	Herbaceous	1	2	Low	Low	Widespread species
Chinese silvergrass	MISI	Herbaceous	4	10	Moderate	High	Emerging Species
Stiltgrass	MIVI	Herbaceous	34	83	High	Low	Widespread species
Reed canary grass	PHAR	Herbaceous	0	0	Moderate	Low	Widespread species
Common Reed - Phragmites	PHAU	Herbaceous	1	2	Low	Low	Widespread species
Japanese knotweed	POCU	Herbaceous	1	2	High	High	Widespread species
Mile-a-minute Vine	POPE2	Herbaceous	1	2	Moderate	Low	Widespread species
Japanese barberry	BETH	Shrub	30	73	Moderate	Low	Widespread species
Winged euonymous	EUAL	Shrub	24	59	High	High	Widespread species
Obtuse-leaved privet	LIOB	Shrub	4	10	Moderate	Moderate	Widespread species
Oriental photinia	PHVI	Shrub	8	20	High	High	Emerging Species
Multiflora rose	ROMU	Shrub	6	15	Moderate	Low	Widespread species
Wineberry	RUPH	Shrub	26	63	Moderate	Low	Widespread species
Linden viburnum	VIDI	Shrub	7	17	High	High	Widespread species
Norway maple	ACPS	Tree	1	2	Moderate	Low	Widespread species
Tree-of-heaven	AIAL	Tree	1	2	Moderate	High	Widespread species
Japanese aralia	AREL	Tree	17	41	High	High	Emerging Species
Toringo Crabapple	MASI	Tree	2	5	Moderate	High	Emerging Species
Sweet cherry	PRAV	Tree	3	7	Low	Low	Widespread species
Callery pear	PYCA	Tree	4	10	Moderate	High	Emerging Species
Oriental bittersweet	CEOR	Vine	19	46	Moderate	Moderate	Widespread species
English ivy	HEHE	Vine	2	5	Moderate	High	Emerging Species
Japanese honeysuckle	LOJA	Vine	9	22	High	Moderate	Widespread species

Recommendations and Goals

Introduction

There are five recommendations and ten associated goals to assure the success of the sites and improve the ecological health of the entire forest ecosystem at South Mountain Reservation.

Recommendation #1: Continue to Reduce Deer Herd Population Size

Goal #1-1: Utilize Forest Health Monitoring Program Goals to Set Deer Harvest Goals

- *Data collected for this report suggest that the current deer population continues to severely degrade forest health across the Reservation.*
- The deer herd size should be reduced until Sentinel Seedling Protocol goals (< 10% browse on planted seedlings) and Forest Secchi Protocol goals (> 70% native woody cover in the browse zone) are met.

The key goal of the sites, that they serve as seed sources to ultimately restore forest health across the entire Reservation, cannot be met unless the deer population is further reduced. It is likely that the target deer population density should be 10 per square mile, or less; annual culling reports indicate that the current density is almost twice that level. However, the guiding principle should not be a target deer density. Rather, the target should be measures of vegetation that reflect continuing improvement and ultimately meeting thresholds that would define a healthy forest. Forest health monitoring using the 'Sentinel Seedling' and 'Forest Secchi' protocols have been performed twice at the Reservation. In 2007/2008, 82% of planted oak seedlings were browsed by deer. In 2012/2013, this number had dropped to 35%. The ultimate goal is 10% browse levels. Improvements were also seen in the cover of native woody plants within the browse zone (2008: 10%; 2013: 30%). The ultimate goal is 70% cover.

Recommendation #2: Perform Regular Enclosure Fencing Inspection and Repair

Goal #2-1: Repair existing breaches

- There are currently four ineffective sites with severe damage. Five additional sites have moderate damage and six additional sites have access issues due to problems with locks. See Table 1 for details.

Goal #2-2: Implement Inspection and Repair Schedule

- Inspections and repairs should occur bi-annually (spring and fall).

Recommendation #3: Perform Strategic Invasive Species Control

Goal #3-1: Eradicate All Emerging Invasive Species Within and Immediately Adjacent to Sites

- See Table 4 and Appendix A for a list of emerging invasive species and their abundance within sites. Emerging invasive species with the potential to be eradicated at the Reservation include: Chinese Silvergrass, Torongo crabapple, Callery pear and English ivy. (It is important to note that Chinese Silvergrass is maintained in the landscaping at the dog park entrance. These plantings will serve as seed sources that will degrade the ecological health of the Reservation.)

Goal #3-2: Selectively Control Widespread Invasive Species Within and Immediately Adjacent to Sites

- See Table 4 and Appendix A for a list of widespread invasive species and their abundance within sites. Widespread species that should be subject of regular control efforts to minimize continued

ecological degradation include: Japanese knotweed, Japanese honeysuckle, Tree-of-Heaven, Phragmites, Common mugwort, and Oriental bittersweet. *Initial efforts should focus on Japanese knotweed located within and immediately adjacent to the 14-acre Wildflower Preserve.*

Goal #3-3: Develop comprehensive annual program to reduce the most highly threatening invasive species across the entire Reservation

- The most threatening species threaten short- and long-term forest health across the entire Reservation. Key species include Oriental Photinia, Siebold's Viburnum, Linden Viburnum, Winged euonymus and Japanese Aralia. These species are all shade-tolerant tall shrubs/small trees that will effectively compete with native species even after deer herd reduction goals are met.
- Oriental photinia is the highest priority. It is rapidly spreading across the Reservation with large individuals/colonies and thousands of small seedlings (especially in the western / central portions of the Reservation). It forms dense colonies that crowd out nearly all other vegetation. Initial actions should focus on eradicating all mature individuals that are currently producing fruit. Because of its current abundance, annual efforts to reduce its abundance will be required into the foreseeable future.
- Japanese aralia is already widespread across the Reservation. Initial efforts should focus on removal of individuals within tree canopy gaps. Continuing efforts should attempt to diminish the number of fruiting individuals.
- Siebold's viburnum was recently detected at the Reservation – all known populations should be eradicated.
- Linden viburnum has recently been re-classified from “emerging” to “widespread” in New Jersey. However, it has not yet become as widespread at the Reservation as other natural areas in the state. Initial efforts should focus on reducing the number of mature, fruiting individuals to limit further spread.
- Winged burning bush widespread in New Jersey and at the Reservation. However, it has been kept in check by deer browsing. The continuing reduction of the deer herd will stimulate the spread of this species. Initial efforts should focus on reducing the number of mature, fruiting individuals to limit further spread.

Recommendation #4: Develop a Plan for Additional Restoration Plantings

Goal #4-1: Install selected herbaceous and shrub species with high likelihood of establishment

- Key species with high potential to survive and spread (following successful implementation of Recommendation #1) include: Maple-leaved viburnum, Spicebush, Bluestem goldenrod, Marginal woodfern, Solomon's seal and False Solomon's seal. These species would form the 'backbone' of any healthy forest in the area and should be fostered at the Reservation because they have largely been eliminated from the site due to decades of overabundant deer.
- *A specific plan should be devised to determine the exact number and location of plantings.*

Goal #4-2: Re-install selected native wildflower species that failed to establish during the initial restoration

- Key species include Bloodroot, Wild ginger, Wood geranium, Rue anemone, Bellwort, Jack-in-the-pulpit and violet species. These species should also be very common at the Reservation. While all of these species are common in New Jersey, their re-installation should proceed with caution to avoid expending resources on species that apparently had great difficulty in surviving their initial plantings.
- *A specific plan should be devised to determine the exact number and location of plantings.*

Recommendation #5: Perform Regular Exclosure Surveys and Reservation-wide Ecological Monitoring

Goal #5-1: Perform regular site plant surveys to track progress

- Repeat surveys every three years for the next nine years (2017, 2020, 2023) using the methods described in this report. Maintenance of sites should not be necessary beyond 2023.

Goal #5-2: Perform regular forest health monitoring throughout the Reservation

- Repeat Sentinel Seedling and Forest Secchi protocols every three years (2016, 2019, 2021 and beyond) to monitor progress of the deer management program.