Developing Regeneration in Woodlots at Gettysburg National Military Park[1]

Todd W. Bowersox, Gerald L. Storm, and Walter M. Tzilkowski

Abstract: Woodlots are significant features of the historic scene at Gettysburg National Military Park, Pennsylvania. Recent inventories of these historic woodlots indicated a general lack of seedling recruitment in the uneven-aged stands with a mature mixed oak overstory and a midstory of ash-cherry-dogwood-hickory. Seedling-sized stems of shrub and tree species were abundant, averaging over 40,000 per hectare. The tree species were dominated by ash and cherry, and many seedlings were browsed by white-tailed deer. April density of white-tailed deer increased from 0.25 white-tailed deer per hectare in 1987 to 0.40 white-tailed deer per hectare in 1992. A management strategy is needed to maintain the structure and species composition of the historic woodlots. We present an approach to develop methods for restoring and maintaining the historic woodlot scene.

INTRODUCTION

Gettysburg National Military Park was established to commemorate the July 1-3, 1863 Civil War battle. The Park presently covers about 1560 hectares with 643 hectares occupied by woodlots. Before 1863, woodlots ranging in size of 2 to 24 hectares were important cultural resources for the associated farms and communities. These woodlots provided shelter for livestock, fuelwood and a source of materials for buildings, fences, furniture and tools. Cavanaugh (1990) searched historic documents and Park photographs from the early 1900's. This research suggested that white oak (*Quercus alba* L.) was a dominate overstory species in these woodlots. On July 1, 1863 these woodlots were important landscape features for the Confederate and Union troops. Some woodlots were actual grounds of conflict whereas others were used as staging areas, screens for military movements or shelter for troops and supplies. To restore and maintain the landscape as it was in 1863, Natural Resource staff at the Park have organized the historic woodlots into two categories. The categories are (A) those associated with significant battle action and (B) those significant to battle movements and positions (Gettysburg National Park 1992).

Category A woodlots are to be restored and managed to reflect their historic appearance as part of an active battlefield. Height of overstory, density of overstory, mix of deciduous and coniferous species, and native species are important factors in preserving these historic scenes. Culp's Hill, Herbst Woods and Rose Woods are examples of Category A woodlots. These woodlots will require substantial vegetation manipulation to restore and intensive cultural practices to maintain the historic scene. Generally, the understory will be kept fairly open as it was at the time of the battle.

Category B woodlots served primarily as screens for army movements and positions, and are best interpreted and preserved as topographic features. Height of the overstory, mix of deciduous and coniferous species, and native species are important features in perpetuating these woodlots. Maintaining the understory conditions like at the time of the battle is of lesser importance in

[1]This research was supported by U.S. Department of Interior, National Park Service Mid-Atlantic Region under Cooperative Agreement 400-9-8004.
[2]School of Forest Resources, The Pennsylvania State University, University Park, PA 16802; Pennsylvania Cooperative Fish and Wildlife Research Unit, University Park, PA 16802; and School of Forest Resources, The Pensylvania State University, University Park, PA 16802.

category B woodlots. These woodlots are to be managed to sustain an uneven-aged structure. Cultural practices to establish artificial and natural regeneration, control of non-native species and selective removal of the overstory canopy may be used to maintain the historic features of these woodlots (Gettysburg National Park 1992).

Fairweather and Cavanaugh (1990) evaluated the species composition and structure of ten Park woodlots. In general, they found that each woodlot had numbers of trees per diameter class that were suggestive of uneven-aged structures. Oaks (*Quercus* spp.) dominated the trees >33 cm DBH whereas non-oaks, mainly black cherry (*Prunus serotina* Ehrh.), flowering dogwood (*Cornus florida* L.), hickories (*Carya* spp.), white ash (*Fraxinus americana* L.) and black cherry (*Prunus* spp.), dominated the trees between 2.5 and 22 cm DBH (Figure 1). Tzilkowski et al. (1993) reported white ash and black cherry were the most abundant seedling-sized stems in six Park woodlots.

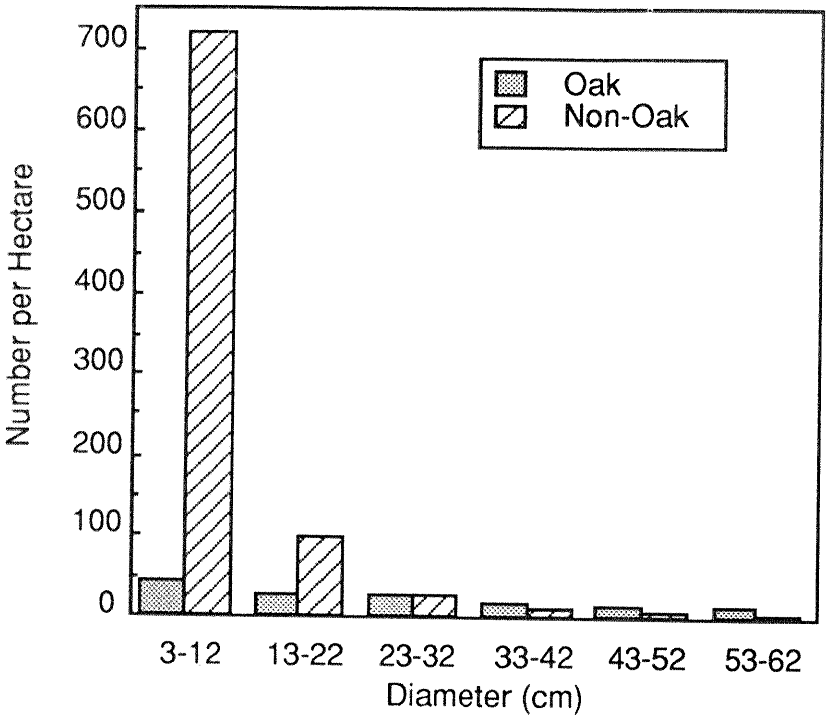

Figure 1.—Average number of trees per hectare for 10 woodlots inventoried 1989-1990 at Gettysburg National Military Park (Tzilkowski et al. 1992).

Deer browsing may account for the shift in species composition from oak dominated communities. Storm et al. (1992) have monitored white-tailed deer (*Odocoileus virginianus*) populations on 2833 ha adjacent to and within the Park since 1987. They used mark-resight and area conversion methods to estimate abundance. The mark-resight method was a bias-adjusted Lincoln-Peterson estimator (Otis et al. 1978, Seber 1982:60, White et al. 1982:19). The area conversion method was a census from complete counts on sample plots. Number of deer in each compartment counted in April varied considerable among the compartments within years but there was an overall increasing trend by compartment from 1987 to 1992 (Figure 2). Overall, April mark-resight estimates increased from 721±60 in 1987 to 1149±57 in 1992. Density increased from 0.25 white-tailed deer per hectare of total land (forested and non-forested) in 1987 to 0.40 per hectare in 1992. These values far exceed the Pennsylvania Game Commission management goal of 0.05 white-tailed deer per hectare for Adams County (Storm et al. 1989). There were no quantitative estimates of

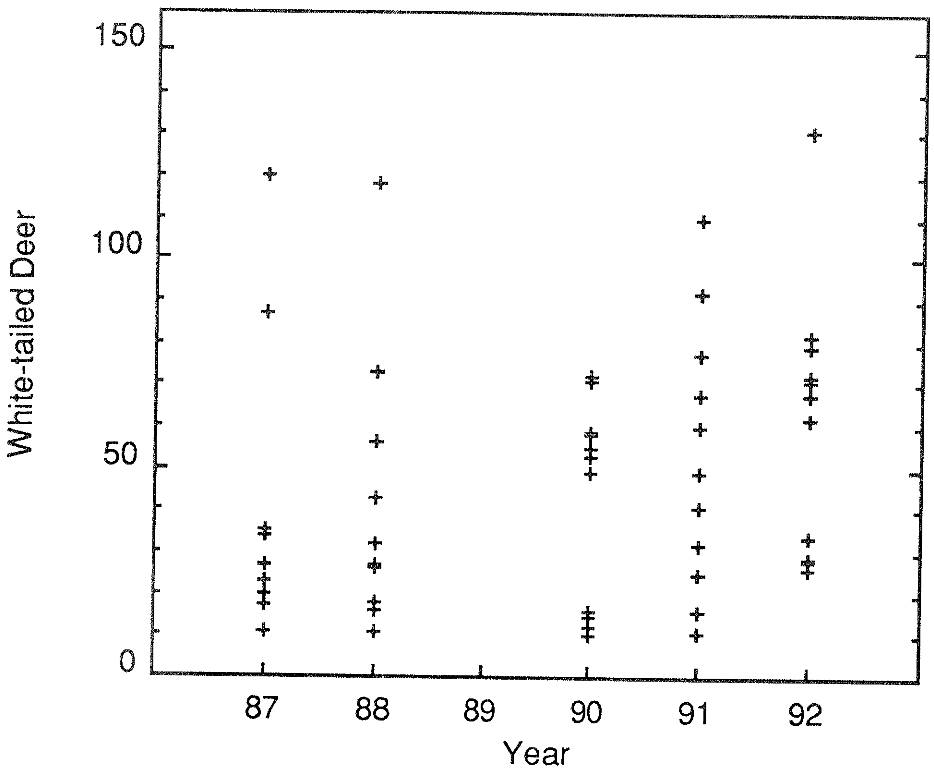

Figure 2.—April evening counts of white-tailed deer for the 11 compartments by year. Each point is an average of three inventories. There were no inventories in 1989.

white-tailed deer abundance prior to 1987 but Park personnel have considered the population to be high for at least 20 years. Storm et al. (1992) have also evaluated the availability and use of woody twigs by white-tailed deer in six Park woodlots. White ash, mazzard cherry (*Prunus avium* L.) and black cherry were most abundant twigs within 1.8 m of ground level with 6,868, 13,359 and 11,166 twigs per hectare, respectively. All oak species totaled 1,661 twigs per hectare. Frequency of browsing on the oak species ranged from none for pin oak (*Quercus palustris* Muenchh.) to 100% for black oak (*Q. velutina* Lam.). White ash and mazzard cherry and black cherry were also browsed with 44, 25 and 24%, respectively, of the twigs clipped by white-tailed deer.

Woodlot management practices may also account for the lack of oak seedlings, saplings and small diameter trees. Storm et al. (1992) evaluated the regeneration present in a pair of 10 x 10 m fenced and unfenced plots in five Park woodlots. Initially in 1987, there were 70,750 seedling-sized woody stems per hectare in the fenced plots and 73,250 stems per hectare in the unfenced plots (Figure 3). After the 1991 growing season the values dropped to 61,250 in the fenced areas and 42,250 in the unfenced areas. Loss of seedling-sized stems between 1987 and 1991 was substantial for white oak which dropped from 26,500 to 7,875 per hectare in the fenced areas and from 36,750 to 4,875 per hectare in the unfenced areas. There was considerable variation among the woodlots and the sample size was small. Nevertheless, these data suggest that seedling survival was being influenced by some factor in addition to white-tailed deer. Competition or interference from the overstory vegetation is one possible reason for seedling mortality. Openings in the canopy may be needed to establish replacements for stems lost to natural mortality, enhance the vigor of the remaining stems and maintain a healthy, sustainable stand structure.

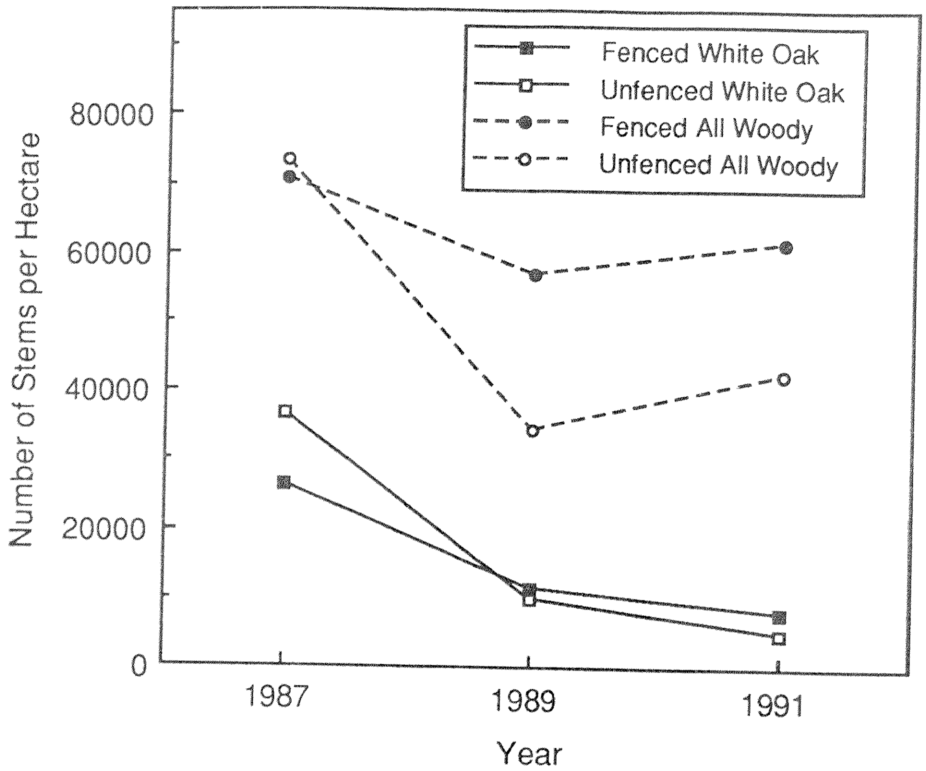

Figure 3.—Abundance of white oak and all woody seedling-sized stems in fenced and unfenced plots, by year of inventory.

Regeneration practices need to be organized so the richness of the flora and fauna in mixed oak communities will be maintained or strengthened. Even-aged regeneration methods are usually recommended for mixed oak stands because light is frequently the factor regulating seedling and sapling growth of most species common to the mixed oak stands. Selective removal of the overstory was a common practice in the woodlots surrounding Gettysburg in 1863. Fairweather and Cavanaugh (1990) suggested that selective cutting, with reduced browsing by white-tailed deer, could be used to increase the abundance of desirable species in the smaller size (younger age) classes. Single tree selection methods have been successful for regenerating shade tolerant species, such as sugar maple (*Acer saccharum* Marsh.). By varying the opening size from 0.08 to 0.81 hectares,, group selection has the potential to promote shade intolerant species.

There are several unknowns that seriously limit the application of selective cutting to any of the Category B mixed oak woodlots. These unknowns are:

1. What size openings in the canopy will be needed to establish and maintain a rich mixture of herbaceous and woody species?

2. Can the planting of seeds, seedlings or saplings be used to establish species that are difficult to regenerate naturally?

3. How can the white-tailed deer influence the nature and composition of the ground level vegetation?

Historical, cultural, biological, ecological and visual values need to be carefully integrated into the restoration and maintenance program for Category B woodlots. A research project has been developed to evaluate the effects of various sized openings in the overstory canopy, with and without white-tailed deer, on the ground level vegetation. This paper describes the development of canopy opening treatments to meet the unique management needs of the Park, and summarizes the pre-treatment understory conditions.

CANOPY TREATMENTS

Regeneration potential is being evaluated in three Category B mixed oak woodlots at the Park. These woodlots are Bushman Hill (22 ha), Herr Ridge (17 ha) and Powers Hill (21 ha). Bushman Hill had 860 trees per hectare, 25.70 m2 of basal area per hectare and was 108% stocked. Herr Ridge was 95% stocked with 717 trees per hectare and 21.35 m2 per hectare of basal area. Powers Hill had 810 trees per hectare, 16.50 m2 of basal area per hectare and was 73% stocked. The gently rolling topography of the Park is in the Piedmont physiographic region of south central Pennsylvania. Bushman Hill and Powers Ridge have many large diabase boulders on mostly well drained Neshaminy (Ultric Hapludalf; fine-loamy, mixed, mesic) and poorly drained Towhee (Typic Fragiaqualf; fine-loamy, mixed, mesic) soils. Herr Ridge has mostly poorly to moderately well drained Lehigh soils (Aquic Hapludalf; fine-loamy, mixed, mesic) and poorly drained Croton (Typic Fragiaqualf; fine-silty, mixed, mesic) soils. These soils were derived from shale and limestone with diabase intrusions. Site quality was about average and if occupied by even-aged stands the site index for oak would be ≥70. All woodlots were >130 years old with uncertain histories before 1895 when the Park was established by the US War Department. No silvicultural activity has occurred in the three woodlots since 1895.

Each study stand will receive three replications of three overstory treatments. These treatments are:

1. Closed. A circular area of 0.2 hectares that is at the closed or fully occupied canopy level. This level will provide information on the regeneration potential with no openings in the overstory canopy. In these areas, direct sunlight can reach the understory vegetation as sun flecks. Indirect sunlight reaching the forest floor will be about 50% of maximum. Root competition from the residual trees on the seedlings and saplings should be very high.

2. Small. A circular area of 0.2 hectares in which the overstory canopy will be reduced to 60% of fully occupied level. Reductions in the canopy will be from single trees that have died or could be cut. This treatment will be representative of the single tree selection method of regeneration. In these areas, direct sunlight through the small openings in the canopy will add to the direct sunlight from sun flecks. Indirect sunlight reaching the forest floor will be increased by openings in the canopy and it is estimated that the amount of indirect sunlight will be about 75% of maximum. Root competition from the residual trees on the seedlings and saplings should be about 60% of full stocking levels.

3. Large. Natural openings from multi-tree mortality or possible tree felling that would have 50% of the opening receiving at least 6 hours of direct sunlight and 100% of the indirect light potential. These circular areas of about 0.2 hectares would be representative of the group section method of regeneration in which the opening radius would be about equal to tree height. Root competition from the residual trees on the seedlings and saplings should be near zero in the center of the openings.

Each woodlot was inventoried to determine the number of trees by species and diameter. Sample points were located in each woodlot on a 60 x 60 m grid which had random starting points. There were at least 15 sample points in each woodlot. Number of living trees by species and diameter at 1.4 m above ground (DBH) were recorded on a circular 202 m^2 plot. Woodlot species and size data were reviewed with Park staff to establish a stand structure that has the biological potential of meeting the Park's vegetation management objectives. A "target" stand structure was developed for each woodlot. Normally, trees exceeding the goal or target number in each diameter class would be removed. However, trees >42 cm DBH were designated by the Park as having the potential of being present in 1863, and should be reserved for their historic value. As the size of the potential historic tree increases with time, there will be less need to comprise the target stand structure or restrict the placement of large canopy openings.

Small Canopy Opening Treatments

Fairweather and Cavanaugh (1990) suggested that the diameter distribution described by a q=2 (by 5 cm diameter classes) should be appropriate for many of the Category B woodlots. This relationship was used to develop a stand structure, which was defined by having:

a. A DBH of 75 cm as the maximum sized tree.
b. An after-treatment stocking level of 60% of full stocking.

Stocking levels were determined from the stocking charts described by Roach and Gingrich (1968). As described above, the Park did not want to remove trees which were >42 cm DBH. Therefore, criteria for tree removal were:

a. Trees <42 cm DBH.
b. By size, trees in excess of the goal level which were of:
   1. Poor health and not likely to be alive in 15 years.
   2. Species that were in abundance.
   3. Species not likely achieve diameters >42 cm DBH.

For some plots it was necessary to remove trees >42 cm DBH to reduce the overstory stocking to 60%.

A target structure, and typical before cut and after cut structure is given in Figure 4. In all small canopy treatment cases, it was necessary to remove more trees <42 cm then would be normally desired. This necessity was not viewed as a major problem, particularly in the <20 cm diameter classes. These diameter classes were dominated by shrub species of flowering dogwood, redbud (*Cercis occidentalis* L.) and spicebush (*Lindra benzoin* L.). In most stands, the shrub species in the <20 cm size classes accounted for 50% of all stems.

Large Canopy Opening Treatment

Size and location of the natural openings in the overstory of each woodlot were recorded. These openings were the result of death or windthrow to overstory trees. Three natural openings were selected in each woodlot. Selected openings were representative of the range of conditions in the woodlot and had no apparent physical limitations to the establishment of regeneration. None of the natural openings had the required 2000 m^2 or 0.2 hectares free of overstory competition. The next option considered was to select openings that could be enlarged to the needed 0.2 hectares by cutting trees that were ≤42 cm. The last option considered was to enlarge the opening by removing trees >42 cm DBH using the same criteria as in the small canopy opening treatment.

REGENERATION

Wire fences 1.2 m high are being used to exclude white-tailed deer. Estimates of the free-ranging white-tailed deer densities for the unfenced areas will be obtained from actual surveys (Storm et al. 1989, Storm and Tzilkowski 1992)

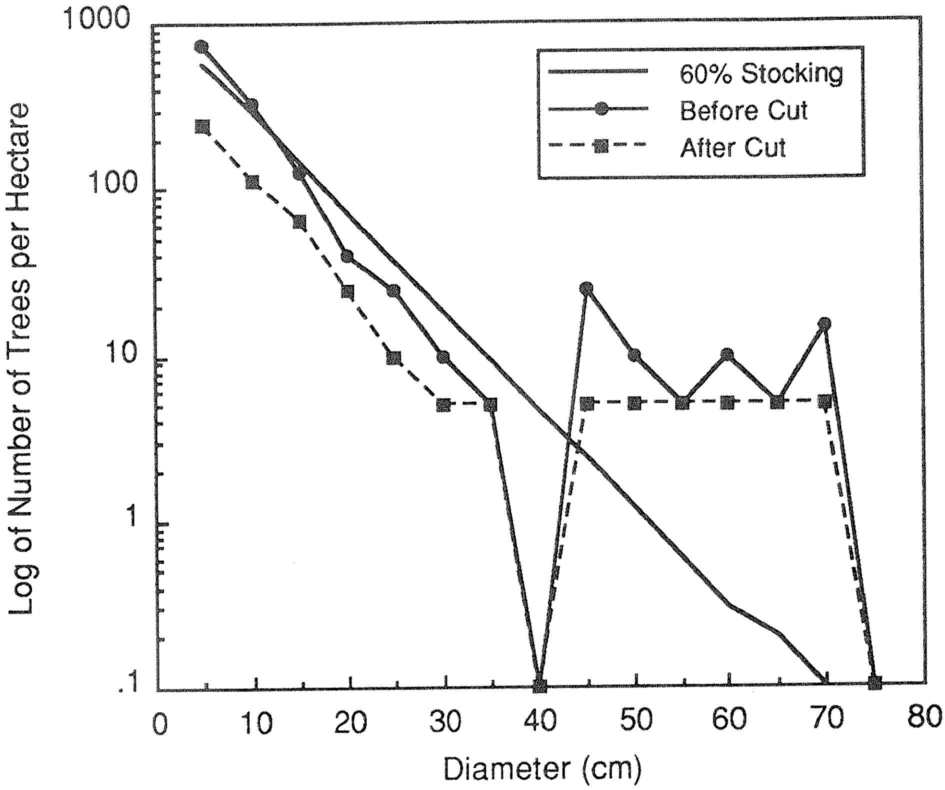

Figure 4.—An example small canopy opening treatment. Number of trees per hectare by 5 cm diameter (DBH) classes for a q of 2 and target stocking of 60%, number before cutting and number after cutting.

Abundance, composition and structure of understory vegetation were measured at the start of the study and will be measured the end of each growing season. We will measure and describe vegetation within each fenced and paired unfenced control plot based on the protocol developed by Storm and Ross (1992). Three pairs of fenced and unfenced 4.0 m2 plots have been established in each 0.20 hectares treatment unit to inventory the naturally established herbaceous and woody plant community. There will be 27 pairs of fenced and unfenced natural regeneration plots per canopy treatment for all study woodlots. For all study woodlots, there are a total of 81 paired natural regeneration plots. Herbaceous vegetation abundance and composition will be inventoried annually in June-July. Size and number of stems per woody species will be inventoried in May and October.

There were an average of 39,815 tree species stems per hectare and 55,865 shrub species stems per hectare for the three woodlots (Table 1). White ash dominated the tree species with an average of 19,800 stems per hectare. There was an average of 8,550 oak stems per hectare. Preliminary evaluations of the pre-treatment seedling-sized vegetation indicated no significant differences in the number of oaks, non-oak tree species, shrub species and total woody stems between the plots selected to be fenced and those to be unfenced. Overall, numbers of woody stems per hectare were significantly different for Bushman Hill (123,335), Herr Ridge (68,610) and Powers Hill (95,095) (Table 1). The average number of oak stems at Bushman Hill of 20,740 per hectare was significantly greater than the 2,408 and 2,871 stems per hectare at Herr Ridge and Powers Hill, respectively.

Table 1.—Average[1] number of stems per hectare for the three woodlots, by species group.

Species	Bushman Hill	Herr Ridge	Power Hill	Overall
	(———	number of stems per hectare	———	)
Oak	20,740a	2,408b	2,871b	8,673
Other tree	44,445a	10,185b	38,795a	31,142
Shrub	58,150a	56,020a	53,425a	55,865
Total	123,335a	68,610c	95,095b	95,680

[1] Woodlot means within species group with the same letter were not significantly different at the 5% level.

[2] Oaks included black, chestnut, northern red, scarlet and white.

[3] Other trees included American elm, bitternut hickory, black cherry, black gum, black walnut, eastern red cedar, hackberry, mazzard cherry, mockernut hickory, Norway maple, pignut hickory, red maple, shagbark hickory, sugar maple, white ash and yellow-poplar.

[4] Shrubs included blackhaw, euonymous, flowering dogwood, grape spp., Japanese barberry, redbud, rose spp., rubus spp., sassafras, serviceberry, spicebush and witch-hazel.

A second set of paired fenced-unfenced plots will be used to evaluate the potential for successfully establishing and growing northern red oak (*Quercus rubra* L.) from direct seeding and planting of seedlings and saplings. Northern red oak was selected as a representative of species difficult to regenerate by natural processes. There will be two 12 m^2 fenced and unfenced plot pairs per replication of each treatment in each woodlot. There will be 18 paired artificial regeneration plots per canopy treatment for all study woodlots. Over all study woodlots, there will be a total of 54 paired artificial regeneration plots. Each 12 m^2 plot will be maintained free of understory competition to evaluate the canopy opening treatments. Each plot will be seeded with 20 acorns, planted with 4 bare-root seedlings (0.5 m tall) and planted with 3 bare-root saplings (>1.0 m tall). In total, 2,160 acorns, 432 seedlings and 324 saplings will be planted at the start of the first growing season after canopy treatment. At the end of each growing season, survival, diameter at 1.4 m and height of the seedlings and saplings will be measured, analyzed and summarized.

SUMMARY

Selective cutting as part of an uneven-aged forest management program may be used to restore and maintain a diversity of native woody vegetation in Category B woodlots at Gettysburg National Military Park. There is limited knowledge on the effects of various sized openings in the overstory canopy, with and without white-tailed deer, on the ground level vegetation. This project is being conducted to determine the potential for installing overstory treatments and to compose the specific treatments. Closed, small and large canopy openings treatments were assigned to replicated locations within each of the three study woodlots. Individual trees were designated to be felled to achieve the specific canopy treatments. Actual treatments to the study woodlots have been approval by the National Park Service. These treatments will be implemented prior to the 1993 growing season.

LITERATURE CITED

Cavanaugh, C. M. 1990. Identification, restoration, and maintenance of historic woodlots at Gettysburg National Military Park. Master of Forest Resources Paper, The Pennsylvania State University, University Park, PA. 119 p.

Fairweather, S. E. and C. M. Cavanaugh. 1990. Identification, restoration, and maintenance of historic woodlots at Gettysburg National Military Park. U. S. Department of Interior, National Park Service, Technical Report NPS/MAR/NRTR - 90/049, Philadelphia, PA. 123 p.

Gettysburg National Military Park. 1992. Evaluation of Alternatives for Managing the Appearance of Cropfields and Woodlots. U. S. Department of Interior, National Park Service, Gettysburg, PA. 26 p.

Otis, D. L., R. P. Burnham, G. C. White and D. R. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monograph 62. 135 p.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters. Charles Griffin and Co., High Wycombe, England. 654 p.

Roach, B. A. and S. F. Gingrich. 1968. Evenaged silviculture for upland central hardwoods. U. S. Department of Agriculture, Forest Service Handbook 335. 39 p.

Storm, G. L., D. F. Cottam, R. H. Yahner and J. D. Nichols. 1992. A comparison of 2 techniques for estimating deer density. Wildlife Society Bulletin 20:197-203.

Storm, G. L., R. H. Yahner, D. F. Cottam, and G. M. Vecello. 1989. Population status, movements, habitat use, and impact of white-tailed deer at Gettysburg National Historic Site, Pennsylvania. U. S. Department of Interior, National Park Service, Technical Report NPS/MAR/NRTR - 89/043, Philadelphia, PA. 513 p.

Storm, G. L. and A. S. Ross. 1992. Manual for monitoring plant communities: forests on public-owned lands in Mid-Atlantic United States. Pennsylvania Cooperative Fish and Wildlife Research Unit, MANV-00192. Pennsylvania State University, University Park, Pa. 89 p.

Storm, G. L. and W. M. Tzilkowski. 1992. Plant community development in historic woodlots in Gettysburg National Military Park. U. S. Department of Interior, National Park Service and Penn State University Cooperative Agreement 4000-9-8004. 5 p.

Tzilkowski, W. M., S. E. Fairweather, G. L. Storm and T. W. Bowersox. 1993. Forest regeneration and white-tailed deer at Gettysburg National Military Park. Proceedings of Seventh Conference on Scientific Research and Management in National Parks. (In press).

White, G. C., D. R. Anderson, K. P. Burham and D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. U. S. Department of Energy LA-8787. Los Alamos National Laboratory, NM. 235 p.