National Park Service
U.S. Department of the Interior

Northeast Region
Philadelphia, Pennsylvania

Vegetation Status in Selected Woodlots at Gettysburg National Military Park Pre and Post White-tailed Deer Management

Technical Report NPS/NER/NRTR--2006/037



ON THE COVER
Bushman Hill Woodlot in 2002.
Photograph by Todd Bowersox.

Vegetation Status in Selected Woodlots at Gettysburg National Military Park Pre and Post White-tailed Deer Management

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March 2006

U.S. Department of the Interior
National Park Service
Northeast Region
Philadelphia, Pennsylvania

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This report was accomplished under Cooperative Agreement CA4000-8-9028, Task/Supplemental Agreement Number 26 with assistance from the NPS. The statements, findings, conclusions, recommendations, and data in this report are solely those of the author(s), and do not necessarily reflect the views of the U.S. Department of the Interior, National Park Service.

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Please cite this publication as:

A. T. Niewinski, T. W. Bowersox, R. L. Laughlin. March 2006. Vegetation Status in Selected Woodlots at Gettysburg National Military Park Pre and Post White-tailed Deer Management. Technical Report NPS/NER/NRTR--2006/037. National Park Service. Philadelphia, PA.

NPS D-177 March 2006

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Executive Summary

Three types of plots (Demonstration, Long-term Monitoring, and Canopy Treatment) were established in Gettysburg National Military Park (NMP) woodlots between 1986 and 1992 to assess vegetation status over time in response to natural processes and experimental changes. The overall objective of these studies was to determine the regeneration and recruitment success of the mixed oak hardwood forests in the park. Specifically the studies were designed to 1) determine what impacts, if any, white-tailed deer were having on the presence of tree species, and 2) measure understory response to openings in the overstory canopy.

Long-term vegetation monitoring was started at Gettysburg NMP in 1986/87 with un-replicated Demonstration Plots in six woodlots (Biesecker, Bushman Hill, Cobean, Pitzer, Slyder, and Spangler). One pair of fenced and unfenced plots in each of the six woodlots was intended to demonstrate differences in the development of vegetation with and without the presence of deer. The Demonstration Plots were inventoried in 1986/87, 1989, 1991, 1994, 1996, and 2002. To describe the status of closed canopy woodlot plant community conditions and the effects of deer foraging on understory vegetation, sets of Long-term Monitoring Plots were established in 1990/92 in six woodlots (Biesecker, Bushman Hill, Herr Ridge, Pitzer, Powers Hill, and Spangler). In 1990, fifteen fenced and fifteen unfenced plots were established in Biesecker woodlot. In 1991, thirty unfenced plots were established in Pitzer woodlot. In 1992, fifteen unfenced plots were established in Bushman Hill, Herr Ridge, Powers Hill, and Spangler woodlots. In 1993, fifteen of the thirty plots already located in the Pitzer woodlot were randomly selected and a 3 x 3 m fence enclosure was constructed in the center of the plot. The Long-term Monitoring Plots were inventoried in 1990/92, 1996, and 2002. Finally, to evaluate understory response to openings in the canopy, replicated Canopy Treatment Plots were installed in three woodlots (Bushman Hill, Herr Ridge, and Powers Hill) in the summer of 1992. Three different overstory canopy treatments, closed canopy (control), partially open canopy (60% of the original overstory canopy remained), and open canopy (all overstory trees removed), were established within each of these woodlots. There were three replications of each canopy treatment within each woodlot for a total of 27 woodlot-treatment plots. The discussion includes baseline (pre-treatment) data results from 1992 and post-treatment data results from inventories in 1994, 1996, and 2002.

Management objectives for Gettysburg NMP include 1) the conservation of important features of the Gettysburg Battlefield Historic District which are necessary for maintaining the rural, agricultural, and memorial character of Gettysburg and conveying to visitors why, where, and how the battle occurred, 2) using the battlefield setting as the primary interpretive resource, and 3) managing the park as a memorial landscape which not only reflects the pre-battle 1863 rural agricultural environment but includes superimposed post-battle elements necessary for commemoration and visitor understanding of the battle (USDI NPS 1995). White-tailed deer and non-native plant species had altered the presence and appearance of understory vegetation thereby making preservation of historic woodlots and interpretation of the battle events difficult for National Park Service personnel.

In 1987, the white-tailed deer density in the 2,862 ha Gettysburg study area was 264 deer/forested square mile (Storm et al. 1992). It increased to 333 deer/forested square mile in 1990 and to 325 deer/forested square mile in 1995 (Storm et al. 2004) (Appendix A). The deer density is for the spring season before new fawns are born. There is high potential for a conversion over time of tree species from oak and hickory to ash and black cherry in areas with high densities of white-tailed deer (Storm et al. 2002, Horsley et al. 2003). In the long term, selective feeding by deer could change the species composition and structure of the forest overstory (Storm et al. 2002). The White-tailed Deer

(*Odocoileus virginianus*) Management Program (Deer Management Program) was started in late 1995 within Gettysburg NMP (Frost et al 1997) to reduce the deer population to the initial goal density of 25 deer/forested square mile and achieve the park's woodlot stocking level goals (USDI NPS 1995). Subsequently, the stocking level goals were reduced to 60% stocking level in order to encourage new recruitment to become established in the woodlots and maintain an uneven-aged tree diameter distribution. The current woodlot stocking level goals are 16,834 seedling tree stems/ha, 2,806 small sapling tree stems/ha, 935 large sapling tree stems/ha, and 306 overstory tree stems/ha (Bowersox 2002). Due to personnel limitations, time restrictions, effectiveness of the control action, movement of deer into the park, and deer productivity, it was expected to take three to four years to achieve the desired deer density goal. The deer population would then be maintained at the desired density goal of 25 deer/forested square mile until results of the woodlot monitoring determined if a change in the initial density goal was required to meet management objectives and woodlot stocking level goals (USDI NPS 1995). The initial reduction effort lowered the density to 158 deer/forested square mile in March 1996 and continued efforts reduced the density to 49 deer/forested square mile in March 2002 (Storm 2004). The initial deer density goal of 25 deer/forested square mile has not yet been achieved.

In both the fenced and unfenced Demonstration Plots, the trend over six woodlots was a decline in seedling tree density and an increase in seedling shrub density from 1986/87 to 2002. From 1986/87 to 1996 there had been a consistent trend of decreasing seedling tree densities in both the fenced and unfenced plots, with the unfenced plots always having fewer seedling tree stems than the fenced plots. However, in 2002 there were more seedling trees in the unfenced plots than in the fenced plots. The reason for the increase in seedling tree density in the unfenced plots between 1996 and 2002 was due to the reduced deer foraging after the implementation of the Deer Management Program in 1995. Seedling tree densities within the fenced Demonstration Plots continued to decrease from 1996 to 2002 because of competition with seedling and sapling shrub species and a build-up of leaf litter within the fenced area. Over all woodlots and both the fenced and unfenced treatments, seedling tree and shrub species diversity increased over time.

In the Long-term Monitoring Plots, there was a trend of decreasing tree species diversity in all size classes from 1990/92 to 1996. From 1996 to 2002, however, there were improvements in species diversity of seedling, sapling, and overstory tree species among the woodlots, with the exception of Herr Ridge woodlot. The increases in seedling and sapling tree species diversity was closely linked to the implementation of the Deer Management Program in 1995. Conversely, the diversity of seedling and sapling oak species and density of oak seedlings and saplings were low, and in the unfenced plots (Biesecker and Pitzer woodlots) the density of oak seedlings declined between 1990/92 and 2002. Over all woodlots, the diversity of seedling and sapling shrub species increased from 1996 to 2002. The invasion and subsequent growth of non-native plant species has increased in all six woodlots.

Among all Long-term Monitoring Plots, the density of large sapling trees decreased from 765 stems/ha in 1990/92 to 456 stems/ha in 2002, consistently lower than the 60% stocking level goal of 935 stems/ha. The lowest densities of large and small sapling trees were recorded in 2002. Over all woodlots, small sapling tree density decreased from 116 stems/ha in 1990/92 to 69 stems/ha in 2002, less than 3% of the 60% stocking level goal of 2,806 stems/ha. Large sapling shrub densities increased over time but were always lower than large sapling tree densities. From 1996 to 2002, the overall small sapling shrub density increased from 69 to 833 stems/ha.

The density of seedling trees decreased among all the unfenced Long-term Monitoring Plots between the 1990/92 and 1996 inventories (20,917 and 14,665 stems/ha, respectively), then increased to 27,260 stems/ha in 2002. Herr Ridge woodlot had declining unfenced seedling tree densities from 1990/92 to

2002, which was probably due to the difficulty in reducing the deer density in that area of the park. Over all woodlots, unfenced seedling shrub densities increased substantially with a doubling of density between 1996 and 2002 (20,508 and 41,251 stems/ha, respectively). In Biesecker and Pitzer woodlots, the density of unfenced oak seedlings steadily decreased over the 1990/92, 1996, and 2002 inventories. By 1997, the Deer Management Program was successful in reducing the white-tailed deer population to less than 20% of the pre-1995 implementation levels in both the Biesecker and Pitzer woodlots (Storm 2004). Therefore, white-tailed deer browsing was not the only reason for oak species seedling decline in these two woodlots after 1996. Light restrictions due to dense overstory canopy, understory competition with shrub species, and small mammal predation were probably having negative impacts on the presence of oak species. Seedling and sapling tree species' densities should improve with continued reduction of the white-tailed deer herd, removal of non-native shrub species, and opening of the overstory tree canopy to the recommended 60% stocking level.

Canopy treatments were experimentally applied to unfenced 0.2 ha areas in Bushman Hill, Powers Hill, and Herr Ridge woodlots in 1992. Sapling plots and seedling subplots were established within the treatment areas. In general, in all canopy treatments and woodlots, sapling tree diversity and density improved between 1992 and 2002 with the greatest increases occurring from 1996 to 2002. Although sapling tree densities improved among all the canopy treatments between 1992 and 2002, sapling (large and small combined) tree densities among all three canopy treatments in 2002 in Bushman Hill (633 stems/ha), Herr Ridge (1,622 stems/ha), and Powers Hill (581 stems/ha) woodlots were substantially less than the 60% stocking level goal for total saplings (3,741 stems/ha) necessary for adequate recruitment. The reason for the lower sapling tree densities may be a combination of intense competition with native and non-native shrub species, poor growing conditions due to light restrictions, and continued browsing by white-tailed deer.

Sapling shrubs benefited from the open canopy treatments more than sapling trees. Over time, there were more sapling shrub species than tree species under all three, canopy treatments. The shrub species were opportunistic of the favorable conditions provided in the open canopy treatments and were able to exploit the resources and grow faster than the tree species. The abundance of sapling shrubs, especially in the open canopy treatments, may have had a deleterious effect on the recruitment of seedling tree and shrub species. The biggest change over time was in the abundance of non-native species, mainly Japanese honeysuckle, Japanese barberry, and multiflora rose. In 2002, non-native shrubs combined comprised 46% of the total sapling shrub density over all canopy treatments and woodlots. Spicebush was the dominant native sapling shrub (4,381 stems/ha) in 2002 comprising 39% of the total sapling shrub density over all woodlots and canopy treatments.

There were increases in native seedling tree species diversity and seedling tree height in the Canopy Treatment Plots since the implementation of the Deer Management Program. Over all canopy treatments in 2002, the seedling tree densities were above the 60% stocking level goal of 16,834 stems/ha in Bushman Hill (36,111 stems/ha) and Powers Hill (28,889 stems/ha) woodlots but not in Herr Ridge woodlot (6,111 stems/ha). Over all woodlots in 2002, seedling tree densities were adequate in the closed (27,500 stems/ha) and partially open (37,222 stems/ha) canopy treatments but not in the open canopy (6,389 stems/ha) treatments. The increase in seedling tree density in the partially open and closed canopy treatments was due to the combination of reduced white-tailed deer herbivory after 1995 and less competition with shrub species than in the open canopy treatments. Although seedling tree densities were lowest in the open canopy treatments in 2002, the more favorable growing conditions when the plots were first established in 1992 enabled the initial seedlings to achieve greater height growth and grow into saplings between 1994 and 1996. By 2002, over all woodlots, more seedling trees had grown into the sapling size category in the open canopy treatments

than in either of the other two canopy treatments. However, seedling trees were not surviving or growing into the upper height classes and being recruited in sapling trees at densities sufficient to achieve the historic forest overstory as described in Fairweather and Cavanaugh (1990).

It is likely that the density of seedling shrubs influenced the presence and growth of seedling trees in the Canopy Treatment Plots. Among all woodlots and canopy treatments, the seedling shrub density increased from 37,834 stems/ha in 1992 to 64,444 stems/ha in 2002. Seedling shrub density was three times greater than seedling tree density (23,704 stems/ha) over all woodlots in 2002. Two native shrub species, *Rubus* and spicebush, were the dominant seedling shrub species with densities of 24,352 and 20,463 stems/ha, respectively, in 2002. Non-native seedling shrubs combined comprised 15% of the total seedling shrub density in 2002.

The National Park Service's initiative in reducing the white-tailed deer herd has enabled the establishment of a sustainable understory. The lower number of white-tailed deer in some woodlots has resulted in greater seedling tree presence and growth. In Herr Ridge woodlot, where the white-tailed deer herd has not been reduced as much as in other areas of the park due to proximity of residential housing and a golf course, the density of seedling tree species was much lower than in the other woodlots. The partially open canopy conditions created by removing individual trees were effective in increasing seedling tree species diversity and density. Multiple-tree openings in the canopy were effective in providing the conditions for seedlings to grow into saplings. Overall, in 2002 there was good potential for tree species to regenerate the woodlots at Gettysburg NMP. Although these studies were not designed to evaluate the effects of non-native invasive plants on the understory tree species, there were strong implications that these plants were poised to expand their presence. The woodlots exhibited the potential to reproduce a great diversity of seedling tree species at densities great enough to regenerate healthy woodlots. Overall, seedling densities increased from 1996 to 2002, exceeding the 60% stocking level goals. Although sapling tree densities generally improved after 1996, the average total sapling (small and large combined) densities over all three types of study plots ranged from 450 to 945 stems/ha, only 12 to 25% of the 60% stocking level goal (3,741 stems/ha) in 2002.

Continuation of the Deer Management Program is vital for an increase in native tree species diversity and height of tree stems. The initial deer density goal of 25 deer/forested square mile has yet to be achieved park-wide. Plant data collected in the summer of 1996 were considered to be representative of conditions prior to the deer population reduction. Data from the 2002 inventory were representative of reduced white-tailed deer populations but not indicative of the effect that would have been achieved had the deer density been at the goal for the previous four to five years. As stated in the final environmental impact statement, the decision to make any adjustments to the deer density goal can not be made until vegetation is resurveyed after the deer density has been maintained at 25 deer/forested square mile for a period of four to five years (USDI NPS 1995). Any effects of a change in level of deer browsing on the presence and growth of tree seedlings would not be known for at least four years, since it takes approximately that long to determine if tree seedlings have become successfully established. A poor seed crop, severe drought, or other environmental factors could affect the establishment of seedlings in the woodlots and extend the length of that period (Todd Bowersox, Professor of Silviculture, The Pennsylvania State University, personal communication). The Pennsylvania Department of Environmental Protection declared Adams County under drought emergency status in 1999 and 2002, and under a drought watch in 2001 (http://www.dep.state.pa.us/dep/subject/hotopics/drought.news.htm).

Therefore, to sustain a healthy diversity and density of native seedling, sapling, and overstory tree and shrub species that will perpetuate the appearance and composition of the historic 1863 woodlots (Fairweather and Cavanaugh 1990) in Gettysburg National Military Park, it is recommended to:

1. Continue to implement the Deer Management Program to reach the goal of 25 deer/forested square mile (USDI NPS 1995), periodically evaluate the effectiveness of this density, and adjust the goal accordingly, if necessary.
2. Continue executing the Exotic Plant Management Program within the park to control the non-native, invasive plant species.
3. Fully implement the park-wide plan for increasing the sustainability of woodlots (Bowersox 2002), where the removal of individual non-sustainable overstory trees will create openings in the canopy to improve the health, vigor, and density of native seedling tree species. Woodlot stocking should be maintained between the 60% and 80% level of full stocking.
4. Develop a plan to recruit seedling tree stems into sapling stems and then into the overstory to replace the aging trees where there is a mixture of vigorous native tree species seedlings that have a competitive advantage over the herbaceous and shrub plants. Although canopy openings of 0.2 ha (radius 21 m) were tested, it is believed that similar opportunities for seedlings to become canopy tree replacements can be achieved with a combination of single-tree and multiple-tree openings (0.05 to 0.1 ha) to reduce the stock to a 45-55% level.
5. Develop a long-term vegetation monitoring program for all wooded areas that are ≥2 ha. The program should be designed to document changes in plant diversity and density for all sizes of tree and shrub species, and forb, grass, grass-like, and vine species groups. When choosing plot locations, take into consideration the effect of moisture on regeneration. Inventory frequency need not be greater than once every five years, but not less than once every ten years.

Summary

Three types of plots (Demonstration, Long-term Monitoring, and Canopy Treatment) were established in Gettysburg National Military Park (NMP) woodlots between 1986 and 1992 to assess vegetation status over time in response to natural processes and experimental management changes. Descriptions of the three types of study plots are summarized in Bowersox et al. 2004. There were several objectives for monitoring woodlot vegetation in Gettysburg National Military Park. The primary objective was to determine if the woodlots are capable of regenerating mixed-oak hardwood forests comparable to the historic woodlot conditions of July 1863 (Fairweather and Cavanaugh 1990). The other two main objectives were to determine what impacts, if any, white-tailed deer were having on the presence and growth of tree species, and to measure understory responses to creating openings in the overstory canopy. The current condition of the woodlots in the park are not characteristic of the historic woodlots due to a number of factors, including but not limited to land use changes, white-tailed deer browsing, and invasive, non-native plant species competition. White-tailed deer and non-native plant species alter the presence and appearance of understory vegetation thereby making preservation of historic woodlots and interpretation of the battle events difficult for National Park Service personnel.

This report (1) provides the complete 2002 inventory results for the Demonstration, Long-term Monitoring, and Canopy Treatment plots, (2) summarizes the trends in tree and shrub species diversity and density from initial baseline data to the inventory in 2002 for all three types of study plots, (3) provides an assessment of the success of the park's Deer Management Program (USDI NPS 1995) for increasing the diversity and density of tree species, and (4) recommends management strategies to achieve the park's goals (USDI NPS 1995) for returning the woodlots to and sustaining them as historic mixed-oak forests.

Long-term vegetation monitoring was started at Gettysburg NMP in 1986/87 with un-replicated Demonstration Plots in six woodlots (Biesecker, Bushman Hill, Cobean, Pitzer, Slyder, and Spangler). One pair of fenced and unfenced plots in each of the six woodlots was intended to demonstrate differences in the development of vegetation with and without the presence of deer. The Demonstration Plots were inventoried in 1986/87, 1989, 1991, 1994, 1996, and 2002. To describe the status of closed canopy woodlot plant community conditions and the effects of deer foraging on understory vegetation, sets of Long-term Monitoring Plots were established in 1990/92 in six woodlots (Biesecker, Bushman Hill, Herr Ridge, Pitzer, Powers Hill, and Spangler). In 1990, fifteen fenced and fifteen unfenced plots were established in Biesecker woodlot. In 1991, thirty unfenced plots were established in Pitzer woodlot. In 1992, fifteen unfenced plots were established in Bushman Hill, Herr Ridge, Powers Hill, and Spangler woodlots. In 1993, fifteen of the thirty plots already located in the Pitzer woodlot were randomly selected and a 3 x 3 m fence enclosure was constructed in the center of the plot. The Long-term Monitoring Plots were inventoried in 1990/92, 1996, and 2002. Finally, to evaluate understory responses to openings in the overstory canopy, replicated Canopy Treatment Plots were installed in three woodlots (Bushman Hill, Herr Ridge and Powers Hill) in the summer of 1992. Within each of these woodlots, three different canopy treatments, closed canopy (control), partially open canopy (60% of the original overstory canopy remaining), and open canopy (all overstory trees removed), were established. There were three replications of each canopy treatment within each woodlot, for a total of 27 woodlot-treatment plots. The discussion includes baseline (pre-treatment) data results from 1992 and post-treatment data results from inventories in 1994, 1996, and 2002.

Management objectives for Gettysburg NMP include 1) the conservation of important features of the Gettysburg Battlefield Historic District which are necessary for maintaining the rural, agricultural, and memorial character of Gettysburg and conveying to visitors why, where, and how the battle occurred, 2) using the battlefield setting as the primary interpretive resource, and 3) managing the park as a memorial landscape which not only reflects the pre-battle 1863 rural agricultural environment but includes superimposed post-battle elements necessary for commemoration and visitor understanding of the battle (USDI NPS 1995). White-tailed deer and non-native species alter the appearance of understory vegetation thereby making interpretation of battle events difficult for National Park Service personnel.

In 1987, the white-tailed deer density in the 2,862 ha Gettysburg study area was 264 deer/forested square mile (Storm et al. 1992). It increased to 333 deer/forested square mile in 1990 and to 325 deer/forested square mile in 1995 (Storm et al. 2004) (Appendix A). The deer density is for the spring season before the new fawns are born. There is high potential for a conversion over time of tree species from oak and hickory to ash and black cherry in areas with high densities of white-tailed deer (Storm et al. 2002). In the long term, selective feeding by deer could change the species composition and structure of the forest overstory (Storm et al. 2002, Horsley et al. 2003). The White-tailed Deer (*Odocoileus virginianus*) Management Program was started in late 1995 within Gettysburg NMP (Frost et al 1997) to reduce the deer population to the initial goal density of 25 deer/forested square mile and achieve the park's woodlot stocking level goals (USDI NPS 1995). Subsequently, the stocking level goals were reduced to 60% stocking level in order to encourage new recruitment to become established in the woodlots and maintain an uneven-aged tree diameter distribution. The current woodlot stocking level goals are 16,834 seedling tree stems/ha, 2,806 small sapling tree stems/ha, 935 large sapling tree stems/ha, and 306 overstory tree stems/ha (Bowersox 2002). Due to personnel limitations, time restrictions, effectiveness of the control action, movement of deer into the park, and deer productivity, it was expected to take three to four years to achieve the desired deer density goal. The deer population would then be maintained at the desired goal density of 25 deer/forested square mile until results of the woodlot monitoring determined if a change in the desired density goal was required to meet management objectives and woodlot stocking level goals (USDI NPS 1995). The initial reduction effort lowered the density to 158 deer/forested square mile in March 1996 and continued efforts reduced the density to 49 deer/forested square mile in March 2002 (Storm 2004). The initial deer density goal of 25 deer/forested square mile has not yet been achieved.

Besides the cultural practices that have changed and subsequently altered the Gettysburg NMP woodlots from historic conditions, another more insidious problem has developed. Multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*), autumn olive (*Elaeagnus umbellate*), Tartarian honeysuckle (*Lonicera tatarica*), and a few other non-native species are beginning to impact the park's natural environment. One hundred years ago, these deleterious non-native species were not a problem because they had not been introduced into the wild. They are now competing with the native vegetation. Invasive, non-native species have the benefit of growing unchecked by natural predators, reproducing prolifically, and in many situations successfully out-competing native vegetation for light, moisture, and nutrients. Due to the established populations of these non-native species, any intensive management plans for the removal of overstory trees will have to be preceded by the chemical and/or mechanical control of the non-native shrub species. Failure to control the non-native species prior to creating gaps in the canopy will result in their eventual colonization of the area beneath. The spread of the non-native species was a significant factor in the results of the monitoring plots. Non-native species like multiflora rose (rose), Japanese barberry, Tartarian honeysuckle, and autumn olive were able to colonize sites more quickly than native tree and shrub species due to their invasive and competitive nature. Once established, the non-native species have the propensity to

eliminate native tree, shrub, and herbaceous vegetation. Mile-a-minute weed was seen growing in Bushman Hill woodlot in 2002 but it was not recorded within a study plot.

Demonstration Plots

Over all woodlots, the trend was a decline in seedling tree density from 1986/87 to 2002 in both the fenced and unfenced plots. Among the fenced Demonstration Plots, the density decreased from 56,167 to 10,283 stems/ha from 1986/87 to 2002. Among the unfenced plots, the density decreased from 39,167 stems/ha in 1986/87 to 1,150 stems/ha in 1996, but then increased to 12,150 stems/ha in 2002. From 1986/87 to 1996, over all woodlots, there were fewer seedling tree stems in the unfenced plots than in the fenced plots. However, in 2002, there were more seedling trees in the unfenced plots than in the fenced plots. The reason for the increase in seedling tree density in the unfenced plots between 1996 and 2002 was due to the reduced deer browse after the implementation of the Deer Management Program in 1995. Seedling tree densities within the fenced Demonstration Plots continued to decrease from 1996 to 2002 because of competition with seedling and sapling shrub species and a build up of leaf litter within the fenced area. Over all woodlots and both the fenced and unfenced treatments, seedling tree and shrub species diversity increased over time.

Seedling tree densities were adequate in four of the Demonstration Plots in 2002 to meet the 60% stocking level goals. Bushman Hill woodlot fenced and unfenced plots (21,700 and 19,800 stems/ha, respectively), Cobean woodlot unfenced plot (22,000 stems/ha), and Spangler fenced plot (20,700 stems/ha) densities exceeded the 60% stocking level goal. The Bushman Hill woodlot fenced plot (4,200 stems/ha) was the only Demonstration Plot to have a small sapling tree density that met the 60% stocking level goal in 2002. The remaining 11 plots had small sapling tree densities that ranged from 0 to 900 stems/ha. Only one of the 12 Demonstration Plots had a large sapling tree density that met the 60% stocking level goal in 2002. The Biesecker woodlot unfenced plot had a large sapling tree density of 1,000 stems/ha. The other 11 plots had densities that ranged from 0 to 900 stems/ha.

In the fenced plots from 1989 to 2002, the density of seedling trees <26 cm in height over all woodlots decreased from 44,433 to 3,983 stems/ha. The density of fenced seedlings ≥26 cm varied slightly over time from 7,450 stems/ha in 1989, peaking at 12,546 stems/ha in 1991, and then decreasing to 6,300 stems/ha in 2002. Seedling tree density in the unfenced plots followed a similar trend as in the fenced plots, with the exception of an increase in density from 1996 to 2002. The density of seedling trees <26 cm in height in the unfenced plots decreased from 36,233 stems/ha in 1989 to 1,083 stems/ha in 1996, then increased to 8,467 stems/ha in 2002. The density of seedling trees ≥26 cm in height was consistently lower in the unfenced plots compared to the fenced plots, but showed an increase between 1996 and 2002 (67 and 3,683 stems/ha, respectively). In the fenced plots, where the density of seedling and sapling shrub species was higher, seedling trees were able to grow into the taller height classes over time. Thus, competition with shrub species was probably not the reason for the lack of seedling trees in the upper height classes in the unfenced plots. In the unfenced plots, deer herbivory was probably the cause for the decline in seedling tree density through 1996. The 2002 inventory results showed the overall seedling tree densities in the unfenced and fenced plots were similar. This would indicate that the Deer Management Program was having a beneficial effect on increasing tree species diversity and height of seedling tree stems.

The following species were recorded from 1986/87 through 2002 in at least one plot: ash (*Fraxinus* spp.), eastern red cedar (*Juniperus virginiana*), sweet cherry (*Prunus avium*), black cherry (*Prunus serotina*), elm (*Ulmus* spp.), mockernut hickory (*Carya tomentosa*), pignut hickory (*Carya glabra*), shagbark hickory (*Carya ovata*), red maple (*Acer rubrum*), black oak (*Quercus velutina*), and white

oak (*Quercus alba*). Blackgum (*Nyssa sylvatica*) and Norway maple (*Acer platanoides*) were recorded from 1994 through 2002. Chestnut oak (*Quercus prinus*) was recorded in 1989 and in 2002, but not in the 1990's. Red oak (*Quercus borealis*) was recorded from 1989 through 2002. Pin oak (*Quercus palustris*) and black walnut (*Juglans nigra*) were first recorded in 2002.

Over all woodlots, the density and diversity of seedling shrubs increased over time in both the fenced and unfenced plots. Within the fenced plots, the density increased from 2,667 to 16,350 stems/ha from 1986/87 to 2002, with peak densities in 1991 (21,221 stems/ha) when *Rubus* and multiflora rose were first recorded in the woodlots. Between 1986/87 and 2002, the overall density in the unfenced plots increased from 1,958 to 13,750 stems/ha. The following species were recorded from 1986/87 through 2002 in at least one plot: smooth blackhaw (*Viburnum prunifolium*), sassafras (*Sassafras albidum*), serviceberry (*Amelanchier arborea*), spicebush (*Lindera benzoin*), eastern redbud (*Cercis canadensis*), and greenbriar (*Smilax rotundifolia*). Japanese barberry and flowering dogwood (*Cornus florida*) were recorded from 1989 through 2002. Grape (*Vitis* spp.) species were only recorded in 1986/87, 1994, and 1996. Multiflora rose, *Rubus*, and Tartarian honeysuckle were recorded from 1994 through 2002. Autumn olive, *Euonymus*, witch hazel (*Hamamelis virginiana*), and *Ribes* were first recorded in 2002. *Rubus* was the predominant seedling shrub species in 1991, 1994, and 2002. Multiflora rose was the dominant sapling shrub species in 2002.

The invasion of non-native plant species also had a deleterious effect on seedling tree recruitment. Non-native species tended to invade the fenced Demonstration Plots sooner than the unfenced plots. Japanese barberry was first recorded in Biesecker, Cobean, and Spangler woodlots in 1989, in Slyder woodlot in 1994, and in Pitzer and Bushman Hill woodlots in 1996. Tartarian honeysuckle was first recorded in Cobean and Pitzer woodlots in 1994 and in Bushman Hill, Slyder, and Spangler woodlots in 2002. Autumn olive was first recorded in Bushman Hill woodlot in 2002. Multiflora rose was first recorded in Biesecker, Bushman Hill, Cobean, and Slyder woodlots in 1991 and in Pitzer woodlot in 1994 (Bowersox et al. 2003). Norway maple was recorded in Slyder woodlot from 1994 through 2002, in Spangler woodlot only in 1994, and in Biesecker and Bushman Hill woodlots in 1996 and 2002. *Ailanthus* (*Ailanthus altissima* or Tree-of-Heaven) was recorded in Bushman Hill woodlot in 1994.

Long-term Monitoring Plots

Long-term Monitoring plots in all six woodlots experienced increased diversity of seedling and sapling tree species. There have also been improvements in species diversity in all the other size categories of tree and shrub species over time within Biesecker, Bushman Hill, Herr Ridge, Pitzer, Powers Hill, and Spangler woodlots, especially since the implementation of the Deer Management Program in 1995, but not within Herr Ridge woodlot. However, the diversity, richness, and density of oak seedlings and saplings are still a concern. The invasion and subsequent growth of non-native plant species has increased in all woodlots.

Results from inventories completed from 1990/92 through 2002 indicate the following changes within the six woodlots. Among all of the woodlots, the density of large sapling trees decreased from 1990/92 to 2002. Among all of the woodlots, the lowest large and small sapling tree densities were recorded in 2002. Large sapling shrub densities increased over time, but were always lower than large sapling tree densities. Small sapling tree densities declined between the 1990/92 and 2002 inventories, while small sapling shrub densities increased substantially.

In 1990/92, the overall density of overstory trees (309 stems/ha) among the Long-term Monitoring Plots started out above the 60% stocking level goal (306 stems/ha), but then decreased to 280 and 290

stems/ha in 1996 and 2002, respectively. The overall average density of large sapling trees was consistently below the 60% stocking level goal (935 stems/ha) during the 1990/92 (765 stems/ha), 1996 (715 stems/ha), and 2002 (456 stems/ha) inventories. The average densities of small sapling trees recorded in 1990/92 (116 stems/ha), 1996 (91 stems/ha), and 2002 (69 stems/ha) were small percentages of the 60% stocking level goal (2,806 stems/ha). The overall average seedling tree densities in the unfenced subplots exceeded the stocking goal of 16,834 stems/ha during the 1990/92 and 2002 (20,917 and 27,260 stems/ha, respectively) inventories but not in 1996 (14,665 stems/ha). However, there were declining unfenced oak seedling densities between 1990/92 and 2002. Unfenced seedling shrub densities increased substantially, with a doubling of density between 1996 and 2002 (20,508 and 41,251 stems/ha, respectively). Herr Ridge was the only woodlot with declining unfenced seedling tree densities from 1990/92 to 2002, probably due to the difficulty controlling the deer herd in that woodlot. While the density of unfenced seedling trees declined over time in Herr Ridge, the density of sapling trees increased. Black cherry was the most abundant sapling tree in the woodlot. There was also a large density of *Rubus* in the woodlot, possibly creating unfavorable conditions for seedling trees.

The woodlots exhibited the potential to reproduce a great diversity of seedling tree species at densities large enough to regenerate healthy woodlots. However, the density of small sapling tree species was severely deficient, less than 2.5% of the 60% stocking level goal in 2002. The overall average density of large saplings was also below the 60% stocking level goal. This indicates a serious problem maintaining the woodlots under the existing conditions. Competition with overstory tree species and sapling shrub species was probably the reason for the low sapling tree species densities. The reduction in the white-tailed deer herd since 1995 has resulted in a positive response in seedling tree densities in the unfenced subplots.

Japanese barberry was recorded in all six woodlots in 2002. Multiflora rose was recorded in four woodlots in 2002. Native *Rubus* densities were very high. Smooth blackhaw was the most abundant seedling shrub species in two of the six woodlots in 2002. Seedling and sapling densities of spicebush in Powers Hill were very high and may pose a serious threat to regenerating tree species.

In Biesecker woodlot, the density of unfenced oak seedlings steadily decreased between the 1990/92, 1996, and 2002 inventories from 1,001 to 417 to 0 stems/ha, respectively. In Pitzer woodlot, the trend during the same inventory period was 1,667 to 0 to 556 stems/ha, respectively. These data indicate a serious problem in regenerating the woodlots to the historic mixed-oak forest. As of 1997, the Deer Management Program was successful in reducing the white-tailed deer population to less than 20% of the pre-1995 implementation levels in both the Biesecker and Pitzer woodlots (Storm 2004). Therefore, white-tailed deer herbivory was not the only reason for oak species seedling decline in these two woodlots after 1997. Light restrictions due to dense overstory canopy conditions, understory competition with shrub species, drought, and small mammal predation, were probably having negative impacts on the presence of seedling oak species. Seedling and sapling tree species densities should improve with continued reduction of the white-tailed deer, removal of non-native plant species, and opening of the overstory tree canopy to the recommended 60% stocking level.

Canopy Treatment Plots

This experiment, conducted in Bushman Hill, Herr Ridge, and Powers Hill woodlots, was designed to test the hypothesis that reductions in the overstory tree canopy would result in greater densities and/or vigorous growth of seedling and sapling trees.

All three woodlots experienced declines in overstory tree density between 1996 and 2002 within the closed and partially open canopy treatment areas. Over all woodlots and canopy treatments, sapling tree diversity and density improved between 1992 and 2002, with the greatest increases occurring from 1996 to 2002. The increases in sapling tree density between 1996 and 2002 were due to increased tree seedling recruitment in 1994 (primarily in the open canopy treatments), and the decrease in the deer herd after 1995. In 2002, the overall density of sapling (small and large combined) trees among the three woodlots was 945 stems/ha, only 25% of sapling tree stems needed to meet the 60% stocking level goal of 3,741 stems/ha necessary for adequate recruitment. From 1992 to 2002, Herr Ridge woodlot continually had greater sapling tree densities than either Bushman Hill or Powers Hill woodlots. This may have been due to fewer shrub species and lower shrub densities in Herr Ridge woodlot than in Bushman Hill and Powers Hill woodlots. In Herr Ridge, the density of seedling trees decreased over time, but the density of sapling trees increased due to limited shrub competition, specifically the absence of spicebush. The predominant sapling tree species in Herr Ridge woodlot in 2002 were black cherry and ash. Black cherry is not preferred or avoided by deer, and increases in dominance with increasing deer density (Horsley et al. 2003).

Between 1996 and 2002, there was an increase in the density of sapling trees in all three canopy treatments, with the greatest increase occurring in the open canopy treatments. The substantial increase in the open canopy treatments was due to the initial release of seedling trees in 1994 when the overstory was first removed. The open canopy treatments enabled the ground level plants to develop without interference from the overstory. The species that flourish in full direct sunlight conditions (*Rubus*, rose, barberry, honeysuckle, ailanthus, black cherry, yellow poplar, and red oak) were able to out-compete the more shade tolerant species (blackgum, ash, hickory, oak, maple, dogwood, redbud, blackhaw, and spicebush). Thus, the average number of sapling tree and shrub species present in 2002 was greater in the open canopy treatments than in the closed or the partially open canopy treatments. It was clear that the open canopy treatments provided the best opportunity for seedlings to grow into the sapling size category. In 2002, the density of sapling trees in the open canopy treatments (1,653 stems/ha) was nearly three times the density in the closed canopy (583 stems/ha) and the partially open canopy (600 stems/ha) treatments. It is very likely that the rapid development of the sapling shrubs in the open canopy treatments from 120 stems/ha in 1996 to 22,133 stems/ha in 2002 limited the density of tree species. In time, it is expected that the tree species will overtop and shade-out some of the shrub species, but the 13-to-1 shrub-to-tree ratio suggests that these open canopy treatments will be dominated by shrubs for a longer than acceptable time period.

In 2002, the density of sapling (large and small combined) trees in the closed, partially open, and open canopy treatments (583, 600, and 1,653 stems/ha, respectively) among the three woodlots, was less than the 60% stocking level goal of 3,741 stems/ha. The reason sapling trees were not adequately being recruited may be a combination of intense competition with shrub species, poor growing conditions due to light restrictions and drought, and continued foraging by white-tailed deer. In 2002, the density of sapling shrubs was substantially greater than the density of sapling trees due to the branching growth habit of shrubs. Overall, shrub species benefited the most from opening the canopy. Multiflora rose, Japanese barberry, and honeysuckle produced numerous, branching stems that covered more area than a seedling or sapling-sized tree species could. This growth habit and the avoidance by white-tailed deer enabled non-native shrubs to out-compete native vegetation for light and moisture. This was particularly a problem in the open canopy treatments.

The total density of sapling shrubs recorded over all woodlots and canopy treatments increased substantially between the 1994 and 2002 inventories, from 408 to 11,162 stems/ha, respectively. Over time, there were more sapling shrub species than sapling tree species in all three canopy treatments.

The density of sapling shrubs in Powers Hill woodlot was significantly different than in both the Bushman Hill and Herr Ridge woodlots from 1994 through 2002. There was no spicebush recorded in Herr Ridge woodlot in 2002; however, it was the most abundant sapling shrub species in both the Bushman Hill (1,098 stems/ha) and Powers Hill (3,634 stems/ha) woodlots. The predominance of spicebush, a native species, may have been the cause for decreased seedling tree density. This was especially noticeable in Powers Hill woodlot where there were thick stands of spicebush. During the 1994 and 1996 inventories, the density of sapling shrubs was greatest in the closed canopy treatments, but that changed in 2002. The density of sapling shrubs in the open canopy treatments increased to 22,133 stems/ha, significantly different than the 8,828 stems/ha in the partially open canopy treatments. The closed canopy treatments had the lowest density with 2,525 stems/ha. The biggest change over time was in the abundance of non-native plant species. Honeysuckle, Japanese barberry, and multiflora rose were prevalent in 2002, comprising 46% of the total sapling shrub density.

Shrub species were opportunistic of the favorable conditions provided by the open canopy treatments over time. They were able to exploit the resources and grow faster than the tree species. The abundance of sapling shrub stems, especially in the open canopy treatments, may have had a deleterious effect on the recruitment of seedling tree and shrub species. It took ten years for sapling shrub species to dominate all of the open canopy treatments. Open canopy treatments had the highest density of sapling shrubs and the lowest density of seedling trees. The vigorous growth habit of Japanese barberry, multiflora rose, and *Rubus* resulted in a complete take-over of the treatment areas. The shrubby vegetation was almost impenetrable, and the center of the plots was accessed by crawling on hands and knees, and cutting paths with clippers. Most of the ground was bare underneath the shrubs. The percent of total herbaceous vegetation cover in the open canopy treatments in 2002 was half of what was present in 1996.

The total number of seedling tree species recorded among all the woodlots and canopy treatments changed little between the 1994 and 2002 inventories. In 1994, seedling tree and shrub species densities over all woodlots were 57,222 and 54,722 stems/ha, respectively (Bowersox et al. 2004). This changed in 2002, when the seedling tree density decreased to 23,704 stems/ha, but the seedling shrub density increased to 64,444 stems/ha. From 1994 to 2002, Bushman Hill and Powers Hill woodlots had greater seedling tree densities than Herr Ridge woodlot, probably due to the reduced white-tailed deer herbivory. Deer management efforts have been successful in the Bushman Hill and Powers Hill woodlot areas, but have not been possible in the Herr Ridge woodlot due to proximity of residential housing. As a result, the seedling populations in Herr Ridge woodlot were under continual deer forage pressure.

Over all the woodlots, there was a shift over time in the density of seedling trees among the canopy treatments. There was no consistently better canopy treatment for seedling tree diversity and density. In 2002, the closed and partially open canopy treatments afforded the greatest seedling tree densities, the opposite of what was expected when the treatments were established. This result was primarily due to a complication of substantial growth and competition by shrubs in the open canopy treatments.

Although seedling tree densities were lower in the open canopy treatments than in either the closed or partially open canopy treatments over all woodlots in 2002, the more favorable growing conditions in the open canopy treatments when they were first established enabled the initial seedlings to achieve greater height growth from 1994 and 1996 and become saplings. In 2002, the closed and partially open canopy treatment subplots had 42% and 29%, respectively, of the seedling trees in the ≥25.1 cm height classes. The open canopy subplots had 70% of the seedling trees ≥25.1 cm in height.

Furthermore, in 2002 there more sapling trees in the open canopy treatments than in either of the other two canopy treatments.

Over all canopy treatments in 2002, the seedling tree densities were above the 60% stocking level goal of 16,834 stems/ha in Bushman Hill (36,111 stems/ha) and Powers Hill (28,889 stems/ha) woodlots, but not in Herr Ridge woodlot (6,111 stems/ha). Over all woodlots in 2002, seedling tree densities were adequate in the closed (27,500 stems/ha) and partially open (37,222 stems/ha) canopy treatments, but not in the open canopy (6,389 stems/ha) treatments. However, over all woodlots and canopy treatments seedling trees were not surviving or growing into the upper height classes and being recruited into sapling trees at densities sufficient to perpetuate the historic forests.

Over all woodlots, there were slight changes in the density of seedling shrubs within each canopy treatment from 1994 to 1996, but between 1996 and 2002 more moderate changes occurred. In 2002, seedling shrub densities in the partially open and closed canopy treatments (86,667 and 69,444 stems/ha, respectively) were significantly different than in the open canopy (37,222 stems/ha) treatments. The competition with mature sapling shrubs was probably the reason for fewer seedling shrubs in the open canopy treatments. However, over all woodlots and canopy treatments, seedling shrubs were more prolific than seedling trees, and growing into the taller height classes more quickly. Since shrubs are less preferable food for white-tailed deer, they may have been afforded some natural immunity from browsing. The 2002 seedling shrub densities in all woodlots and canopy treatments were more than adequate to establish a dense understory that will perpetuate itself and inhibit the recruitment of favorable trees.

It is likely that the density of seedling shrubs influenced the presence of seedling trees. Among all woodlots and canopy treatments, the seedling shrub density increased from 37,834 stems/ha in 1992 to 56,667 stems/ha in 1996 and to 64,444 stems/ha in 2002. Over all woodlots in 2002, seedling shrub density was three times greater than seedling tree density (23,704 stems/ha). The extent to which seedling shrubs were competitive with the initial seedling trees is not known and probably dependent on the architecture of the shrub species and the growth characteristics of the tree species. From 1994 to 2002, the greatest increases in seedling shrub density were for the following species: autumn olive (185 to 741 stems/ha), spicebush (18,704 to 20,000 stems/ha), honeysuckle (0 to 185 stems/ha), Japanese barberry (93 to 6,204 stems/ha), multiflora rose (556 to 2,500 stems/ha), and *Rubus* (18,889 to 24,352 stems/ha).

The abundance of two native shrub species also posed a problem for seedling trees. *Rubus* and spicebush were dominant components of the seedling inventory in 2002, with overall seedling densities above 20,000 stems/ha. Spicebush was the most abundant sapling shrub species among all the woodlots, with an average density of 4,381 stems/ha. There were solid stands of spicebush in Powers Hill woodlot, with a density of 3,634 saplings stems/ha over all the canopy treatments. The proliferation of native spicebush was most likely a negative factor on the presence and growth of seedling tree species in Powers Hill woodlot. *Rubus* and redbud saplings averaged 747 and 540 stems/ha, respectively, among all the woodlots and canopy treatments. *Rubus* tended to grow in thickets, dense patches of growth that were nearly impenetrable. Spicebush and redbud also seemed to grow in stands, seemingly in the same age class. All three species create shade beneath their branches, blocking out essential light for seedling trees. The amount of competition between seedlings of these native shrubs and seedling trees in the partially open and closed canopy conditions was intense.

The current trend in the woodlots looks like a severely increasing shrub population that has not yet reached its maximum capacity. The drastic increase in seedling and sapling shrub species densities

over the last ten years is probably not at a sustainable level. Without human intervention, one of these two scenarios will occur: the shrub density will reach an equilibrium at some unknown density, or there will be a dramatic decline in growth due to natural phenomena like drought, disease, or infestation. While either of these two scenarios occurs, the density of seedling and sapling tree species will not be great enough to maintain the woodlots as tree-dominated communities in accordance with preserving the park's historic scene. Careful management of the shrub species will be essential to achieving optimal tree densities.

Conclusions and Recommendations

The National Park Service's initiative in reducing the white-tailed deer herd has enabled the establishment of a sustainable understory. The lower number of white-tailed deer present in some woodlots has resulted in greater seedling tree diversity and density. In Herr Ridge woodlot, where the white-tailed deer herd has not been reduced as much as in other areas of the park, the density of seedling tree species was lower than in the other woodlots. The partially open canopy conditions created by removing individual trees were effective in increasing seedling tree species diversity and density. Multiple-tree openings (partially open and open canopy treatments) in the overstory canopy were effective in providing the conditions for seedlings to grow into saplings. Overall, in 2002 there was good potential for native tree species to regenerate the woodlots at Gettysburg NMP, as long as non-native plant species and white-tailed deer are controlled. Although these studies were not designed to evaluate the effects of non-native plants on the understory tree species, there were strong implications that these plants were poised to expand their presence. The woodlots exhibited the potential to reproduce a great diversity of seedling tree species at densities great enough to regenerate healthy woodlots. Overall seedling densities increased from 1996 to 2002, exceeding the 60% stocking level goals. Although sapling tree densities generally improved after 1996, the average total sapling (small and large combined) densities over all three types of study plots ranged from 450 to 945 stems/ha, only 12 to 25% of the 60% stocking level goal (3,741 stems/ha) in 2002.

Continuation of the Deer Management Program is vital for an increase in native tree species diversity and height of tree stems. The initial deer density goal of 25 white-tailed deer/forested square mile has yet to be achieved. Plant data collected in the summer of 1996 were considered to be representative of conditions prior to the deer population reduction. Data from the 2002 inventory were representative of reduced white-tailed deer populations but not indicative of the effect that would have been achieved had the deer density been at goal for the previous four-five years.

Therefore, to sustain a healthy diversity and density of native seedling, sapling, and overstory tree and shrub species that will perpetuate the appearance and composition of the historic 1863 woodlots (Fairweather and Cavanaugh 1990) in Gettysburg National Military Park, it is recommended to:

1. Continue to implement the Deer Management Program to reach the goal of 25 deer/forested sq. mile (USDI NPS 1995), periodically evaluate the effectiveness of this density, and adjust the goal accordingly, as necessary.
2. Continue executing the Exotic Plant Management Program within the park to control the non-native, invasive plant species.
3. Fully implement the park-wide plan for increasing the sustainability of woodlots (Bowersox 2002), where the removal of individual non-sustainable overstory trees will create openings in the canopy to improve the health, vigor, and density of native seedling tree species. Woodlot stocking should be maintained between the 60% and 80% level of full stocking.
4. Develop a plan to recruit seedling tree stems into sapling stems and then into overstory to replace the aging trees where there is a mixture of vigorous native tree species seedlings that

have a competitive advantage over the herbaceous and shrub plants. Although canopy openings of 0.2 ha (radius 21 m) were tested, it is believed that similar opportunities for seedlings to become canopy tree replacements can be achieved with a combination of single-tree and multiple-tree openings (0.05 to 0.1 ha) to reduce the stock to a 45-55% level.

5. Develop a long-term vegetation monitoring program for all wooded areas that are ≥2 ha. The program should be designed to document changes in plant diversity and density for all sizes of tree and shrub species, and forb, grass, grass-like, and vine species groups. When choosing plot locations, take into consideration the effect of moisture on regeneration. Inventory frequency need not be greater than once every five years, but not less than once every ten years.

Introduction

Gettysburg National Military Park (NMP) was established in 1895 to commemorate the July 1863 Civil War battle. Before the battle, woodlots were important resources for the residents. The park's authorized boundary encompasses about 2,320 ha, with 835 ha occupied by woodlots and woodlands (Storm et al 2002). Historic photographs and documents and recent reports (Fairweather and Cavanaugh 1990, Storm et al. 1995) suggest a general pattern to the 1863 condition and subsequent development of these woodlots. Species identified in Civil War era (1885-1890) photographs at Gettysburg NMP included oaks, hickories, ash, and red-cedar (Storm et al. 2002). Open-grown white oak (*Quercus alba* L.) was the dominant vegetation in the 1863 woodlots that were being used as pastures. Perpetuation and restoration of woodlot characteristics is an element of the management objectives for Gettysburg NMP (USDI NPS 1995).

Silvicultural management practices and foraging by white-tailed deer (*Odocoileus virginianus*) influenced the understory species composition of the woodlots at Gettysburg NMP (Bowersox et al. 1993, Tzilkowski et al. 1993). Before the battle, the woodlots had an uneven-aged structure that was maintained by frequent partial cutting. However, when the park was established all tree-cutting practices in the woodlots were ended. This allowed for the development of second and third groups of trees, mainly oaks (*Quercus* spp.), hickories (*Carya* spp.), cherries (*Prunus* spp.), flowering dogwood (*Cornus florida* L.) and white ash (*Fraxinus americana* L.). The deer population of a 2,862 ha area in and around the park has been monitored since 1987 according to procedures described by Storm et al. (1992). There is high potential for a conversion of tree species from oak and hickory to ash and wild black cherry in areas with excessive populations of white-tailed deer (Storm et al. 2002). In the long term, selective feeding by deer could change the species composition and structure of the forest overstory (Storm et al. 2002).

Management objectives for Gettysburg NMP include 1) the conservation of important features of the Gettysburg Battlefield Historic District which are necessary for maintaining the rural, agricultural, and memorial character of Gettysburg and conveying to visitors why, where, and how the battle occurred, 2) using the battlefield setting as the primary interpretive resource, and 3) managing the park as a memorial landscape which not only reflects the pre-battle 1863 rural agricultural environment but includes superimposed post-battle elements necessary for commemoration and visitor understanding of the battle (USDI NPS 1995). White-tailed deer and non-native species alter the appearance of understory vegetation thereby making interpretation of battle events difficult for National Park Service personnel.

Long-term vegetation monitoring was started at Gettysburg NMP in 1986/87 with un-replicated Demonstration Plots in six woodlots (Biesecker, Bushman Hill, Cobean, Pitzer, Slyder, and Spangler). One pair of fenced and unfenced plots in each of the six woodlots was intended to demonstrate differences in the development of vegetation with and without the presence of deer. The Demonstration Plots were inventoried in 1986/87, 1989, 1991, 1994, 1996, and 2002. To describe the status of closed canopy woodlot plant community conditions and the effects of deer foraging on understory vegetation, sets of Long-term Monitoring Plots were established in 1990/92 in six woodlots (Biesecker, Bushman Hill, Herr Ridge, Pitzer, Powers Hill, and Spangler). In 1990, fifteen fenced and fifteen unfenced plots were established in Biesecker woodlot. In 1991, thirty unfenced plots were established in Pitzer woodlot. In 1992, fifteen unfenced plots were established in Bushman Hill, Herr Ridge, Powers Hill, and Spangler woodlots. In 1993, fifteen of the thirty plots already located in the Pitzer woodlot were randomly selected and a 3 x 3 m fence enclosure was constructed in the center of

the plot. The Long-term Monitoring Plots were inventoried in 1990/92, 1996, and 2002. Finally, to evaluate understory responses to creating openings in the canopy, replicated canopy treatment plots were installed in three woodlots (Bushman Hill, Herr Ridge and Powers Hill) in the summer of 1992. Within each of these woodlots, three different canopy treatments, closed canopy (control), partially open canopy (60% of the original overstory), and open canopy (all trees removed), were established. There were three replications of each canopy treatment within each woodlot, for a total of 27 woodlot-treatment plots. In this report, the discussion includes baseline (pre-treatment) data results from 1992, and post-treatment data results from inventories in 1994, 1996, and 2002. The 1992 data were seedling densities reported by Storm et al. (1995) from the Long-term Monitoring Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots. These plots were not the precise locations of the Canopy Treatment subplots, but were indicative of the seedling conditions within the perspective woodlots, and provided the data for pre-treatment conditions (1992). The 1992 inventory was completed one year prior to the canopy treatment areas being established.

Surveys of the herbaceous and vine species in selected woodlots have been completed within Gettysburg NMP since 1992. In the spring-summer of 1992 (May 20 to July 7) and in the spring of 1995 (May 16 to June 21) the Long-term Monitoring Plots in Biesecker, Bushman Hill, Herr Ridge, and Powers Hill woodlots were inventoried for herbaceous and vine species growth. During the summer of 1995 (July 23-27), a third inventory was completed, during which a fifth woodlot, Pitzer, was investigated in addition to the original four woodlots. During the spring of 2002 (May 14 to June 19) a fourth inventory was completed in all five woodlots. The first survey was part of a larger study to evaluate the impact of deer on vegetation in Gettysburg NMP (Storm, et al. 1995). The purposes of the 1992 inventory were to establish what herbaceous and vine species were present in the woodlots and obtain quantitative data to supplement data being collected on the woody species in the same plots. The subsequent surveys were done to determine if any changes had occurred, either in the kinds of species present or in their relative presence and/or growth. An increase in length of the line-transect covered by a given species or in the percent cover estimated within the quadrants for a species could be interpreted as increase in size of previous individuals or more individuals of that species or both. If there was a significant increase in cover by a particular species in the unfenced plots and minimal increase in the fenced plots, the presumption was that the increase could be attributed to the reduction in deer browse. Quantitative data on the herbaceous and vine species were collected in the Canopy Treatment subplots in August 1995 and in the spring of 2002. Because few evergreen herbaceous species are present in the woodlots of Gettysburg NMP, the above-ground parts of most annuals and perennials must be generated each year. The degree of development by a given time will vary from year to year depending on weather conditions. Since some species develop later in the growing season, there is some variation in the species makeup and relative presence depending upon the time of sampling. The two surveys in 1995, one in the spring and one in the summer, were completed to determine if there was a significant impact of seasonal effects on the quantitative analysis of the herbaceous species present. No significant seasonal effect was seen.

The 1986-1994 data from Demonstration Plots and the 1990/92 data from Long-term Monitoring Plots were summarized in Storm et al. (1995). The 1992 data from Canopy Treatment Plots were presented in Bowersox et al. (1992). Results from inventories in 1992, 1993, 1994, and 1996 specific to the regeneration response to the canopy treatments were summarized in Bowersox et al. (2002). The 1996 data from the Demonstration Plots, the 1994-1996 data from the Long-term Monitoring Plots, and the1994-1996 data from the Canopy Treatment Plots were summarized in Bowersox et al. (2004). These studies provided reference data by which future changes in woody and herbaceous vegetation could be assessed.

In 1987, the white-tailed deer density in the 2,862 ha Gettysburg study area was 264 deer/forested square mile (1.02 deer/forested ha). It then increased to 333 deer/forested square mile (1.29 deer/forested ha) in 1990 and to 325 deer/forested square mile (1.83 deer/forested ha) in 1995 (Storm et al 2004) (Appendix A). The deer density is for the spring season before the new fawns are born. The White-tailed Deer (*Odocoileus virginianus*) Management Program was started in 1995 within Gettysburg NMP (Frost et al 1997) to reduce the deer population to the goal density of 25 deer/forested square mile (0.10 deer/forested ha) (USDI NPS 1995). Due to personnel limitations, time restrictions, effectiveness of the control action, movement of deer into the park, and deer productivity, it was expected to take three to four years to achieve the initial deer density goal. The population would then be maintained at the initial density goal of 25 deer/forested square mile until results of the monitoring of the woodlots determined if a change in the initial density goal was required to meet management objectives (USDI NPS 1995). The initial herd reduction effort lowered the density to 158 deer/forested square mile (0.61 deer/forested ha) in March 1996, and continued efforts reduced the density to 49 deer/forested square mile (0.19 deer/forested ha) in March 2002 (Storm 2004). However, the initial deer density goal of 25 deer/forested square mile has not yet been achieved. Plant data collected in the summer of 1996 were considered to be representative of conditions prior to the deer population reduction. Data from the 2002 inventory were representative of reduced white-tailed deer populations, but not indicative of the effect that would have been achieved had the deer density been at goal for four to five years. As stated in the final environmental impact statement, the decision to make any adjustments to the deer density goal can not be made until vegetation is resurveyed after the deer density has been maintained at the goal density for a period of four to five years (USDI NPS 1995). Any effects of a change in level of deer browsing on the presence and growth of tree seedlings would not be known for at least four years, since it takes approximately that long to determine if tree seedlings have become successfully established. A poor seed crop, severe drought, or other environmental factors could affect the establishment of seedlings in the woodlots and extend the length of that period (Todd Bowersox, Professor of Silviculture, The Pennsylvania State University, personal communication). The Pennsylvania Department of Environmental Protection declared Adams County under drought emergency status in 1999 and 2002, and in a drought watch in 2001 (http://www.dep.state.pa.us/dep/subject/hotopics/drought.news.htm).

This report describes the 2002 status of woodlot woody and herbaceous plant communities in the Demonstration, Long-term Monitoring, and Canopy Treatment plots. Data from the 2002 inventory were compared to those from previous inventories, in particular the 1996 data, to evaluate the effects of reduced foraging by white-tailed deer and variable light levels on the development of understory vegetation at Gettysburg National Military Park. The 2002 data were compared to the park's woodlot management goals to determine if the goals have been achieved.

Methods

Demonstration Plots

In 1986/87, a pair of fenced (exclosure) and unfenced plots were established in Bushman Hill, Biesecker, Cobean (Butterfield Farm), Pitzer, Slyder, and Spangler woodlots. Exclosures were 10 x 10 m, 2.4 m high constructed of 5 x 10 cm welded mesh wire, and supported by cedar posts and steel pipes. Distance and azimuth from the center of each exclosure to the center of the corresponding 10 x 10 m unfenced plot were recorded to identify the location of the plots in the future. Fiberglass stakes had been placed at the center and corners of each unfenced plot, but not all remained intact as of spring 2002.

An inventory of all seedling and sapling tree and shrub species growing within the fenced and unfenced 10 x 10 m plots was done in July 2002. An illustration of a Demonstration Plot is shown in Appendix B. All of the seedling and sapling stems were measured and recorded by species. In 2002, seedling stems were classified as being ≤150 cm in height and in height classes of 0-25, 25.1-50, 50.1-75, 75.1-100, 100.1-125, and 125.1-150 cm. Saplings were >1.5 m in height and <12 cm dbh (diameter at breast height- 1.37 m above ground).

Statistical analysis was not completed on the Demonstration Plot data because of the small sample size and un-replicated plot design.

Herbaceous and vine vegetation coverage surveys were completed in July 2002 in the same six woodlots. The coverages of grasses, forbs, and vines were visually estimated to the nearest percent in each quadrant of two 2 x 2 m subplots. One subplot was located at the center of the fenced 10 x 10 m plot. The other subplot was located in a randomly selected corner of a 40 x 40 m unfenced-control plot, with a footprint that overlaid the fenced plot, sharing the same center stake and with sides that lined up parallel along the same axes. The unfenced-control plot was used only for herbaceous inventory purposes. If one species overlapped another, only that plant tissue visible from above was counted. The sampling methods used were the same as in 1992 (Storm et al. 1995).

In Bushman Hill, Biesecker, and Pitzer woodlots, additional herbaceous data were collected from May to June 2002 in the 2 x 2 m subplot located at the center of each fenced 10 x 10 m Demonstration Plot and in a randomly selected corner of the unfenced-control 40 x 40 m plot. Two, 100-cm line transects were run in two 0.981 m^2 quadrants of each subplot. Every attempt was made to locate the line transects in the same position as in the 1992 and 1995 inventories. The number of individual plants intercepted by the transect lines, length of intercepts, and number of intervals intercepted by each species were determined. Percent coverage of species present in each line-transect quadrant was also recorded using the methods described in Storm et al (1995).

Importance Value (IV), Shannon Diversity Index (SDI), Evenness Index (EI), and Coefficient of Community Similarity (CCS) were calculated from the line transect data (Brower et al. 1990). The Shannon Diversity Index is zero if only one species is present and increases with increasing numbers of species and the evenness of distribution of individuals among the species. The Evenness Index measures how evenly the numbers of individuals present are spread among the species. It is calculated by comparing the Shannon Diversity Index to what it would be if the individuals were evenly distributed among the species present. Its maximum value is one when the individuals present are

equally divided among the species present. Its minimum value is zero when only one species is represented. These indices are based on numbers of individuals and number of species present, unlike the IV which is based not only on numbers of individuals per species, but also on their dominance and occurrence frequency in the sampling area. The Coefficient of Community Similarity is calculated by the formula:

$$CCS = 2c / (sp1 + sp2)$$

Where, "c" is the number of species common between the two communities and "sp1" and "sp2" are the number of species in each community. Friedman tests were used to compare changes over time among the different woodlots and between the different fence treatments.

Scientific and common names of tree and shrub species recorded in the Demonstration Plots in 2002 are listed in Appendix C. The list of common and scientific names of herbaceous and vine species encountered in the line transects in the Demonstration Plots in 2002 is included in Appendix D. Nomenclature of the plant species follows that of Rhoads and Kline (1993).

Long-term Monitoring Plots

In 1990/92, a fixed plot monitoring system of 20 x 20 m plots was established to survey tree and shrub species and herbaceous and vine coverages in six selected woodlots at Gettysburg National Military Park. The Long-term Monitoring Plots were inventoried from May to July 2002. Biesecker and Pitzer woodlots each had thirty plots, while Herr Ridge, Spangler, Bushman Hill, and Powers Hill woodlots each had fifteen plots. The plots were oriented along north-south and east-west axes and subdivided into four 10 x 10 m quadrants (A, B, C, D). The quadrants were designated in a clockwise order starting with A for northwest, B for northeast, C for southeast, and D for southwest. At the center of each plot, 2 x 2 m subplots were located for measuring seedling density and herbaceous and vine coverages. An illustration of a Long-term Monitoring Plot is shown in Appendix B. The subplots were oriented along the same axes as the plots and divided into four 1 x 1 m quadrants (a, b, c, d) designated in the same manner as the plot quadrants. A fence treatment, consisting of a 3 x 3 m fence exclosure surrounding the 2 x 2 m subplot, was assigned to 15 of the 30 plots within Biesecker and Pitzer woodlots, in order to simulate the removal of deer herbivory. Bushman Hill, Herr Ridge, Powers Hill, and Spangler woodlots had no fence treatments; all fifteen plots in each of these woodlots were unfenced. In 2002, navigation to plot centers was done by identifying witness trees with metal tags and locating the center stakes. Some of the wooden center stakes were rotten and unidentifiable, so investigators measured distances and navigated direction from the witness trees, according to past records.

Comprehensive vegetation surveys of overstory, sapling, and seedling tree and shrub species were completed between May and July 2002 in all six woodlots. Species and dbh of each overstory and sapling tree and shrub stem were recorded in each quadrant within the 20 x 20 m plot. Overstory stems were characterized as >1.5 m in height and ≥12 cm dbh. Large saplings were >1.5 m in height and 2–11.9 cm dbh, and small saplings were >1.5 m in height and <2 cm dbh. Dbh of overstory trees and shrubs was measured with tapes in inches and the data were later converted into centimeters for data analysis. Sapling stem dbh was measured with digital calibers in centimeters. Dbh measurements were used to calculate an average dbh (cm) and total basal area (m^2 per ha) for each species. Density (stems/ha), dbh, and basal area were calculated for each overstory and sapling-size tree and shrub species by woodlot and size class. Inventories of seedling tree and shrub species were recorded in each quadrant within the 2 x 2 m subplot. Seedlings stems were ≤150 cm in height and recorded in height

classes of 0-25, 25.1-50, 50.1-75, 75.1-100, 100.1-125, or 125.1-150 cm. All seedling tree and shrub stems within fifteen unfenced subplots were inventoried in each of Bushman Hill, Herr Ridge, Powers Hill, and Spangler woodlots. All seedling tree and shrubs were inventoried within twelve fenced and six unfenced subplots in Biesecker woodlot and within ten fenced and nine unfenced subplots in Pitzer woodlot (the same plots that were inventoried in 1996). Each seedling stem was counted and measured for height. Seedling densities (stems/ha) were calculated for each species by height class and woodlot. In each quadrant of the subplots inventoried for seedlings, the coverage of grasses, forbs, and vines was visually estimated to the nearest percent and recorded by component.

Analysis of variance (ANOVA) was performed to test for significant differences (α=0.05) in overstory and sapling tree and shrub density and basal area values, and seedling tree and shrub density values between the fenced and unfenced treatments in Biesecker and Pitzer woodlots.

Scientific and common names of tree and shrub species recorded in the Long-term Monitoring Plots in 2002 are listed in Appendix E. The list of common and scientific names of herbaceous and vine species recorded in the Long-term Monitoring Plots in 2002 is included in Appendix D.

From May to June 2002, additional herbaceous and vine vegetation surveys were completed in fifteen unfenced 2 x 2 m subplots in Bushman Hill, Herr Ridge, and Powers Hill woodlots. In Biesecker and Pitzer woodlots combined, fifteen fenced and fifteen unfenced subplots were randomly selected from the 60 plots located in these two woodlots, and another 15 unfenced-control subplots were located within the corner of a 40 x 40 m plot overlaid on the center of the selected fenced plot. The unfenced-control subplots were thought to better serve as controls for the fenced subplots because the randomly located unfenced subplots were often some distance from the fenced subplots. No surveys were completed in Spangler woodlot in 2002. The data were collected and analyzed as per the methods stated in the Demonstration Plots section. Since there was no significant difference found between the results obtained in the spring and in the summer of 1995 (Appendix F), the comparisons made in this report are from data collected in the spring of 1992, 1995, and 2002, except for the Pitzer woodlot data. Previous surveys in Pitzer woodlot were only conducted in the summer of 1995 and spring of 2002.

Canopy Treatment Plots

Prior to the 1993 growing season, three 0.2 ha circular canopy treatments (closed, partially open, and open) were assigned within Bushman Hill, Herr Ridge, and Powers Hill woodlots to evaluate understory responses to creating openings in the canopy. Each treatment was replicated three times within each woodlot for a total of 27 treatment areas. Average stocking levels (Roach and Gingrich 1968) in the closed canopy treatment areas were 115, 110, and 99% for Bushman Hill, Herr Ridge, and Powers Hill woodlots, respectively. No trees were felled in the closed canopy treatment areas, whereas all stems >2 cm in diameter were cut in the open canopy treatment areas. In the partially open canopy treatment areas, single-tree felling achieved average stocking levels of 53, 55, and 52% in Bushman Hill, Herr Ridge, and Powers Hill woodlots, respectively (Bowersox et al. 1993). Directional felling was used to uniformly distribute the residue over the treatment area. To preserve the archeological resources in each woodlot, no disturbance to the soil was permitted when the canopy trees were felled. Therefore, no material was removed from the treatment areas. Boles and branches were cut to place all material within 1.0 m of the ground.

There was a stake located at the center of each 0.2 ha canopy treatment area. Each canopy treatment area contained a 20 x 20 m plot located in the middle of the treatment area, offset two meters north of the center stake. There was a 2 x 2 m subplot located at the center of the 20 x 20 m plot. An

illustration of a canopy treatment area with plots is shown in Appendix B. In July 2002, overstory, sapling and seedling stems, and herbaceous and vine coverages were inventoried in all twenty-seven canopy treatments. Overstory tree and shrub stems (>1.5 m in height and ≥12 cm dbh) were inventoried by species in the 0.2 ha treatment area. Dbh of overstory tree and shrub species was measured with a tape in inches and the data were later converted into centimeters for data analysis. Sapling tree and shrub species (>1.5 m in height and <12 cm dbh) were inventoried by species in the 20 x 20 m plot and their dbhs were measured with digital calibers. Seedling tree and shrub stems ≤150 cm in height were inventoried within the 2 x 2 m subplot by species and in height classes of 0-25, 25.1-50, 50.1-75, 75.1-100, 100.1-125, or 125.1-150 cm. Density (stems/ha) was calculated for each overstory, sapling, and seedling tree and shrub species. Percent coverage was determined for the grass, forb, vine, and total herbaceous vegetation in the 2 x 2 m subplot. Analysis of variance ($\alpha = 0.05$) was used to determine the effects of woodlot and canopy treatment on the diversity and density of overstory, sapling, and seedling (size class effects also analyzed for seedling heights) tree, shrub, and total species. For grass, forb, vine, and total herbaceous vegetation, main effects tested were woodlot and canopy treatment. Mean separation procedures were performed using Tukey's method of multiple comparisons.

Additional herbaceous and vine vegetation line transect and percent coverage data were obtained in May and June 2002, from the unfenced 2 x 2 m subplot at the center of each 0.2 ha canopy treatment in the same manner as in the Long-term Monitoring Plots. A Friedman F_r test for Randomized Block Design was used to compare the results of different canopy treatments among woodlots and between 1992 and 2002 to determine if statistically significant changes had occurred due to treatments and/or time.

Scientific and common names of tree and shrub species recorded in the canopy treatment plots in 2002 are listed in Appendix G. Recorded herbaceous and vine species are listed in Appendix D.

Results

Biesecker Woodlot

Twelve tree species were recorded (fenced and unfenced plots combined) during the seedling inventory in 2002. The number of seedling trees was 8,400 stems/ha in the fenced plot. Seedling tree density was 3,400 stems/ha in the unfenced plot (Table 1). Cherry were the most abundant seedling tree species in the fenced plot with a density of 3,900 stems/ha. Ash was the most abundant seedling tree species in the unfenced plot with 2,500 stems/ha (Figure 1).

In 2002, the density of seedling trees <26 cm in height in the fenced plot (3,100 stems/ha) was slightly greater than in the unfenced plot (2,400 stems/ha) (Figure 2). The density of seedling trees ≥26 cm in height in the fenced plot (5,300 stems/ha) was greater than in the unfenced plot (1,000 stems/ha).

In the 2002 sapling tree inventory, the fenced plot had a greater density (1,400 stems/ha) and greater species diversity (eight species) than the unfenced plot (Table 1). The density for the four species inventoried in the unfenced plot was 1,000 stems/ha, with pignut hickory accounting for 600 stems/ha. In the fenced plot, the density was more evenly dispersed across the different species, but hickory were slightly more predominant with 700 stems/ha (Figure 3). The density of small saplings in the fenced and unfenced plot was 500 and zero stems/ha, respectively. The density of large saplings in the fenced and unfenced plot was 900 and 1,000 stems/ha, respectively.

Six shrub species were recorded (fenced and unfenced combined) in the seedling inventory. The density of seedling shrubs was 17,400 stems/ha in the fenced plot and 200 stems/ha in the unfenced plot. *Rubus* was dominant in the fenced plot having a density of 12,600 stems/ha, while smooth blackhaw was the only shrub species present in the unfenced plot (Figure 4). The density of seedling shrubs <26 cm in height in the fenced plot (6,700 stems/ha) was substantially greater than in the unfenced plot (200 stems/ha) in 2002. The density of shrub stems ≥26 cm in height was 10,700 stems/ha in the fenced plot; however, there were no stems recorded in the unfenced plot (Figure 5).

No sapling-sized shrub species were recorded in either the fenced or unfenced plot in the 2002 inventory.

The average total herbaceous and vine vegetation coverage in the unfenced-control subplot was only 4%, much lower than the 33% recorded in the fenced subplot. Forb coverage was different between the fence treatments. In the unfenced-control subplot it averaged 4%, but was 20% in the fenced subplot. There were no grasses recorded in either subplot. There were no vines present in the unfenced-control subplot, but vine coverage averaged 13% in the fenced subplot (Table 2).

In the fenced subplot, Virginia-creeper had the greatest IV in 2002, which was 3.5 times greater than the second-ranked species (Table 3). Cinquefoil (*Pontentilla canadensis*) was second-ranked in 2002. The Shannon Diversity Index was 0.52 in 2002, and the Evenness Index was 0.86 (Tables 4 and 5). In the unfenced-control subplot in 2002, the IV of spring-beauty was two times that of wild licorice, the only other species found in the line transects (Table 6). Cut-leaved toothwort was present in the quadrants. The Shannon Diversity Index was 0.22 in 2002, and the Evenness Index was 0.72 (Tables 4 and 5).

Table 1. Densities (stems/ha)[a] of seedling[b] and sapling[c] tree and shrub species in the fenced and unfenced 10 x 10 m Demonstration Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

	SEEDLING		SAPLING	
	Unfenced	Fenced	Unfenced	Fenced
	----------Density (stems/ha)----------			
Ash	2,500	1,900	0	100
Blackgum	0	200	0	0
Cherry, sweet	100	1,100	0	0
Cherry, black	200	2,800	100	200
Elm, American	0	200	0	0
Elm, slippery	0	400	0	100
Hickory, mockernut	0	300	0	100
Hickory, pignut	200	200	600	200
Hickory, shagbark	0	300	200	400
Maple, Norway	0	100	0	100
Oak, northern red	0	200	0	0
Oak, white	400	700	100	200
Total Tree	3,400	8,400	1,000	1,400
Barberry, Japanese	0	100	0	0
Blackhaw, smooth	200	1,300	0	0
Dogwood, flowering	0	500	0	0
Rubus	0	12,600	0	0
Sassafras	0	1,200	0	0
Serviceberry	0	1,700	0	0
Total Shrub	200	17,400	0	0

[a] Values for the 2002 surveys were from the entire 10 x 10 m plot (100 m^2). Values within columns may not add up to the value for Total Tree and Total Shrub due to rounding.
[b] Stems ≤150 cm in height.
[c] Stems >1.5 m in height and <12 cm dbh.

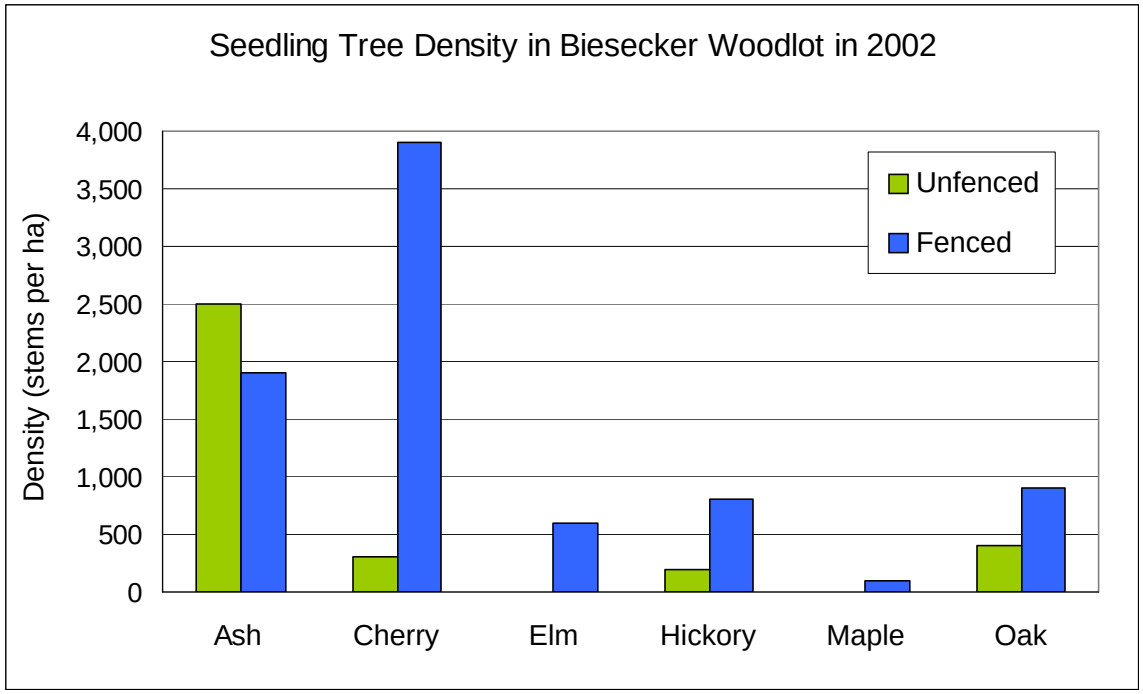


Figure 1. Density of seedling (≤150 cm in height) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

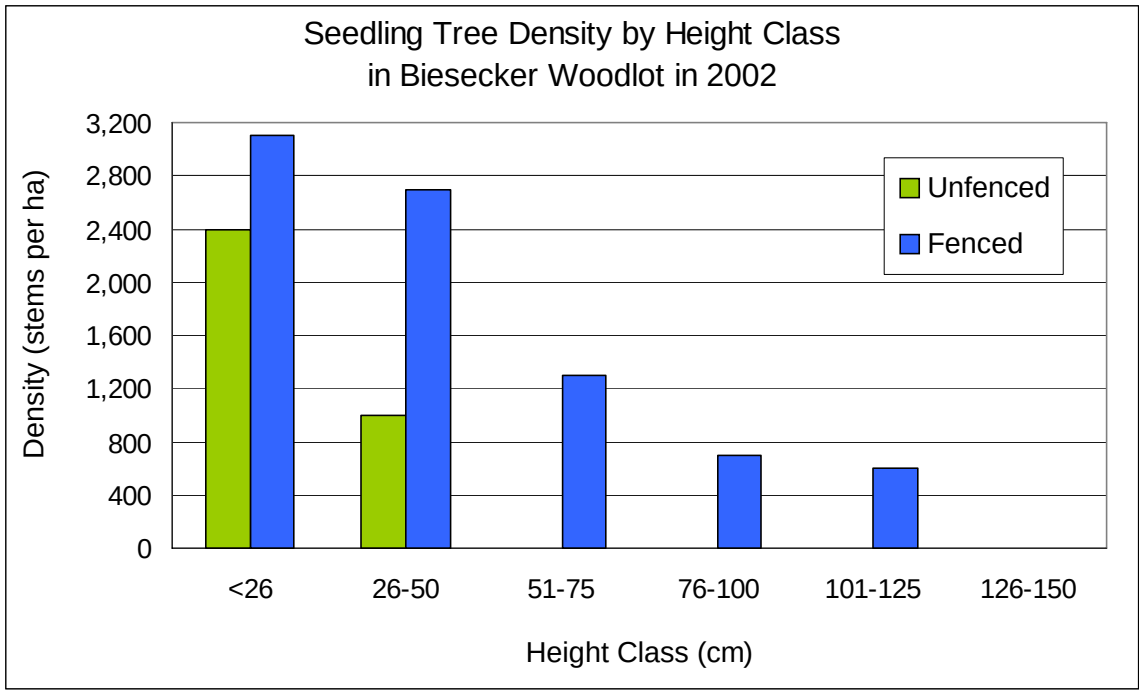


Figure 2. Density of seedling (≤150 cm in height) tree species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

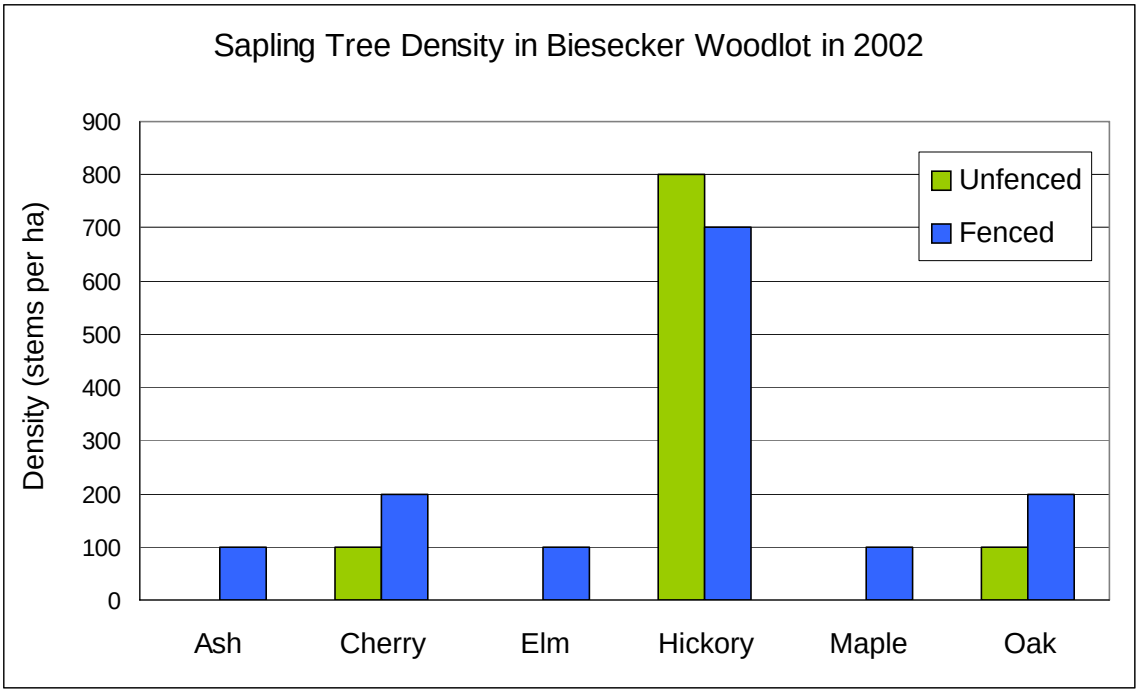


Figure 3. Density of sapling (>1.5 m in height and <12 cm dbh) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

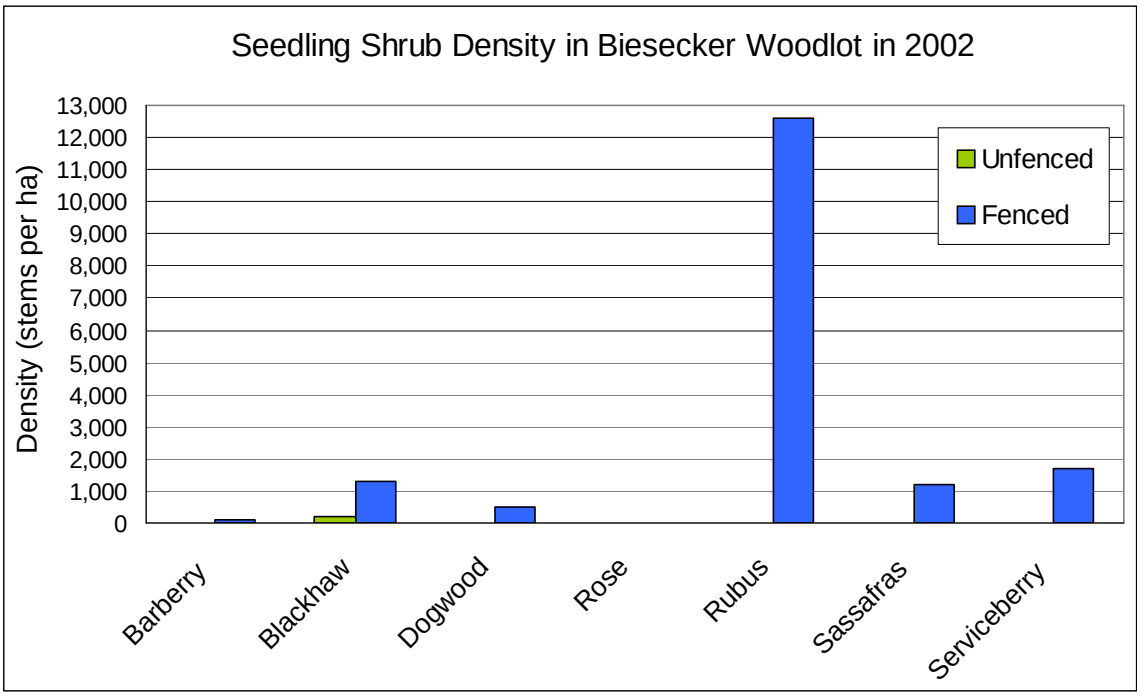


Figure 4. Density of seedling (≤150 cm in height) shrub species in the fenced and unfenced 10 x 10 m Demonstration Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

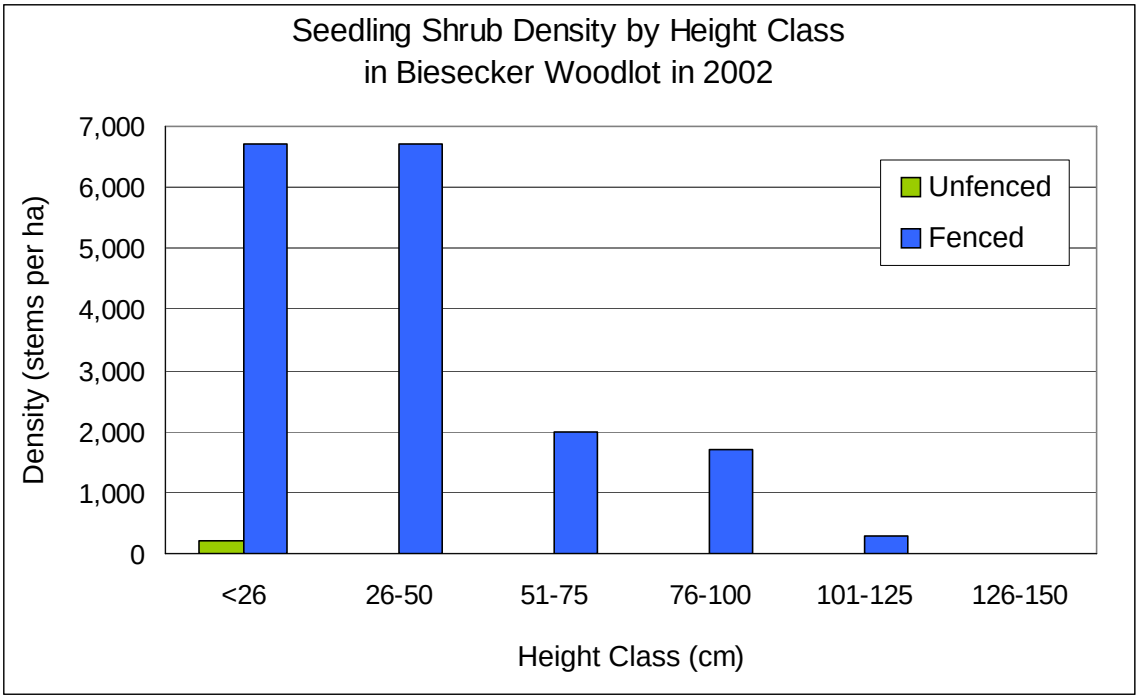


Figure 5. Density of seedling (≤150 cm in height) shrub species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

Table 2. Average coverage for grass, forb, vine, and total species in the fenced 10 x 10 m Demonstration Plot[a] and unfenced-control 40 x 40 m plot[b] in Biesecker woodlot, Gettysburg National Military Park, 2002.

	Fenced Average Coverage (%)	Unfenced-control Average Coverage(%)
Grass	0	0
Forb	20	4
Vine	13	0
Total	33	4

[a] The 10 x 10 m fenced plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.
[b] The 40 x 40 m unfenced-control plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.

Table 3. A comparison of the greatest Importance Values (IV) of the herbaceous and vine species present in a subplot of the fenced 10 x 10 m Demonstration Plot in Biesecker woodlot, Gettysburg National Military Park, 1992 to 2002. The IVs were calculated from line transect data[a].

1992		1995		2002	
Species	IV	Species	IV	Species	IV
Virginia-creeper	128.4	Virginia-creeper	244.4	Virginia-creeper	182.1
Spring-beauty	80.6	Cinquefoil	38.2	Cinquefoil	51.8
Cinquefoil	53.6	Cut-leaved toothwort	17.4	Cut-leaved toothwort	40.8
Wild licorice	37.4			Sedge spp.	25.3

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

Table 4. A comparison of Shannon Diversity Index values for herbaceous and vine species present in a subplot of the fenced 10 x 10 m Demonstration Plot and unfenced-control 40 x 40 m plot in Biesecker, Bushman Hill, and Pitzer woodlots, Gettysburg National Military Park, 1992 to 2002. The calculations were based on line transect data[a].

	Biesecker		Bushman Hill		Pitzer	
Year	Fenced	Unfenced-control	Fenced	Unfenced-control	Fenced	Unfenced-control
1992	0.58	0.00	0.56	0.83	—	—
1995	0.30	0.30	0.66	0.77	0.30	0.30
2002	0.52	0.22	0.57	0.91	0.47	0.00

Table 5. A comparison of Evenness Index values for herbaceous and vine species present in a subplot of the fenced 10 x 10 m Demonstration Plot and the unfenced-control 40 x 40 m plot in Biesecker, Bushman Hill, and Pitzer woodlots, Gettysburg National Military Park, 1992 to 2002. The calculations were based on line transect data[a].

	Biesecker		Bushman Hill		Pitzer	
Year	Fenced	Unfenced-control	Fenced	Unfenced-control	Fenced	Unfenced-control
1992	0.96	0.00	0.94	0.92	—	—
1995	0.64	1.00	0.95	0.74	0.50	0.99
2002	0.86	0.72	0.73	0.87	0.60	0.00

Table 6. A comparison of the Importance Values (IV) of the herbaceous and vine species present in a subplot of the unfenced-control 40 x 40 m plot in Biesecker woodlot, Gettysburg National Military Park, 1992 to 2002. The IVs were calculated from line transect data[a].

1992		1995		2002	
Species	IV	Species	IV	Species	IV
Spring-beauty	300.0	Cut-leaved toothwort	157.6	Spring-beauty	207.8
		Spring-beauty	142.4	Wild licorice	92.2

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

Bushman Hill Woodlot

The number of tree species recorded (fenced and unfenced plots combined) was twelve in the 2002 seedling inventory. The density of seedling trees was 19,800 stems/ha in the fenced plot and 21,700 stems/ha in the unfenced plot (Table 7). Ash accounted for the largest percentage of the total seedling tree density in both the unfenced and fenced plots, 39% and 41% or 8,400 and 8,100 stems/ha, respectively. White oak seedling density was greater in the unfenced plot (6,700 stems/ha) than in the fenced plot (2,300 stems/ha) (Table 7). Ash, cherry, hickory, and oak seedling densities were slightly greater in the unfenced plot (Figure 6). Slippery elm (*Ulmus rubra*), and maple (*Acer* spp.) seedling densities were greater in the fenced plot (Figure 6).

In 2002, the density of seedling trees <26 cm in height in the fenced plot (5,900 stems/ha) was half of the density in the unfenced plot (12,600 stems/ha). The density of seedling trees ≥26 cm in height in the fenced plot (13,900 stems/ha) was greater than in the unfenced plot (9,100 stems/ha). The tallest stems in the unfenced plot were in the 76-100 cm range, and in the fenced plot were in the 125-150 cm range (Figure 7).

Sapling trees were recorded in the fenced plot, but not in the unfenced plot in 2002 (Table 7). The sapling tree density was 4,900 stems/ha, with slippery elm being the dominant species accounting for 59% of the total density. The other species present in the sapling category were American elm, ash, black cherry, mockernut and pignut hickory (Figure 8). The density of small saplings was 4,200 stems/ha, and the density of large saplings was 700 stems/ha.

Eleven shrub species were recorded (fenced and unfenced combined) in the 2002 seedling inventory. The density of seedling shrubs was 23,400 stems per in the fenced plot and 40,700 stems/ha in the unfenced plot (Table 7). In 2002, shrub species diversity was greater in the unfenced plot (ten species) than in the fenced plot (eight species). The dominant species in the unfenced plot was Japanese barberry with a density of 11,700 stems/ha, accounting for 29% of the total seedling shrub density. Spicebush was the second most prolific species, followed by *Rubus* and smooth blackhaw. In the fenced plot, *Rubus* were dominant seedling shrub species with a density of 9,200 stems/ha. Smooth blackhaw and spicebush were also prolific with 6,600 and 4,700 stems/ha, respectively (Figure 9).

The density of seedling shrubs <26 cm in height in the fenced plot (10,800 stems/ha) was similar to the density in the unfenced plot (11,800 stems/ha). The density of seedling shrubs ≥26 cm in height in the fenced plot (12,600 stems/ha) was less than half the density recorded in the unfenced plot (28,900 stems/ha). Seedling shrubs were recorded in all the height classes in both fence treatments in 2002 (Figure 10).

Sapling-sized shrubs were inventoried in the unfenced and fenced plots in 2002, with densities of 3,400 and 4,200 stems/ha, respectively (Table 7). The dominant species in the unfenced plot were spicebush (1,800 stems/ha) and Japanese barberry (900 stems/ha). However, in the fenced plot the dominant sapling shrubs were smooth blackhaw (2,400 stems/ha) and multiflora rose (1,500 stems/ha).

Herbaceous vegetation coverage was slightly greater in the unfenced-control subplot than in the fenced subplot. The average total coverage was 55% in the unfenced-control subplot and 32% in the fenced subplot. Forb, grass, and vine coverages were greater in the unfenced-control subplot than in the fenced subplot (Table 8).

In the fenced subplot, Virginia-creeper had the greatest IV in 2002 (Table 9). Greenbriar had the second greatest IV and Jack-in-the-pulpit (*Arisaema triphyllum*) was third-ranked in the transects in 2002. The Shannon Diversity Index was 0.57 in 2002, and the Evenness Index was 0.73 (Tables 4 and 5).

In the unfenced-control subplot, Japanese honeysuckle was first rank in 2002 (Table 10). Jack-in-the-pulpit was second-ranked and Enchanter's-nightshade third rank in 2002. The Shannon Diversity Index was 0.91 in 2002, and the Evenness Index was 0.87 (Tables 4 and 5).

Table 7. Densities (stems/ha)[a] of seedling[b] and sapling[c] tree and shrub species in the fenced and unfenced 10 x 10 m Demonstration Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

	SEEDLING		SAPLING	
	Unfenced	Fenced	Unfenced	Fenced
	----------Density (stems/ha)----------			
Ash	8,400	8,100	0	900
Cherry, sweet	1,100	500	0	0
Cherry, black	2,500	700	0	200
Elm, American	0	0	0	600
Elm, slippery	700	5,000	0	2,900
Hickory, mockernut	300	600	0	200
Hickory, pignut	1,000	600	0	100
Hickory, shagbark	700	700	0	0
Maple, Norway	0	100	0	0
Maple, red	100	600	0	0
Oak, northern red	0	600	0	0
Oak, white	6,700	2,300	0	0
Walnut, black	200	0	0	0
Total Tree	21,700	19,800	0	4,900
Barberry, Japanese	11,700	0	900	0
Black-haw, smooth	4,500	6,600	300	2,400
Dogwood, flowering	2,000	0	0	0
Grape	0	0	100	0
Honeysuckle, Tartarian	100	0	0	0
Olive, autumn	400	200	0	0
Redbud, eastern	2,600	600	0	100
Rose, multiflora	1,500	1,800	300	1,500
Rubus	6,200	9,200	0	0
Serviceberry	0	100	0	100
Spicebush	10,200	4,700	1,800	100
Witch hazel	1,500	200	0	0
Total Shrub	40,700	23,400	3,400	4,200

[a] Values for the 2002 surveys were from the entire 10 x 10 m plot (100 m^2). Values within columns may not add up to the value for Total Tree and Total Shrub due to rounding.
[b] Stems ≤150 cm in height.
[c] Stems >1.5 m in height and <12 cm dbh.

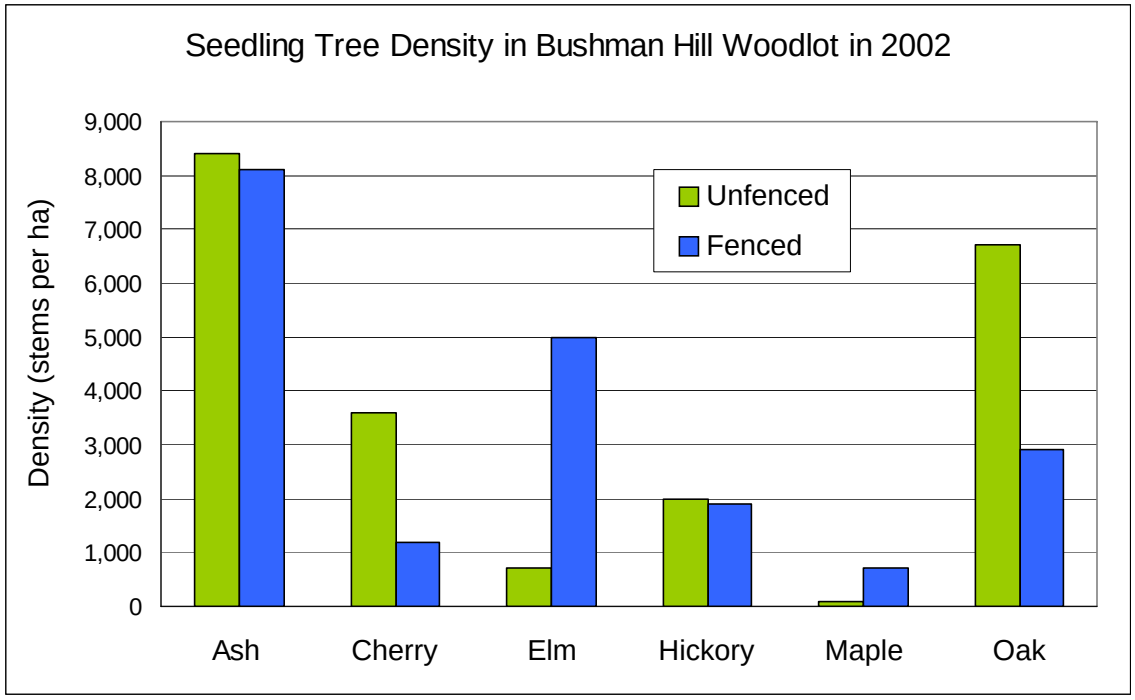


Figure 6. Density of seedling (≤150 cm in height) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

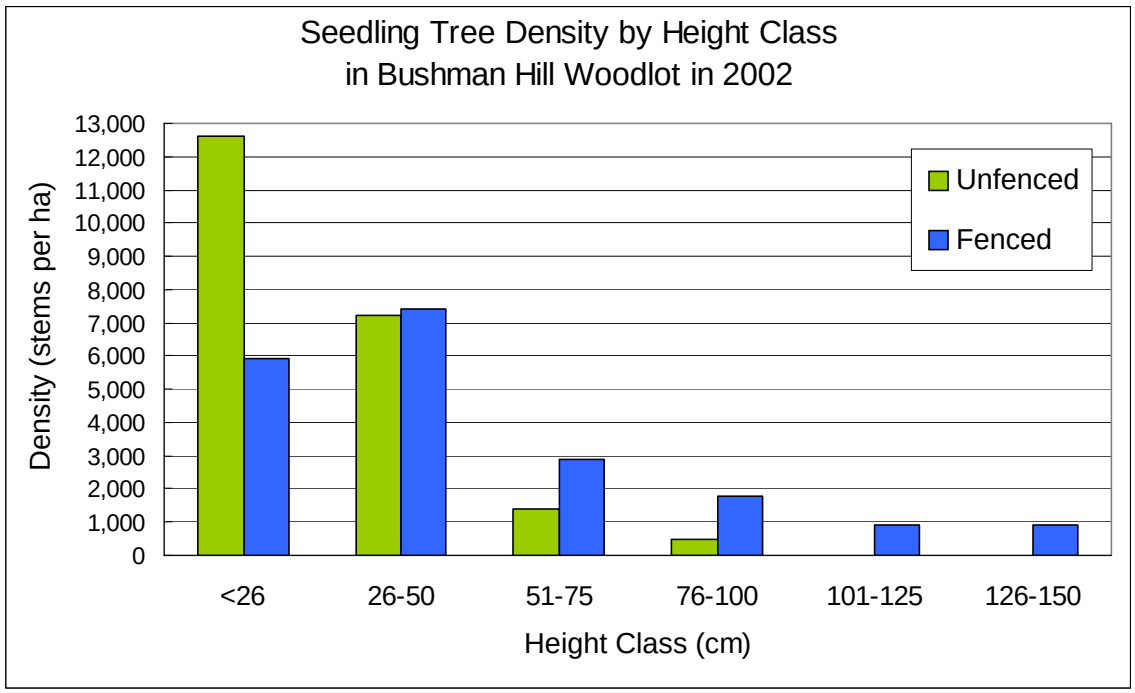


Figure 7. Density of seedling (≤150 cm in height) tree species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

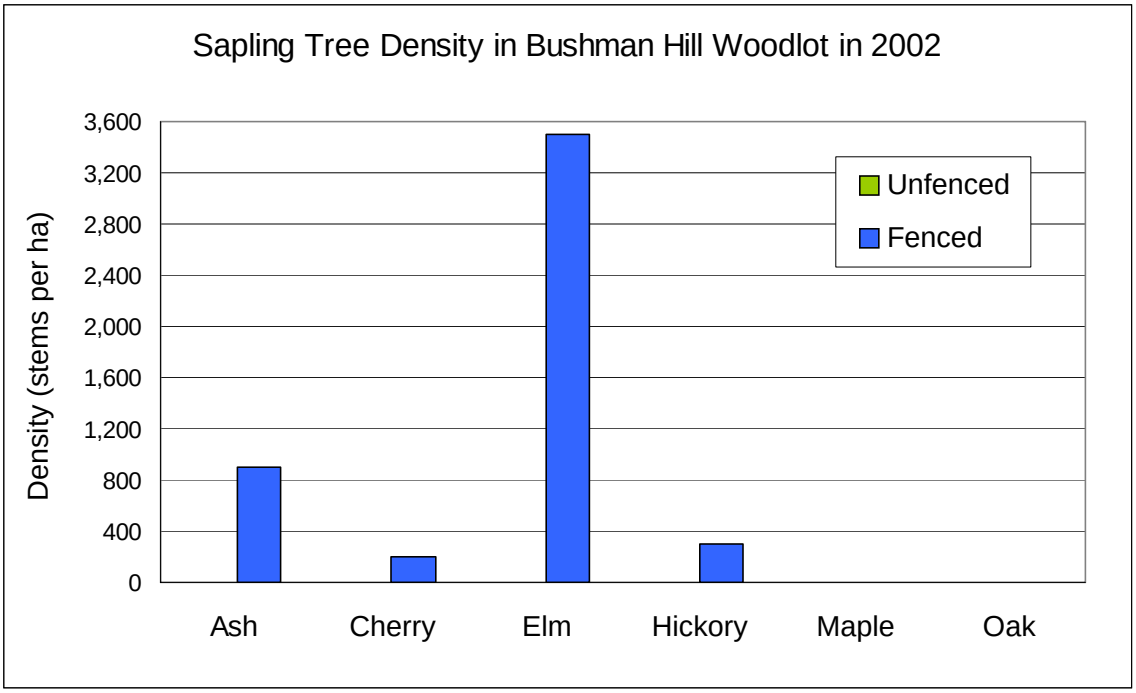


Figure 8. Density of sapling (>1.5 m in height and <12 cm dbh) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

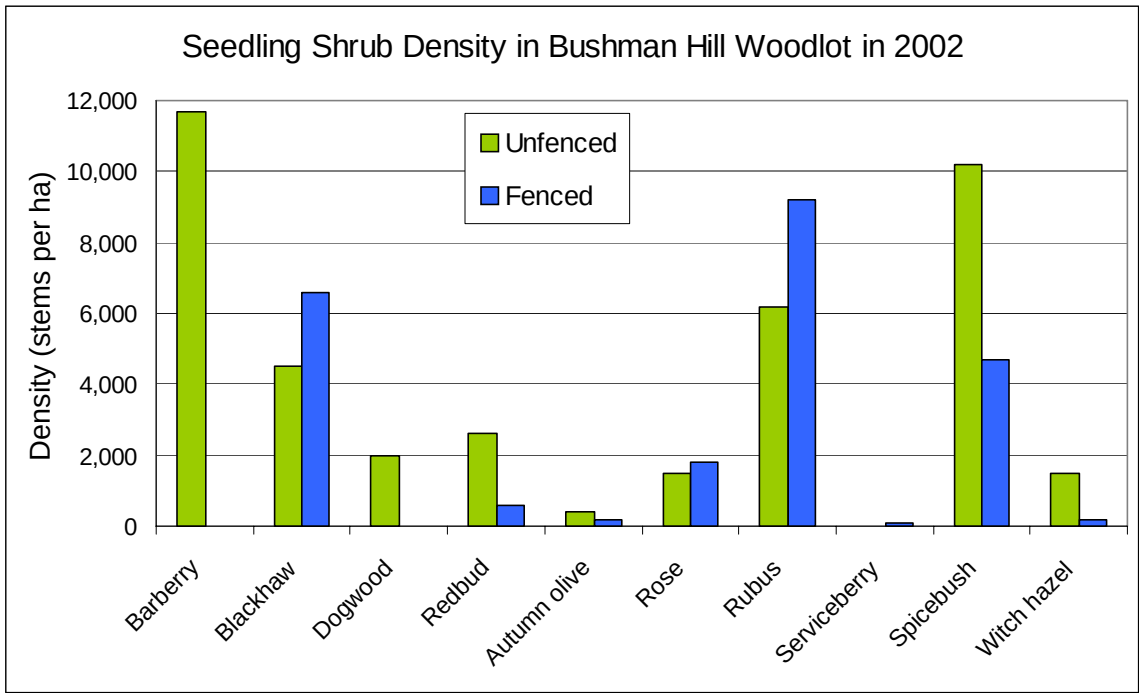


Figure 9. Density of seedling (≤150 cm in height) shrub species in the fenced and unfenced 10 x 10 m Demonstration Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

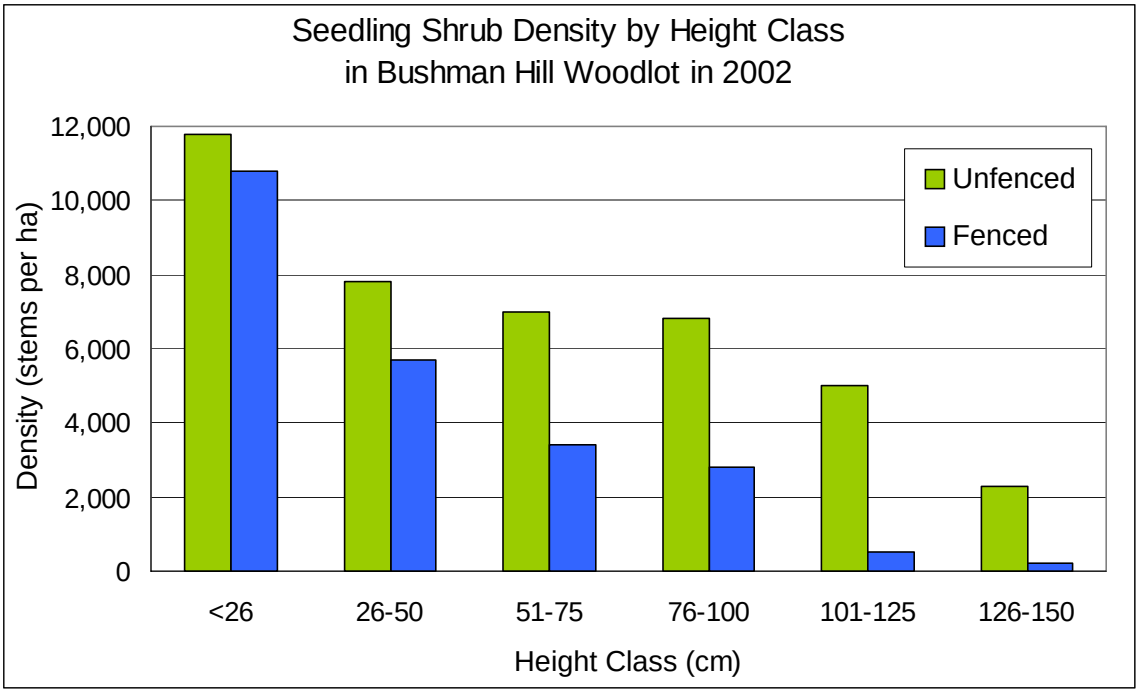


Figure 10. Density of seedling (≤150 cm in height) shrub species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

Table 8. Average coverage for grass, forb, vine, and total species in the fenced 10 x 10 m Demonstration Plot[a] and unfenced-control 40 x 40 m plot[b] in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

	Fenced Average Coverage (%)	Unfenced-control Average Coverage (%)
Grass	0	2
Forb	30	46
Vine	2	7
Total	32	55

[a] The 10 x 10 m fenced plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.
[b] The 40 x 40 m unfenced-control plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.

Table 9. A comparison of the greatest Importance Values (IV) of the herbaceous and vine species present in a subplot of the fenced 10 x 10 m Demonstration Plot in Bushman Hill woodlot, Gettysburg National Military Park, 1992 to 2002. The IVs were calculated from line transect data[a].

1992		1995		2002	
Species	IV	Species	IV	Species	IV
Rough bedstraw	104.7	Virginia-creeper	100.8	Virginia-creeper	151.4
White-snakeroot	80.6	Carrion-flower	69.8	Greenbriar	60.6
Jack-in-the-pulpit	69.0	Wild strawberry	52.8	Jack-in-the-pulpit	27.8
Virginia-creeper	45.6	Rough bedstraw	43.7	Carrion-flower	27.8
		Wild licorice	32.9	Enchanter's-nightshade	17.8
				Japanese honeysuckle	14.5

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

Table 10. A comparison of the greatest Importance Values (IV) of the herbaceous and vine species present in a subplot of the unfenced-control 40 x 40 m plot in Bushman Hill woodlot, Gettysburg National Military Park, 1992 to 2002. The IVs were calculated from line transect data[a].

1992		1995		2002	
Species	IV	Species	IV	Species	IV
Cinquefoil	77.4	Cinquefoil	79.4	Japanese honeysuckle	60.1
Wild licorice	53.7	Rough bedstraw	76.4	Jack-in-the-pulpit	59.3
Jack-in-the-pulpit	48.0	Enchanter's-nightshade	63.9	Enchanter's-nightshade	44.0
Smartweed (*persicaria*)	34.8	Smartweed spp.	20.7	Agrimony	28.1
Enchanter's-nightshade	33.4	Wild licorice	14.5	Summer grape	27.3
Rough bedstraw	23.6	Japanese honeysuckle	12.1	Wild-comfrey	19.3
Jewelweed	20.5	Skullcap spp.	9.9	Virginia-creeper	12.6
Summer grape	8.7	Agrimony	8.8	Stiltgrass	10.2
		Summer grape	6.3	Black sanicle	6.1
		Jack-in-the-pulpit	4.0		
		Wild-comfrey	4.0		

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

Cobean (Butterfield Farm) Woodlot

Eight species of trees were recorded (fenced and unfenced plots combined) in the 2002 seedling inventory (Table 11). The density of seedling trees in the unfenced plot was much greater (22,000 stems/ha) than in the fenced plot (3,100 stems/ha). The dominant tree species in the unfenced plot was ash with 19,800 stems/ha (Figure 11). Black cherry contributed the second most stems with a density of 1,500 stems/ha. Both of these species were prevalent in the fenced plot but at lower density values. Black cherry and ash each had densities of 1,200 stems/ha. Oak species were present in the fenced and unfenced plots, but at lower values (200 and 300 stems/ha, respectively) (Figure 11).

The density of seedling trees <26 cm in height in the fenced plot (1,300 stems/ha) was much lower than in the unfenced plot (20,600 stems/ha) (Figure 12). The density of seedling trees ≥26 cm in height in the fenced plot (1,800 stems/ha) was almost equal to the density in the unfenced plot (1,400 stems/ha).

In the 2002 sapling inventory, the fenced plot had a greater density of trees (700 stems/ha) than the unfenced plot (100 stems/ha) (Table 11). Black cherry was the only species in the unfenced plot, and was the dominant species in the fenced plot (400 stems/ha). Shagbark hickory, ash, and American elm were also found in the fenced plot (Figure 13). The density of small saplings in the fenced and unfenced plots was 600 and zero stems/ha, respectively. The density of large saplings in the fenced and unfenced plots was 100 stems/ha each.

Six shrub species were recorded (fenced and unfenced combined) in the 2002 seedling inventory. The density was 22,500 stems/ha in the fenced plot and 23,800 stems/ha in the unfenced plot (Table 11). The density of *Rubus* was 17,100 stems/ha in the fenced plot and 14,000 stems/ha in the unfenced plot (Figure 14). The density of multiflora rose was 2,300 and 7,200 stems/ha in the fenced and unfenced plots, respectively. Smooth blackhaw densities were 1,300 and 600 stems/ha in the fenced and unfenced plots, respectively. Sassafras was only recorded in the fenced plot in 2002, with a density of 900 stems/ha (Figure 14).

The density of seedling shrubs <26 cm in height was 10,400 and 12,900 stems/ha in the fenced and unfenced plots, respectively. For the fenced shrubs ≥26 cm in height, density was 9,600 stems/ha. The density of unfenced shrubs ≥26 cm in height was 13,400 stems/ha in 2002 (Figure 15).

In the 2002 sapling inventory, the unfenced plot density was 3,700 stems/ha, while the fenced plot density was slightly greater at 7,200 stems/ha (Table 11). Five species of shrubs were identified in both plots. Tartarian honeysuckle and multiflora rose were equally dominant in the unfenced plot, with densities of 1,700 and 1,800 stems/ha, respectively. Rose was the dominant species in the fenced plot accounting for 5,100 stems/ha.

The herbaceous vegetation coverage in the two plots was similar. The average total coverage in the fenced subplot was 31% and in the unfenced subplot 42%. There were no grass species present in either subplot. The forb coverage was greater in the unfenced subplot, but the vine coverage was greater in the fenced subplot (Table 12).

Table 11. Densities (stems/ha)[a] of seedling[b] and sapling[c] tree and shrub species in the fenced and unfenced 10 x 10 Demonstration Plots in Cobean woodlot, Gettysburg National Military Park, 2002.

	SEEDLING		SAPLING	
	Unfenced	Fenced	Unfenced	Fenced
	----------Density (stems/ha)----------			
Ash	19,800	1,200	0	100
Cherry, black	1,500	1,200	100	400
Elm, American	0	100	0	100
Elm, slippery	100	0	0	0
Hickory, pignut	200	200	0	0
Hickory, shagbark	0	200	0	100
Oak, black	300	200	0	0
Oak, northern red	100	0	0	0
Total Tree	22,000	3,100	100	700
Blackhaw, smooth	600	1,300	100	200
Honeysuckle, Tartarian	1,900	900	1,700	200
Redbud, eastern	100	0	0	0
Rose, multiflora	7,200	2,300	1,800	5,100
Rubus	14,000	17,100	100	1,000
Sassafras	0	900	0	700
Total Shrub	23,800	22,500	3,700	7,200

[a] Values for the 2002 surveys were from the entire 10 x 10 m plot (100 m^2). Values within columns may not add up to the value for Total Tree and Total Shrub due to rounding.
[b] Stems ≤150 cm in height.
[c] Stems >1.5 m in height and <12 cm dbh.

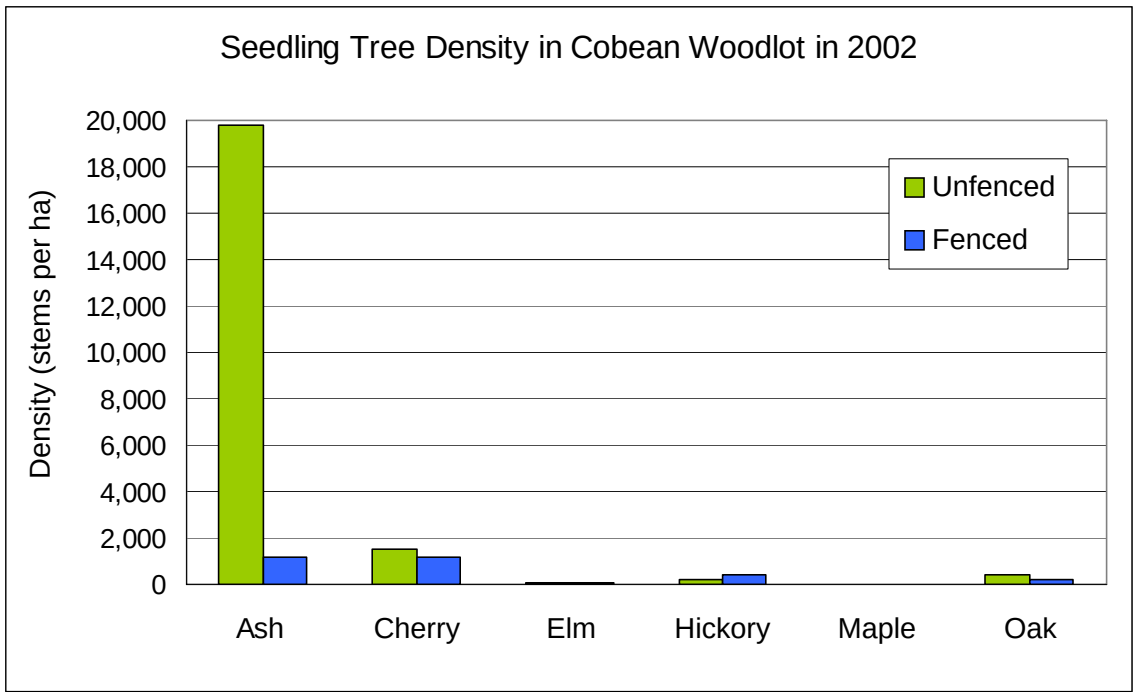


Figure 11. Density of seedling (≤150 cm in height) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Cobean woodlot, Gettysburg National Military Park, 2002.

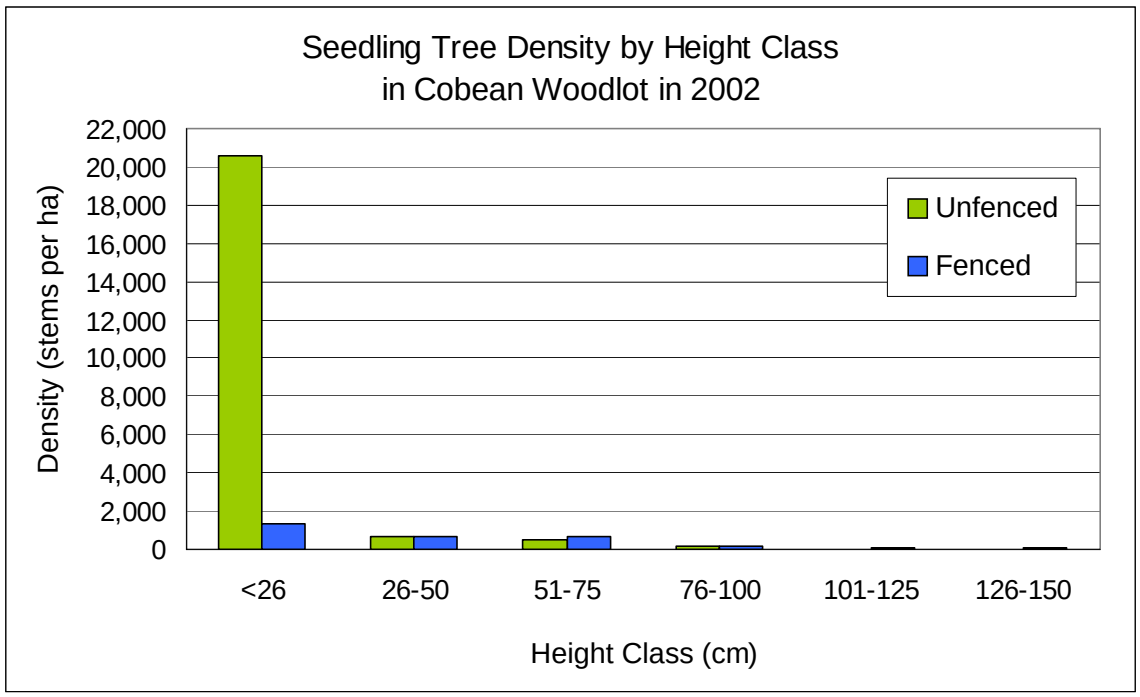


Figure 12. Density of seedling (≤150 cm in height) tree species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Cobean woodlot, Gettysburg National Military Park, 2002.

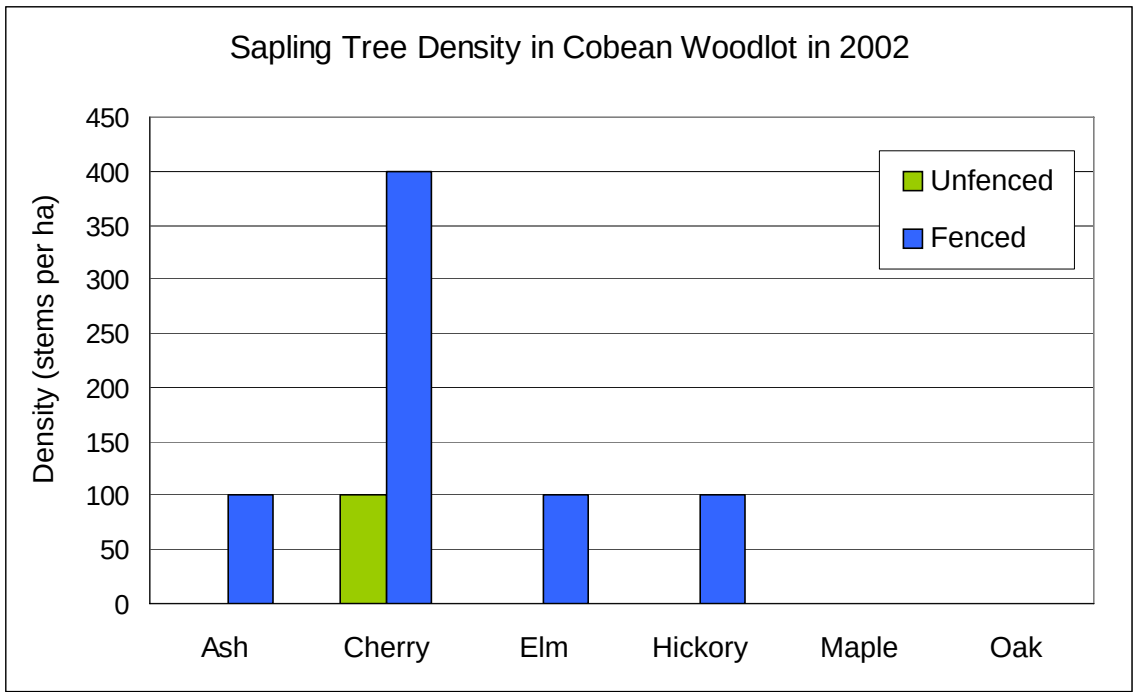


Figure 13. Density of sapling (>1.5 m in height and <12 cm dbh) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Cobean woodlot, Gettysburg National Military Park, 2002.

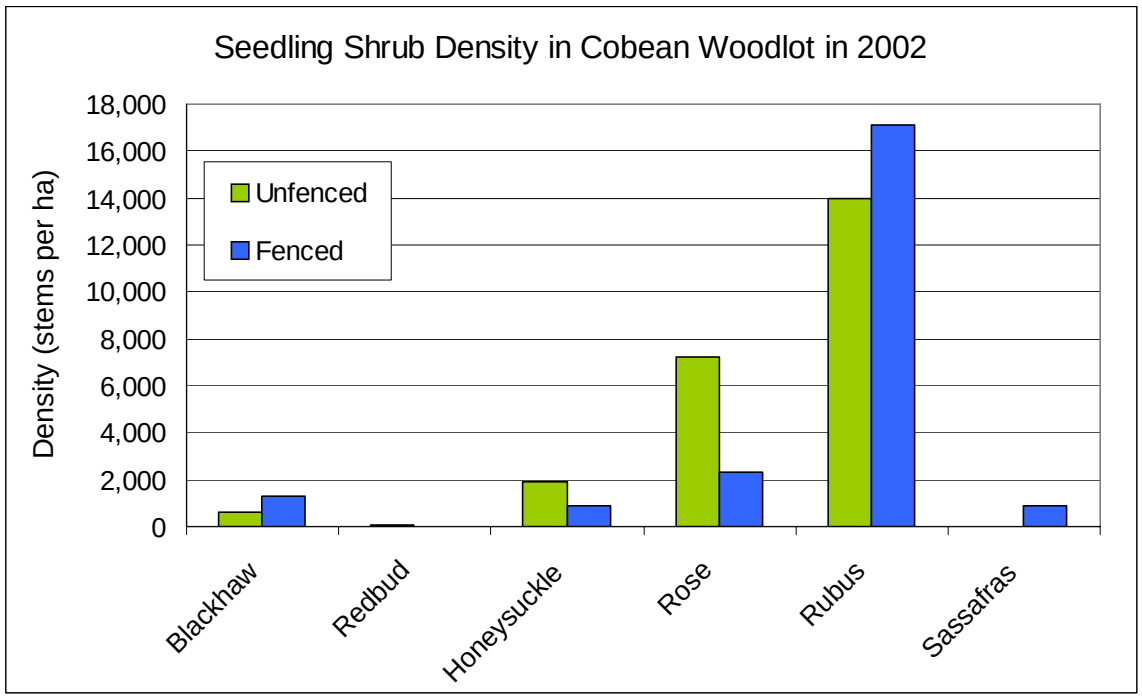


Figure 14. Density of seedling (≤150 cm in height) shrub species in the fenced and unfenced 10 x 10 m Demonstration Plots in Cobean woodlot, Gettysburg National Military Park, 2002.

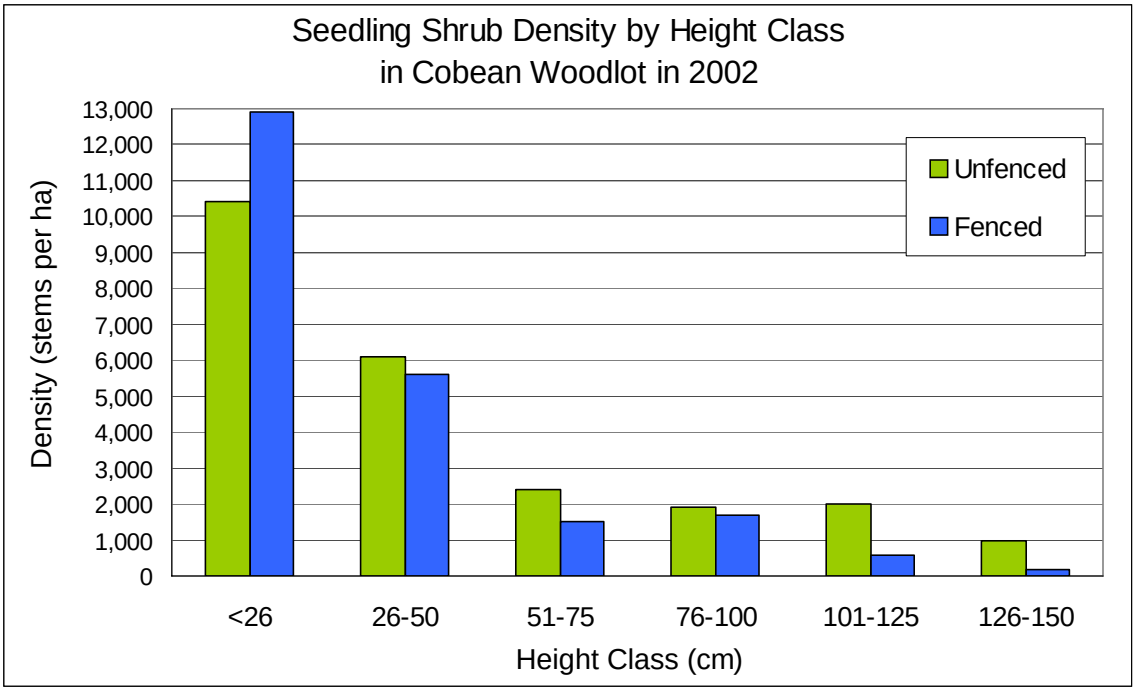


Figure 15. Density of seedling (≤150 cm in height) shrub species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Cobean woodlot, Gettysburg National Military Park, 2002.

Table 12. Average coverage for grass, forb, vine, and total species in the fenced 10 x 10 m Demonstration Plot[a] and unfenced-control 40 x 40 m plot[b] in Cobean woodlot, Gettysburg National Military Park, 2002.

	Fenced Average Coverage (%)	Unfenced-control Average Coverage (%)
Grass	0	0
Forb	19	33
Vine	12	9
Total	31	42

[a] The 10 x 10 m fenced plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.
[b] The 40 x 40 m unfenced-control plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.

Pitzer Woodlot

Twelve tree species were recorded (fenced and unfenced plots combined) in the seedling inventory in 2002. The seedling tree density was 8,200 stems/ha in the fenced plot and 4,100 stems/ha in the unfenced plot (Table 13). White oak was the most abundant seedling tree in the fenced plot with a density of 4,500 stems/ha, whereas there were only 100 stems/ha in the unfenced plot. There were substantially more white oak seedlings in the Pitzer woodlot than in any other woodlot. There was a greater diversity of oak species seedlings in this woodlot (black, northern red, white and chestnut oak). The density of oak species seedlings was much greater in the fenced plot than in the unfenced plot (5,200 versus 400 stems/ha, respectively) (Figure 16). Black cherry and ash seedlings were slightly more dominant than the other seven species in the unfenced plot, with densities of 1,000 and 900 stems/ha, respectively (Table 13).

The density of seedling trees <26 cm in height was 4,500 stems/ha in the fenced plot and 2,700 stems/ha in the unfenced plot. For seedling trees ≥26 cm in height, the density in the fenced plot was 3,700 stems/ha and in the unfenced plot 1,400 stems/ha (Figure 17). There were no seedling trees ≥76 cm in height in the unfenced plot.

In 2002, there was a greater density of sapling trees (900 stems/ha) in the fenced plot than in the unfenced plot (500 stems/ha) (Table 13). Shagbark hickory was the only species in the unfenced plot. Eastern red cedar was the dominant species in the fenced plot (400 stems/ha). Shagbark hickory, black cherry, and white oak had lower sapling tree densities (Figure 18). The density of small saplings in the fenced and unfenced plots was 300 and zero stems/ha, respectively. The density of large saplings in the fenced and unfenced plots was 600 and 500 stems/ha, respectively.

Four species of shrubs were recorded (fenced and unfenced plots combined) in the 2002 seedling inventory. The density of seedling shrubs was 4,600 stems/ha in the fenced plot and 2,000 stems/ha in the unfenced plot (Table 13). Smooth blackhaw was the dominant seedling shrub with 2,700 stems/ha in the fenced plot (Figure 19). *Rubus* was also prevalent with 1,700 stems/ha. Smooth blackhaw and *Rubus* were equally dominant in the unfenced plot, with densities of 900 stems/ha each (Table 13).

The density of seedling shrubs <26 cm in height was 1,500 stems/ha in the fenced plot and 1,400 stems/ha in the unfenced plot. The density of seedling shrubs ≥26 cm in height was 3,100 stems/ha in the fenced plot and 600 stems/ha in the unfenced plot (Figure 20). There were no shrubs ≥76 cm in height recorded in the unfenced plot.

The 2002 inventory showed a low density of sapling shrubs. There were none recorded in the unfenced plot and only 100 stems/ha of smooth blackhaw in the fenced plot (Table 13).

The amount of herbaceous and vine vegetation coverage in the unfenced subplot was 76%, whereas in the fenced subplot it was 33%. Grasses were only recorded in the fenced subplot. The forb coverage was greater in the fenced subplot (14% versus 2%), but the vine coverage was greater in the unfenced subplot (74% versus 15%) (Table 14).

In the fenced plot, Japanese honeysuckle dominated the transects in 2002 having an IV 2.8 times greater than the next highest value (Table 15). Grass spp. were second rank in 2002, and false solomon's-seal (*Simlacina racemosa*) was ranked third. The Shannon Diversity Index was 0.47 in 2002, and the Evenness Index was 0.60 (Tables 4 and 5).

In the unfenced-control plot, no herbaceous or vine species were present in the line transects in 2002 (Table 16). One species was present in the quadrants in 2002. The Shannon Diversity Index and the Evenness Index were both zero in 2002 (Tables 4 and 5).

Table 13. Densities (stems/ha)[a] of seedling[b] and sapling[c] tree and shrub species in the fenced and unfenced 10 x 10 m Demonstration Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

	SEEDLING		SAPLING	
	Unfenced	Fenced	Unfenced	Fenced
	----------Density (stems/ha)----------			
Ash	900	400	0	0
Cedar, eastern red	500	400	0	400
Cherry, sweet	100	600	0	0
Cherry, black	1,000	800	0	200
Hickory, mockernut	500	0	0	0
Hickory, pignut	0	100	0	0
Hickory, shagbark	700	600	500	200
Maple, red	0	100	0	0
Oak, black	0	400	0	0
Oak, chestnut	100	200	0	0
Oak, northern red	200	100	0	0
Oak, white	100	4,500	0	100
Total Tree	4,100	8,200	500	900
Blackhaw, smooth	900	2,700	0	100
Ribes	200	0	0	0
Rose, multiflora	0	200	0	0
Rubus	900	1,700	0	0
Total Shrub	2,000	4,600	0	100

[a] Values for the 2002 surveys were from the entire 10 x 10 m plot (100 m^2). Values within columns may not add up to the value for Total Tree and Total Shrub due to rounding.
[b] Stems ≤150 cm in height.
[c] Stems >1.5 m in height and <12 cm dbh.

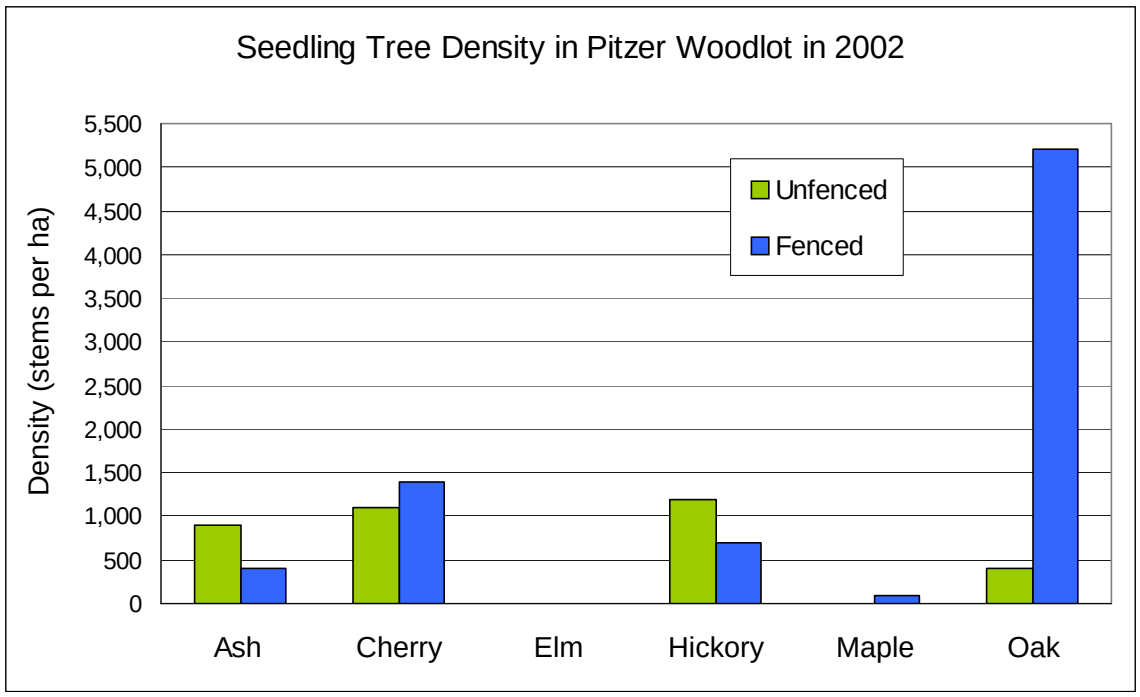


Figure 16. Density of seedling (≤150 cm in height) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

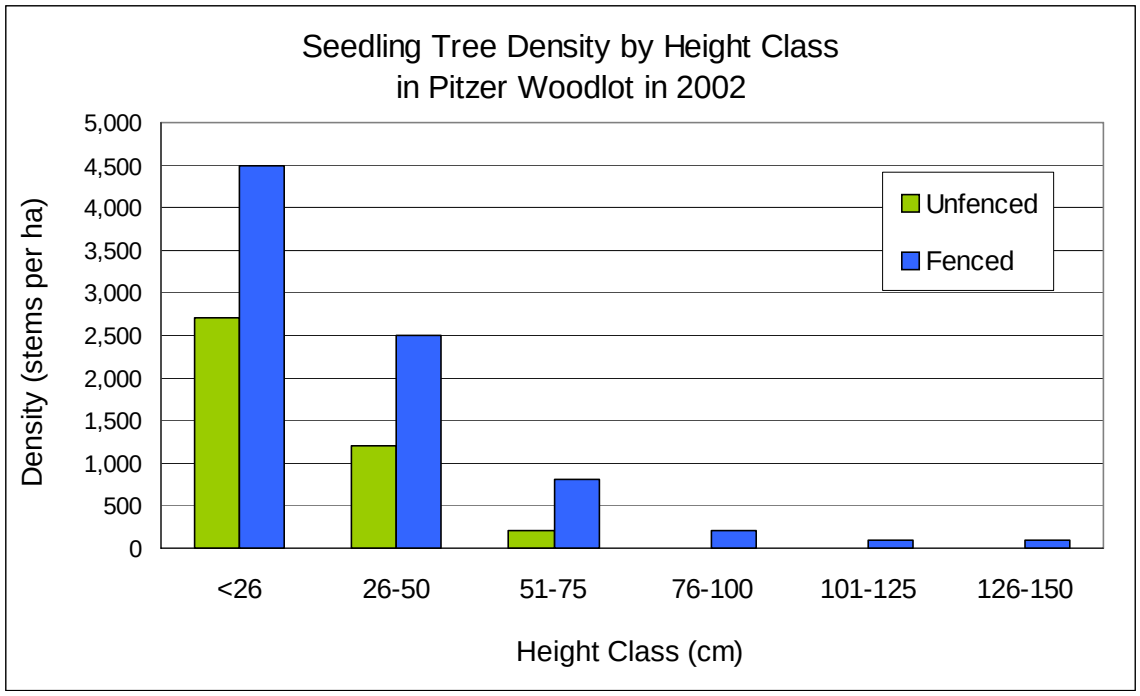


Figure 17. Density of seedling (≤150 cm in height) tree species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

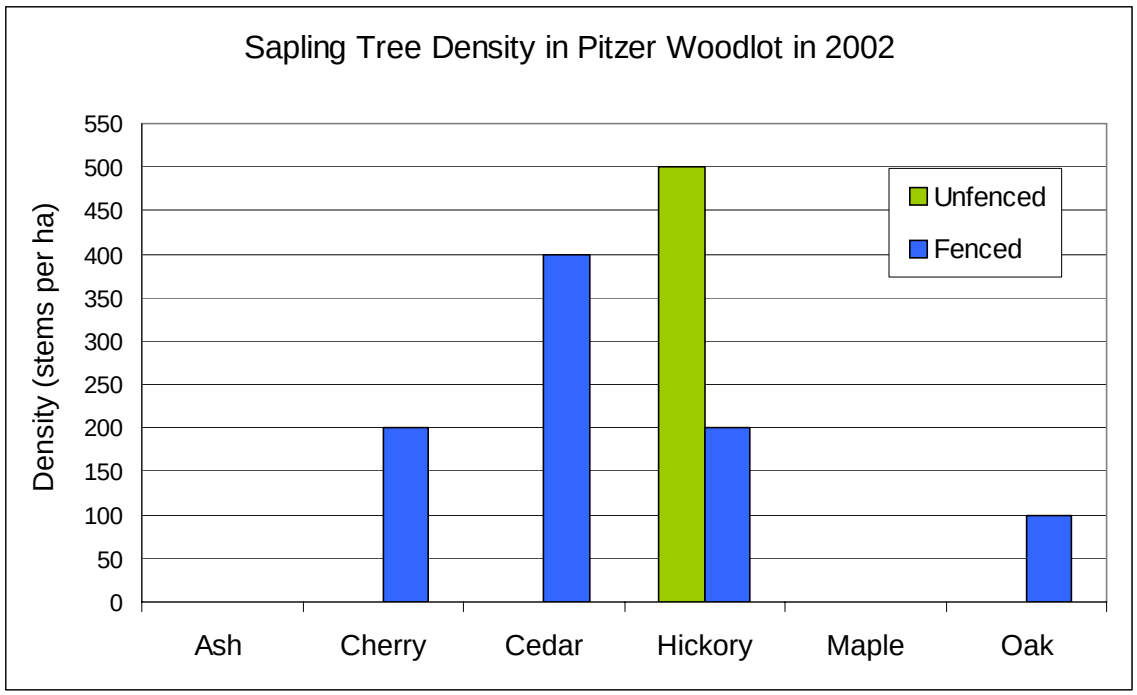


Figure 18. Density of sapling (>1.5 m in height and <12 cm dbh) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

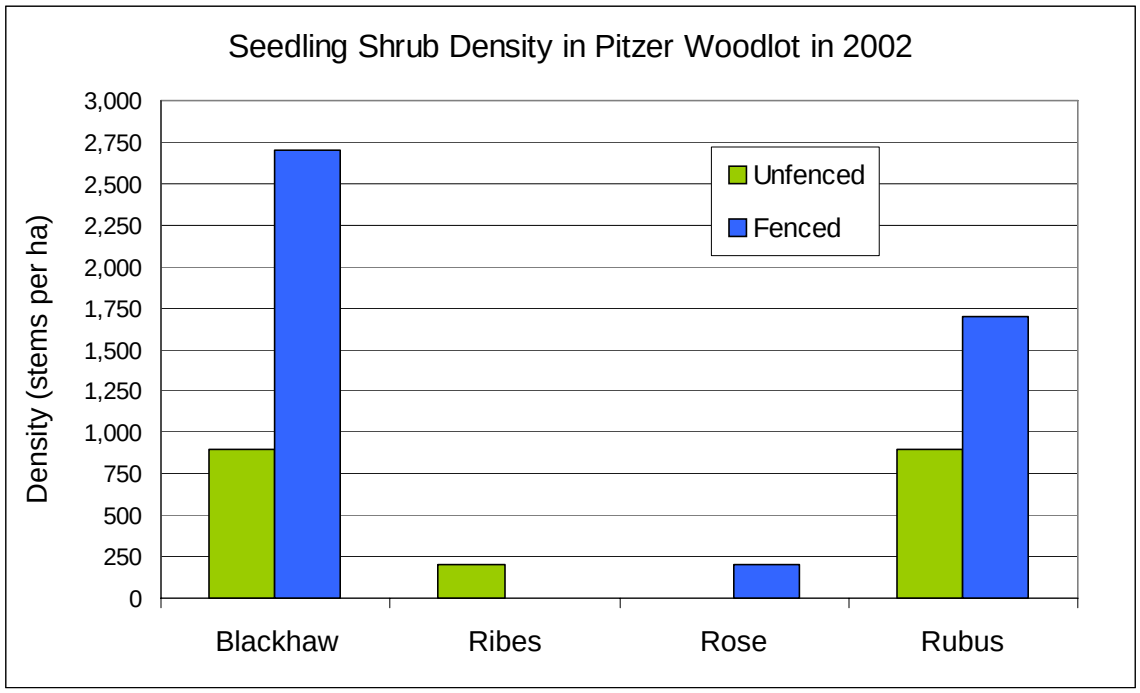


Figure 19. Density of seedling (≤150 cm in height) shrub species in the fenced and unfenced 10 x 10 m Demonstration Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

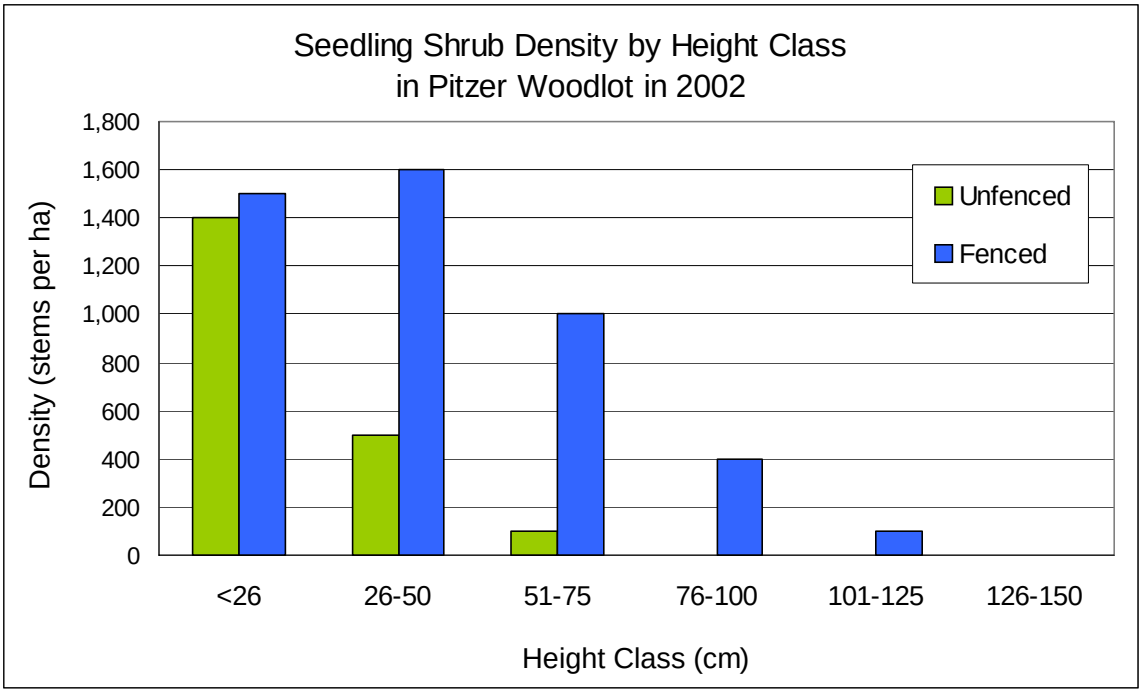


Figure 20. Density of seedling (≤150 cm in height) shrub species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

Table 14. Average coverage for grass, forb, vine, and total species in the fenced 10 x 10 m Demonstration Plot[a] and unfenced-control 40 x 40 m plot[b] in Pitzer woodlot, Gettysburg National Military Park, 2002.

	Fenced Average Coverage (%)	Unfenced Average Coverage (%)
Grass	4	0
Forb	14	2
Vine	15	74
Total	33	76

[a] The 10 x 10 m fenced plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.
[b] The 40 x 40 m unfenced-control plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.

Table 15. A comparison of the greatest Importance Values (IV) of the herbaceous and vine species present in a subplot of the fenced 10 x 10 m Demonstration Plot in Pitzer woodlot, Gettysburg National Military Park, 1995 to 2002. The IVs were calculated from line transect data[a].

1995		2002	
Species	IV	Species	IV
Japanese honeysuckle	235.4	Japanese honeysuckle	186.2
Goldenrod spp.	31.0	Grass spp.	66.0
False Solomon's-seal	17.6	False solomon's-seal	24.6
Grass spp.	16.0	Violet wood-sorrel	9.1
		Enchanter's-nightshade	7.5
		Jewelweed	6.6

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

Table 16. A comparison of the greatest Importance Values (IV) of the herbaceous and vine species present in a subplot of the unfenced-control 40 x 40 m plot in Pitzer woodlot, Gettysburg National Military Park, 1995 to 2002. The IVs were calculated from line transect data[a].

1995		2002	
Species	IV	Species	IV
Japanese honeysuckle	171.2	None	
Wild licorice	128.8		

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

Slyder Woodlot

Eight species of trees were recorded (fenced and unfenced plots combined) in the seedling inventory in 2002. The seedling tree density was 1,500 stems/ha in the fenced plot and 9,600 stems/ha in the unfenced plot (Table 17). Pin oak was the most abundant seedling tree species in the fenced plot (800 stems/ha), and ash was most abundant in the unfenced plot (8,800 stems/ha) (Figure 21). Northern red oak was only recorded in the unfenced plot and had a density of 200 stems/ha (Figure 21). Pin oak densities were 800 stems/ha in the fenced plot and 200 stems/ha in the unfenced plot.

The density of seedling trees <26 cm in height in the fenced plot (200 stems/ha), was much lower than in the unfenced plot (2,200 stems/ha) (Figure 22). The density of seedling trees ≥26 cm in height in the fenced plot (1,300 stems/ha) was also lower than in the unfenced plot (7,400 stems/ha).

The 2002 sapling tree inventory showed a greater density of tree species in the fenced plot (1,000 stems/ha) than in the unfenced plot (300 stems/ha) (Table 17). In the fenced plot, there was an even distribution of six species of trees (northern red oak, pin oak, pignut hickory, black cherry, Norway maple, and American elm). However, shagbark hickory was the only tree species growing in the unfenced plot (Figure 23). The density of small saplings in the fenced and unfenced plots was 600 and 100 stems/ha, respectively. The density of large saplings in the fenced and unfenced plots was 400 and 200 stems/ha, respectively.

Eight shrub species were recorded (fenced and unfenced plots combined) in the seedling inventory in 2002. The seedling shrub density was 11,300 and 4,700 stems/ha in the fenced and unfenced plots, respectively (Table 17). *Rubus* was the dominant shrub with densities of 3,900 and 1,700 stems/ha in the fenced and unfenced plots, respectively (Figure 24). Multiflora rose and spicebush were also very abundant in the fenced plot with densities of 3,300 and 2,800 stems/ha, respectively. Smooth blackhaw was prevalent in the unfenced plot with 1,300 stems/ha.

In 2002, the density of seedling shrubs <26 cm in height in the fenced plot was 900 stems/ha, and the density in the unfenced plot was 500 stems/ha. The density of seedling shrubs ≥26 cm in height in the fenced plot was 10,400 stems/ha, while the density in the unfenced plot was 4,200 stems/ha (Figure 25).

The 2002 sapling inventory showed a relatively high density of shrubs, especially in the fenced plot. The unfenced plot density was 4,500 stems/ha, while the fenced plot density was 15,800 stems/ha (Table 17). Eight species of shrubs were identified in the plots. Multiflora rose was dominant in the fenced plot with a density of 9,200 stems/ha, and Tartarian honeysuckle was second most prevalent with 4,100 stems/ha. Japanese barberry was the dominant shrub species in the unfenced plot with 2,800 stems/ha.

The average herbaceous and vine vegetation coverage was 32% in the fenced subplot and 40% in the unfenced subplot (Table 18). Grasses were only recorded in the unfenced subplot. The forb coverage was definitely greater in the unfenced subplot (24%) than in the fenced subplot (3%), but vine coverage was greater in the fenced subplot (29%) than in the unfenced subplot (2%).

Table 17. Densities (stems/ha)[a] of seedling[b] and sapling[c] tree and shrub species in the fenced and unfenced 10 x 10 m Demonstration Plots in Slyder woodlot, Gettysburg National Military Park, 2002.

	SEEDLING		SAPLING	
	Unfenced	Fenced	Unfenced	Fenced
	----------Density (stems/ha)----------			
Ash	8,800	100	0	0
Cherry, sweet	200	100	0	0
Cherry, black	100	300	0	200
Elm, American	100	0	0	100
Hickory, pignut	0	100	0	100
Hickory, shagbark	0	0	300	0
Maple, Norway	0	100	0	100
Oak, northern red	200	0	0	200
Oak, pin	200	800	0	300
Total Tree	9,600	1,500	300	1,000
Barberry, Japanese	200	300	2,800	0
Blackhaw, smooth	1,300	900	700	500
Euonymus	0	0	0	100
Grape	0	0	100	100
Honeysuckle, Tartarian	0	0	0	4,100
Redbud, eastern	100	100	0	0
Rose, multiflora	600	3,300	100	9,200
Rubus	1,700	3,900	800	100
Spicebush	800	2,800	0	1,700
Total Shrub	4,700	11,300	4,500	15,800

[a] Values for the 2002 surveys were from the entire 10 x 10 m plot (100 m^2). Values within columns may not add up to the value for Total Tree and Total Shrub due to rounding.
[b] Stems ≤150 cm in height.
[c] Stems >1.5 m in height and <12 cm dbh.

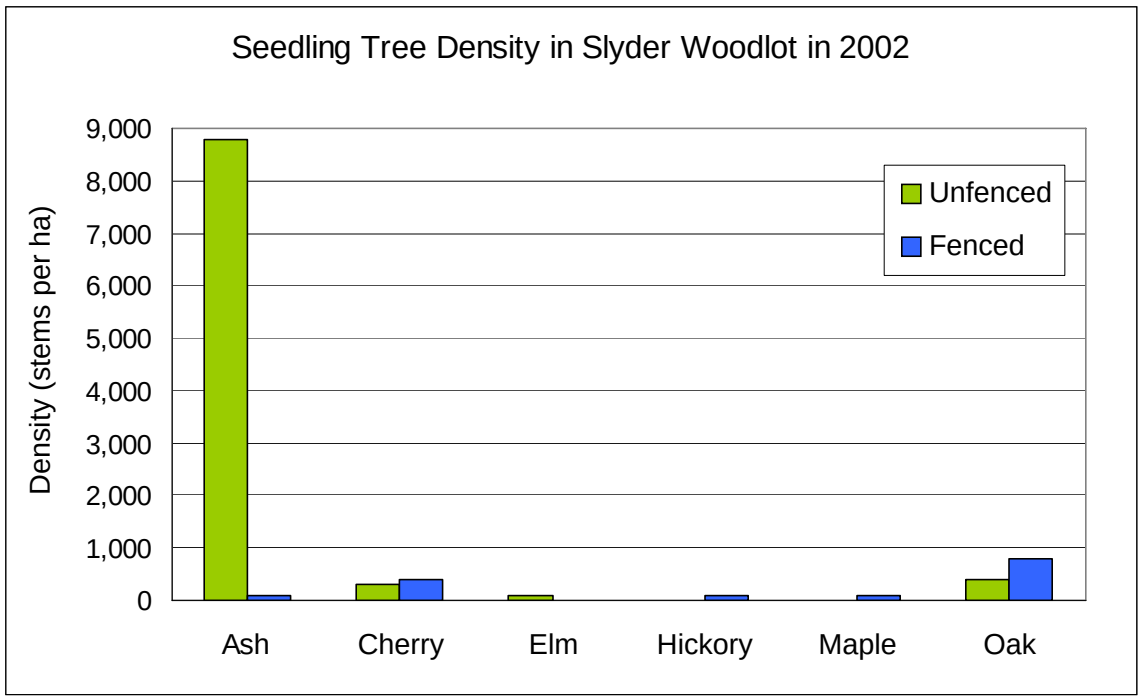


Figure 21. Density of seedling (≤150 cm in height) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Slyder woodlot, Gettysburg National Military Park, 2002.

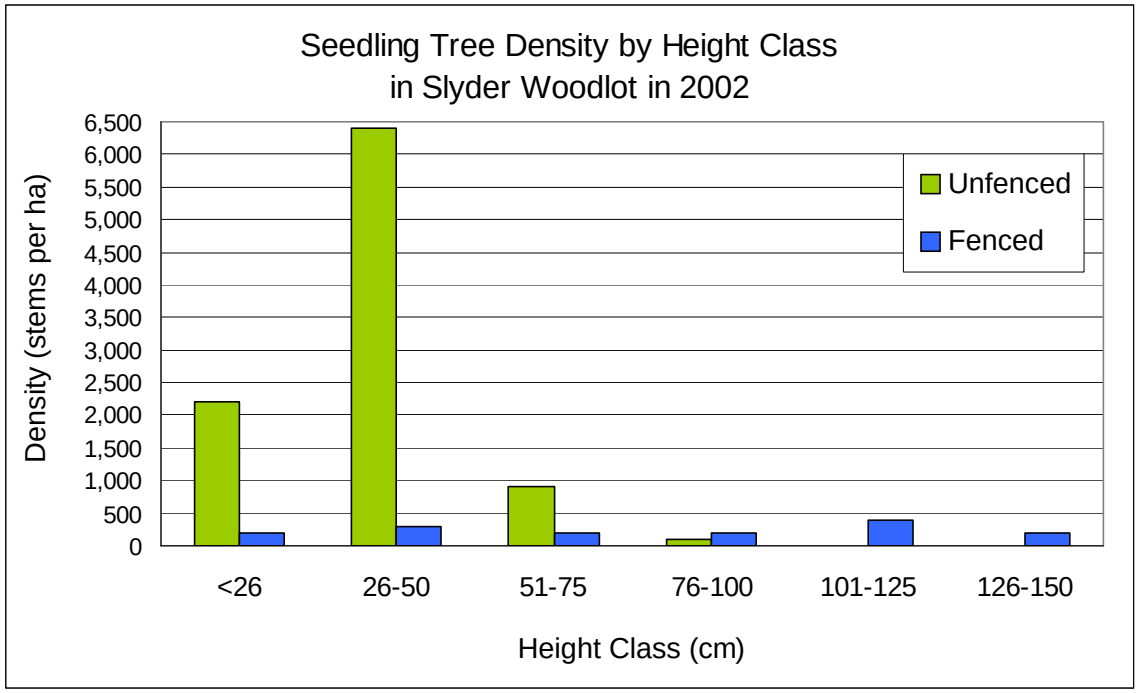


Figure 22. Density of seedling (≤150 cm in height) tree species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Slyder woodlot, Gettysburg National Military Park, 2002.

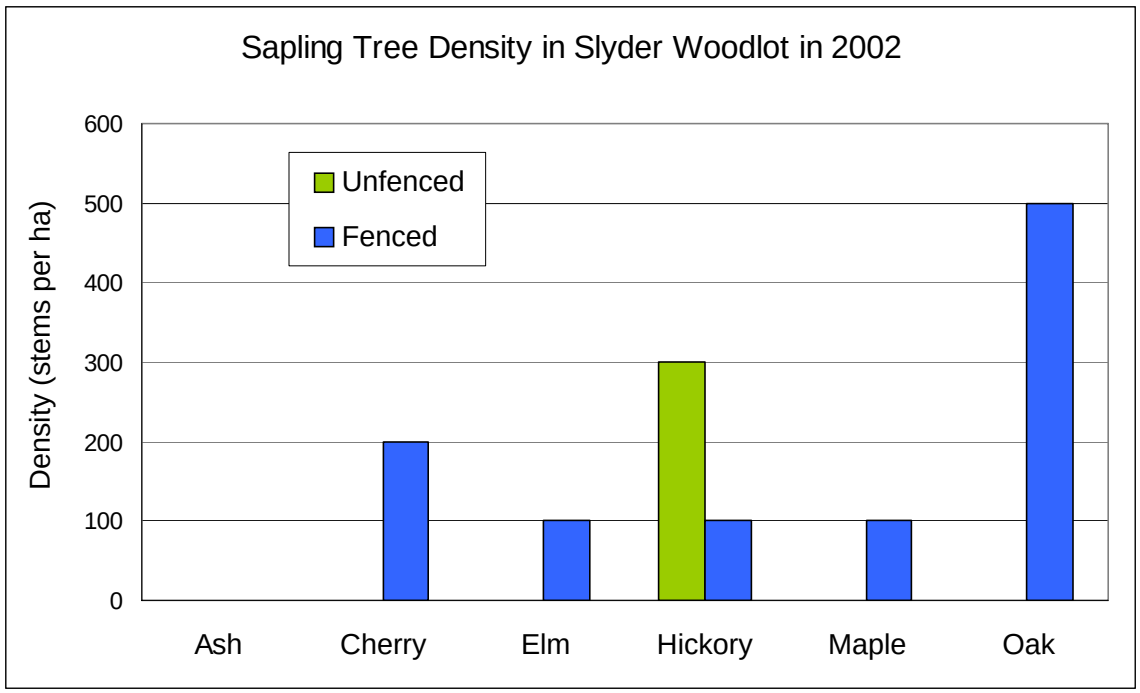


Figure 23. Density of sapling (>1.5 m in height and <12 cm dbh) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Slyder woodlot, Gettysburg National Military Park, 2002.

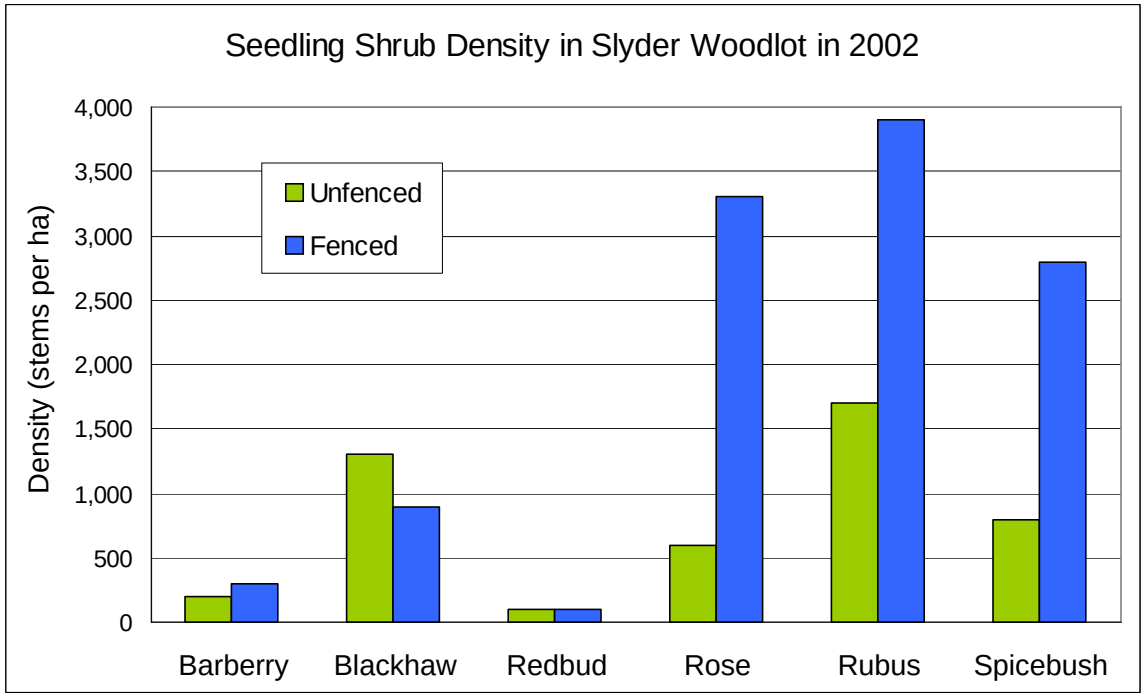


Figure 24. Density of seedling (≤150 cm in height) shrub species in the fenced and unfenced 10 x 10 m Demonstration Plots in Slyder woodlot, Gettysburg National Military Park, 2002.

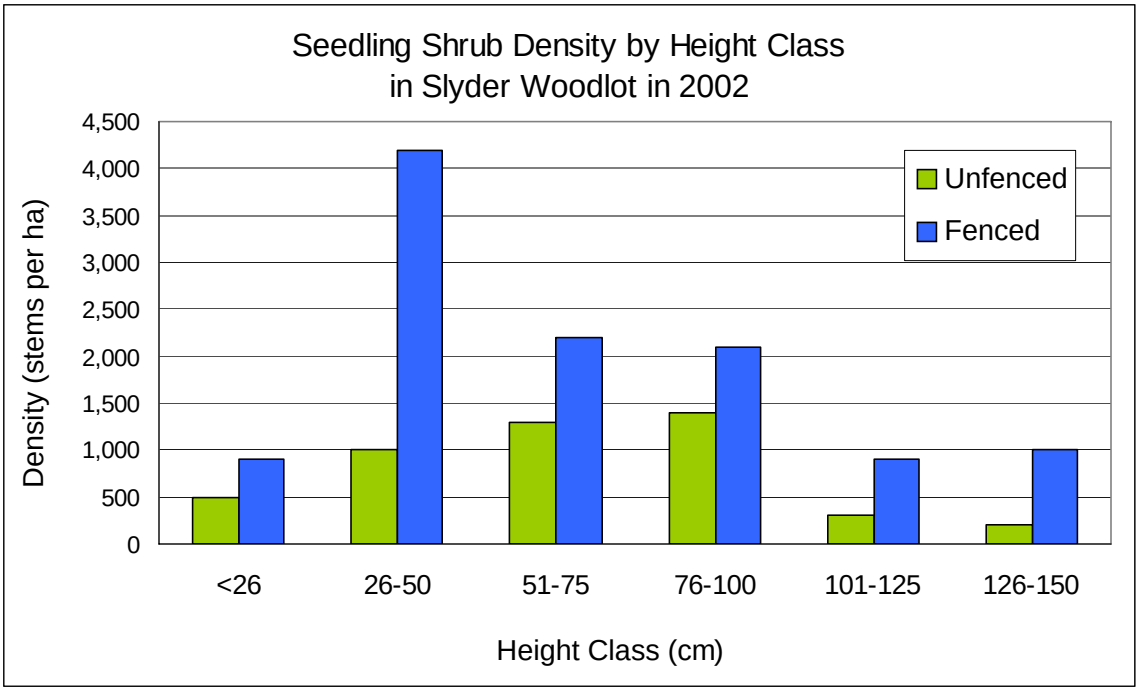


Figure 25. Density of seedling (≤150 cm in height) shrub species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Slyder woodlot, Gettysburg National Military Park, 2002.

Table 18. Average coverage for grass, forb, vine, and total species in the fenced 10 x 10 m Demonstration Plot[a] and unfenced-control 40 x 40 m plot[b] in Slyder woodlot, Gettysburg National Military Park, 2002.

	Fenced Average Coverage (%)	Unfenced Average Coverage (%)
Grass	0	14
Forb	3	24
Vine	29	2
Total	32	40

[a] The 10 x 10 m fenced plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.
[b] The 40 x 40 m unfenced-control plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.

Spangler Woodlot

Twelve tree species were recorded (fenced and unfenced plots combined) in the seedling inventory in 2002. The seedling tree density was 20,700 stems/ha in the fenced plot and 12,100 stems/ha in the unfenced plot (Table 19). Ash was the dominant tree species in both the fenced and unfenced plots with a density of 16,000 and 7,900 stems/ha, respectively (Figure 26). Black cherry was the second most prevalent seedling tree, with equal densities of 2,100 stems/ha in both plots. White oak seedlings were recorded only in the fenced plot (100 stems/ha), and northern red oak seedlings were recorded only in the unfenced plot (100 stems/ha) (Table 19).

In 2002, the density of seedling trees <26 cm in height was 8,900 stems/ha in the fenced plot and 10,300 stems/ha in the unfenced plot (Figure 27). The density of seedling trees ≥26 cm in height was 11,800 stems/ha in the fenced plot, and 1,800 stems/ha in the unfenced plot.

Six species of trees were recorded in the sapling category in the 2002 inventory (Table 19). Ash and black cherry were the most abundant sapling trees in the fenced plot, with densities of 600 and 500 stems/ha, respectively. All the hickory species combined accounted for another 600 stems/ha. In the unfenced plot, the density of sapling trees was more evenly distributed among the five species present. Hickory dominated the unfenced plot with a total density of 500 stems/ha (Figure 28). The density of small saplings in the fenced and unfenced plots was 900 and zero stems/ha, respectively. The density of large saplings in the fenced and unfenced plots was 900 and 800 stems/ha, respectively.

Nine species of shrub were recorded (fenced and unfenced plots combined) in the seedling inventory in 2002 (Table 19). The density of seedling shrubs in the fenced plot was 18,900 stems/ha, and in the unfenced plot the density was 11,100 stems/ha (Table 19). *Rubus* was the dominant seedling shrub in the fenced plot with a density of 10,600 stems/ha, and *Ribes* was second most prevalent with 5,000 stems/ha. In the unfenced plot, Japanese barberry, *Rubus*, and multiflora rose had densities of 2,900, 2,400, and 2,200 stems/ha, respectively (Figure 29).

The density of seedling shrubs <26 cm in height was 7,000 stems/ha in the fenced plot and 2,900 stems/ha in the unfenced plots. The density of seedling shrubs ≥26 cm in height was 6,900 stems/ha in the fenced plot and 8,200 stems/ha in the unfenced plot (Figure 30).

Five species of shrubs were identified in the 2002 sapling inventory. The sapling shrub densities in the fenced and unfenced plots were 900 and 300 stems/ha, respectively. Multiflora rose was the only sapling shrub recorded in the unfenced plot, whereas there were four shrub species recorded in the fenced plot (Smooth blackhaw, *Rubus*, *Ribes*, and sassafras). Smooth blackhaw was the most abundant species with a density of 500 stems/ha (Table 19).

The amount of herbaceous and vine vegetation coverage in the fenced (55%) and unfenced (43%) subplots was similar (Table 20). Grasses were not recorded in either subplot. The forb coverage was slightly greater in the fenced subplot (55%) than in the unfenced subplot (41%), and vines were only recorded in the unfenced subplot at 1% coverage.

Table 19. Densities (stems/ha)[a] of seedling[b] and sapling[c] tree and shrub species in the fenced and unfenced 10 x 10 m Demonstration Plots in Spangler woodlot, Gettysburg National Military Park, 2002.

	SEEDLING		SAPLING	
	Unfenced	Fenced	Unfenced	Fenced
	----------Density (stems/ha)----------			
Ash	7,900	16,000	200	600
Blackgum	100	0	0	0
Cedar, eastern red	100	0	0	0
Cherry, sweet	900	1,000	100	100
Cherry, black	2,100	2,100	0	500
Elm, slippery	100	200	0	0
Hickory, mockernut	200	300	100	100
Hickory, pignut	100	100	300	200
Hickory, shagbark	400	0	100	300
Maple, red	100	900	0	0
Oak, northern red	100	0	0	0
Oak, white	0	100	0	0
Total Tree	12,100	20,700	800	1,800
Barberry, Japanese	2,900	1,100	0	0
Black-haw, smooth	1,700	1,600	0	500
Honeysuckle, Tartarian	0	100	0	0
Ribes	1,700	5,000	0	100
Rose, multiflora	2,200	0	300	0
Rubus	2,400	10,600	0	200
Sassafras	0	300	0	100
Serviceberry	100	100	0	0
Witch hazel	100	100	0	0
Total Shrub	11,100	18,900	300	900

[a] Values for the 2002 surveys were from the entire 10 x 10 m plot (100 m^2). Values within columns may not add up to the value for Total Tree and Total Shrub due to rounding.
[b] Stems ≤150 cm in height.
[c] Stems >1.5 m in height and <12 cm dbh.

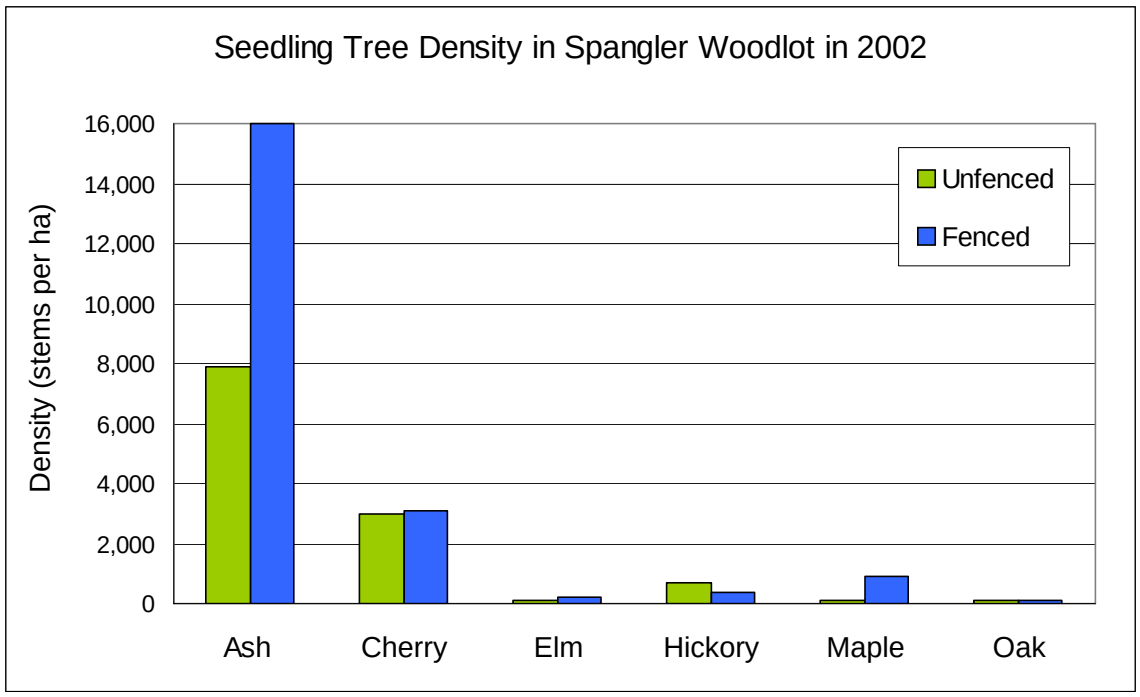


Figure 26. Density of seedling (≤150 cm in height) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Spangler woodlot, Gettysburg National Military Park, 2002.

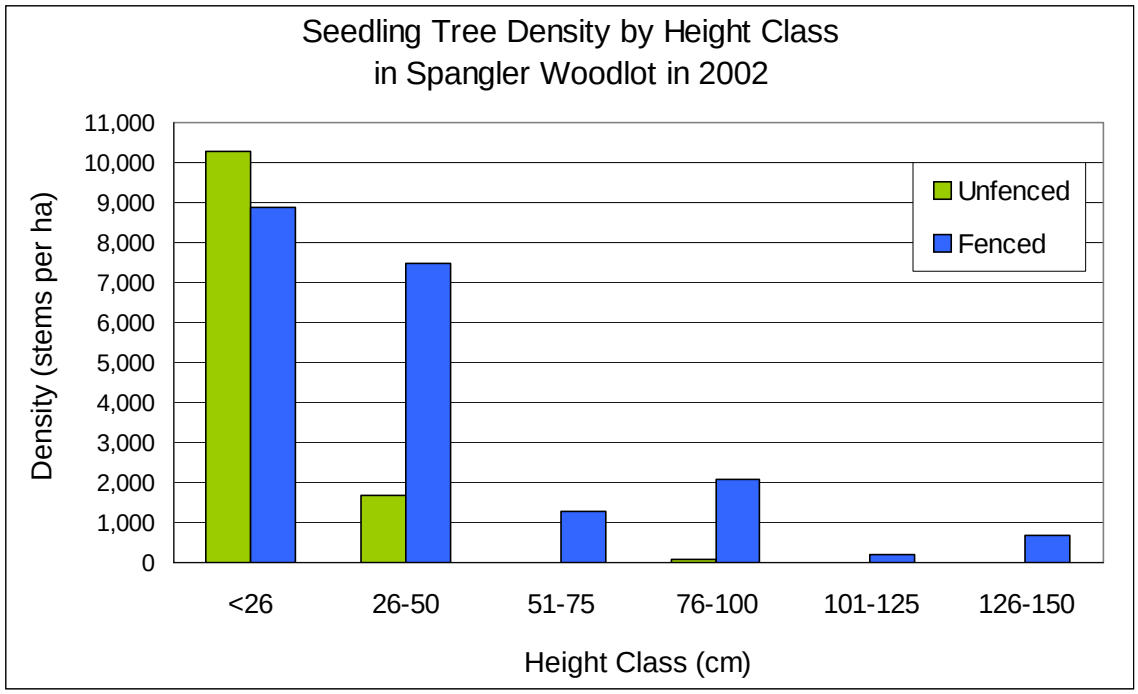


Figure 27. Density of seedling (≤150 cm in height) tree species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Spangler woodlot, Gettysburg National Military Park, 2002.

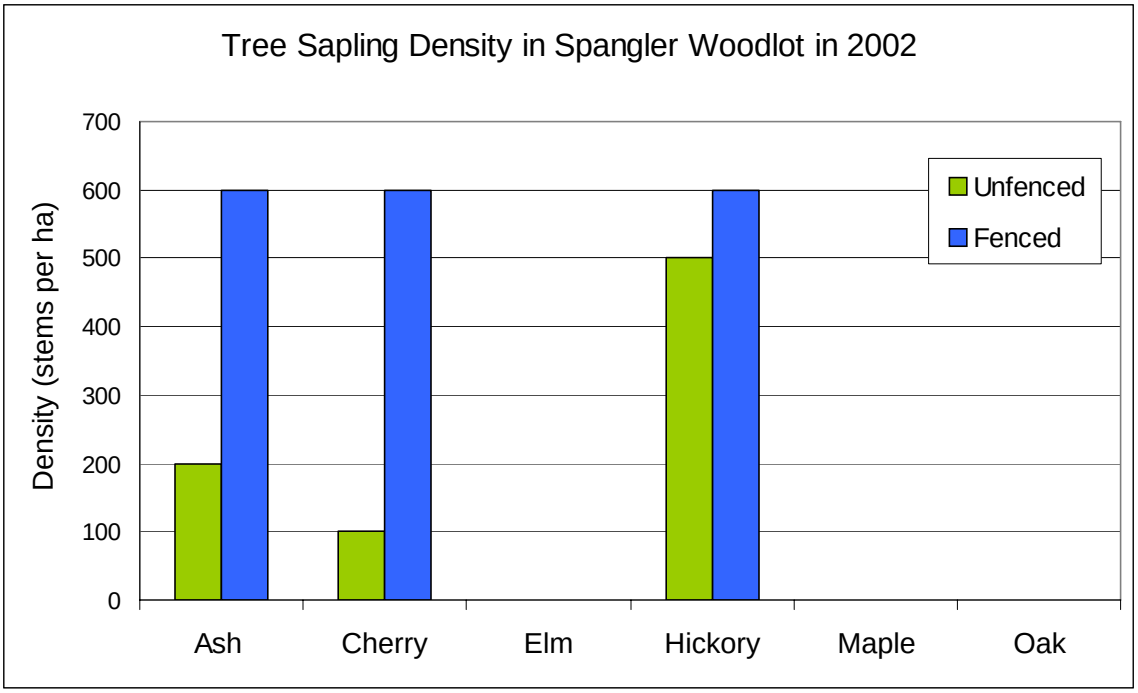


Figure 28. Density of sapling (>1.5 m in height and <12 cm dbh) tree species in the fenced and unfenced 10 x 10 m Demonstration Plots in Spangler woodlot, Gettysburg National Military Park, 2002.

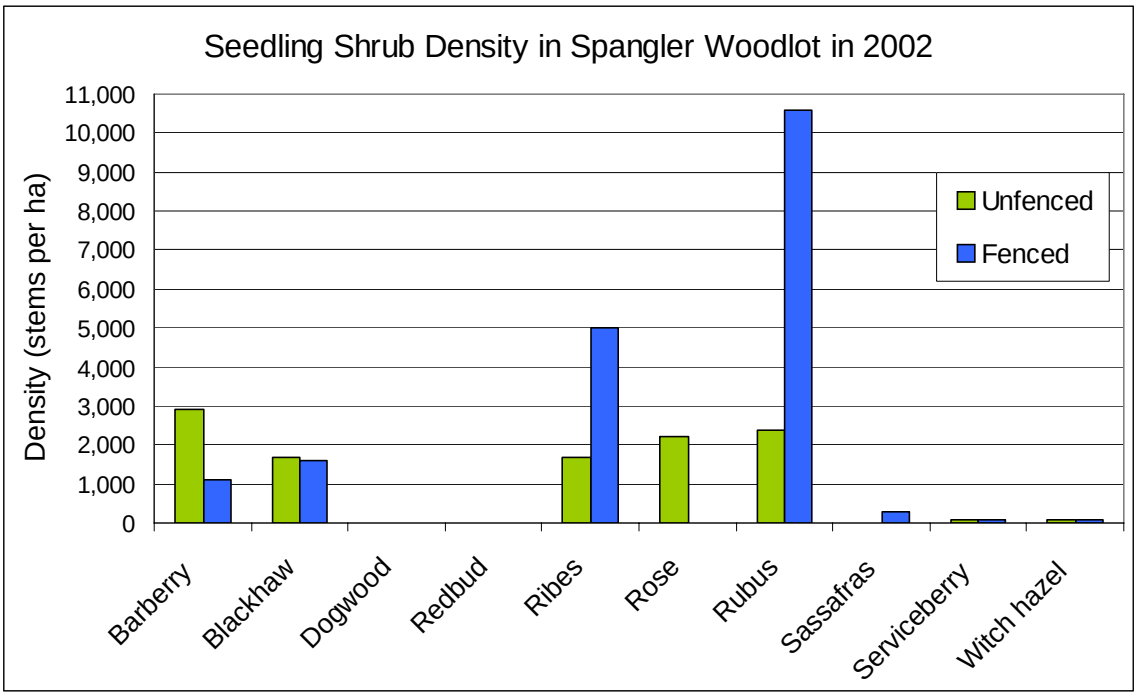


Figure 29. Density of seedling (≤150 cm in height) shrub species in the fenced and unfenced 10 x 10 m Demonstration Plots in Spangler woodlot, Gettysburg National Military Park, 2002.

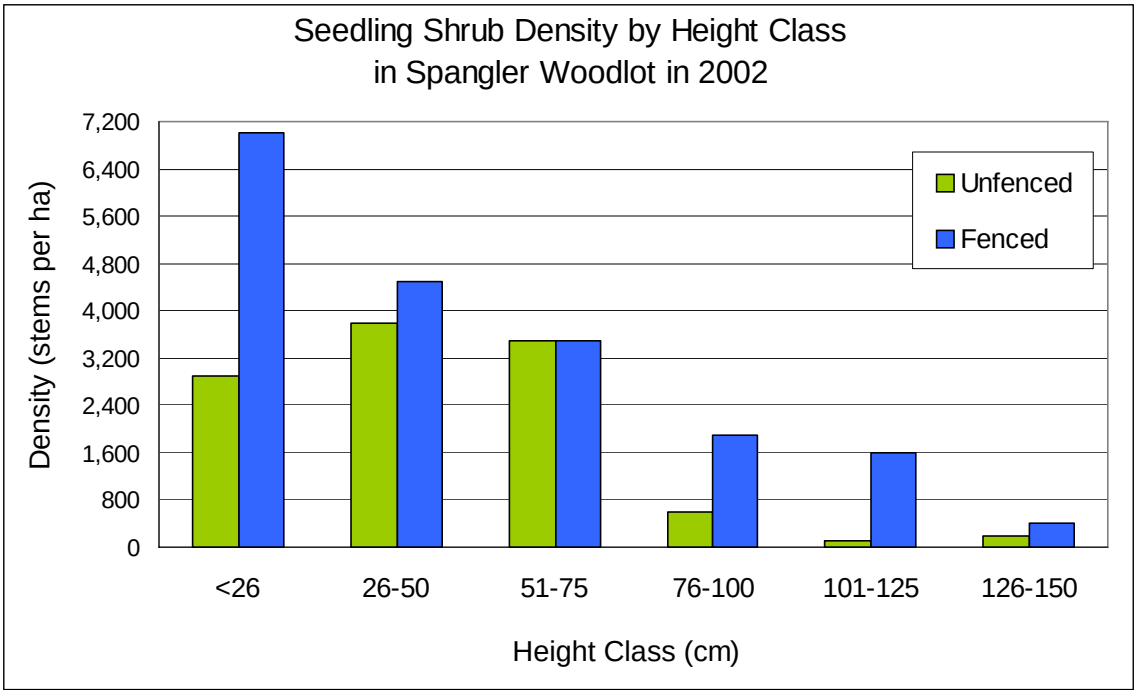


Figure 30. Density of seedling (≤150 cm in height) shrub species by height class in the fenced and unfenced 10 x 10 m Demonstration Plots in Spangler woodlot, Gettysburg National Military Park, 2002.

Table 20. Average coverage for grass, forb, vine, and total species in the fenced 10 x 10 m Demonstration Plot[a] and unfenced-control 40 x 40 m plot[b] in Spangler woodlot, Gettysburg National Military Park, 2002.

	Fenced Average Coverage (%)	Unfenced-control Average Coverage (%)
Grass	0	0
Forb	55	41
Vine	0	1
Total	55	43

[a] The 10 x 10 m fenced plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.
[b] The 40 x 40 m unfenced-control plot had a 2 x 2 m subplot in which herbaceous and vine vegetation was inventoried.

Discussion

2002 Inventory

In 2002, the overall (all woodlots and both fence treatments) seedling tree density was 11,217 stems/ha. For tree species, the seedling density was 10,283 stems/ha in the fenced plots and 12,150 stems/ha in the unfenced plots. Among all the woodlots, the seedling tree density ranged from 1,500 to 20,700 stems/ha in the fenced plots, and from 3,400 to 22,000 stems/ha in the unfenced plots. The average total number of tree species among all woodlots and both fence treatments was eight. In the fenced plots, the average total number of species was nine, and in the unfenced plots the average was eight species. Pin oak and black walnut were new species inventoried for the first time in 2002 in the Demonstration Plots.

Over all woodlots and both fence treatments, the seedling shrub density was 15,050 stems/ha. For shrub species, the seedling density was 16,350 stems/ha in the fenced plots and 13,750 stems/ha in the unfenced plots. Among all the woodlots, the seedling shrub density ranged from 4,600 to 23,400 stems/ha in the fenced plots, and from 200 to 40,700 stems/ha in the unfenced plots. There was an average total number of six shrub species among all the woodlots and both fence treatments. The average in the fenced plots was six species, and the average in the unfenced plots was five species. Autumn olive, witch hazel, and *Ribes* were inventoried for the first time in 2002 in the Demonstration Plots.

Bushman Hill woodlot was the only woodlot in which seedling tree density was comparable between the fence treatments. In Biesecker, Pitzer, and Spangler woodlots, the density of seedling trees was greater in the fenced plots than in the unfenced plots. These woodlots also had more seedling shrubs in the fenced plots than in the unfenced plots. Biesecker, Pitzer, and Spangler woodlots had lower numbers of white-tailed deer than other areas of the park due to the greater success of the Deer Management Program. The greater seedling tree densities in the fenced plots were probably due to the lower sapling shrub densities in the fenced plots, so there was less competition between the seedling and sapling-sized stems.

Over all woodlots and both fence treatments, the density of seedling shrubs was greater than seedling trees, 180,600 to 134,600 stems/ha, respectively. Looking at the data from the fence treatments separately, two trends were evident. Among the fenced plots, there were more seedling shrubs than seedling trees. Among the unfenced plots, four of the six woodlots had seedling tree densities greater than seedling shrub densities (Figure 31).

Bushman Hill woodlot had an unusually high concentration of seedling shrubs in the unfenced plot, but equal densities of seedling trees in the fenced and unfenced plots. Biesecker, Pitzer, and Spangler woodlots had seedling tree densities in the fenced plots nearly double that of the corresponding unfenced plots. However, in Cobean woodlot seedling tree density in the unfenced plot (22,000 stems/ha) was seven times greater than in the fenced plot (3,100 stems/ha). Similarly, in Slyder woodlot the density of seedling trees was six times greater in the unfenced plot than in the fenced plot (Figure 31).

The Cobean woodlot is in an area where the Deer Management Program has not been as successful because of proximity to residential housing. However, there was a greater density of seedling trees in the unfenced plot than in the fenced plot. The seedling shrub density in both plots was equal.

Evidence within this woodlot indicates that competition with sapling-sized shrubs may be a factor in the presence and growth of seedling trees. This is also supported by the sapling inventory data, because Cobean woodlot had the second greatest sapling shrub densities with 7,200 stems/ha in the fenced plot and half that, 3,700 stems/ha, in the unfenced plot. The seedling tree density in the unfenced plot was seven times greater than in the fenced plot.

Slyder woodlot exhibited a similar trend. Seedling tree density was greater in the unfenced plot than in the fenced plot, but seedling shrub density was greater in the fenced plot than in the unfenced plot. Sapling tree density was greater in the fenced plot than in the unfenced plot. Also, sapling shrub density was three times greater in the fenced plot. More sapling trees, seedling shrubs, and sapling shrubs were growing in the fenced plot. Competition between tree and shrub species, especially between seedling-sized trees and sapling-sized shrubs, is probably the reason for lower seedling tree density in the fenced plot.

Bushman Hill woodlot had the greatest density of sapling trees, but all were within the fenced plot. There were none growing in the unfenced plot. Sapling shrubs were growing in both the fenced and unfenced plot. Spicebush had greater density in the unfenced plot, but smooth blackhaw had greater density in the fenced plot. Similarly, Japanese barberry was only growing in the unfenced plot, while the majority of multiflora rose grew in the fenced plot.

Another important trend was identified in the seedling data from all six woodlots. In the unfenced plots there were no seedling trees taller than 100 cm. However, five out of the six woodlots had seedling trees growing up to 150 cm in height in the fenced plots. This was not seen in the seedling shrub data, where fence treatment showed no effect on seedling shrub height.

Over all woodlots and both fence treatments, eighteen species of trees were recorded in the 2002 seedling inventory. Ash was the dominant seedling tree inventoried in 2002, comprising 56% of the total seedling tree density. More ash stems were recorded in the unfenced plots than in fenced plots. Black cherry and white oak were equally prevalent in the fenced and unfenced plots (11% each), but not across woodlots. Black cherry was found in all six woodlots and almost equally distributed between the fence treatments. However, white oak seedlings were only growing in four woodlots, mostly in Bushman Hill and Pitzer woodlots. White oak seedlings in Bushman Hill woodlot were surviving more successfully in the unfenced plot; however, in the Pitzer woodlot, they were surviving almost solely in the fenced plot.

Over all woodlots and both fence treatments, thirteen species of shrubs were recorded in the 2002 seedling inventory. *Rubus* were clearly the dominant species, accounting for 44% of the total seedling shrub density. *Rubus* density was greater in fenced plots than in unfenced plots. Smooth blackhaw was the second most prevalent species comprising 13% of the total density, and was found in all six woodlots. Smooth blackhaw densities were generally greater in fenced plots.

Over all woodlots and fenced and unfenced treatments combined, thirteen species of trees were recorded in the 2002 sapling inventory. The average total number of tree species recorded among the fenced plots was six, and among the unfenced plots the average was two. The average total density of saplings trees among all woodlots and both fence treatments was 1,117 stems/ha. The average total density in the fenced and unfenced plots was 1,783 and 450 stems/ha, respectively. Slippery elm was the dominant tree species accounting for 22% of the total sapling tree density, compiled among all the woodlots and both fence treatments. However, it was only growing in the fenced plots of two woodlots, almost entirely within Bushman Hill. Shagbark hickory was the second most dominant

species, with a more even distribution across four woodlots. Black cherry and ash were equally present with greater density values in the fenced plots than in the unfenced plots. The sapling tree density was consistently greater in the fenced plots than in the unfenced plots (Figure 32).

Over all woodlots and both fence treatments, twelve species of shrubs were recorded in the 2002 sapling inventory. Within the fenced plots, the average total number of species was four, and within the unfenced plots the average was three. The average total density of sapling shrubs among all woodlots and both fence treatments was 3,342 stems/ha. The average density was 4,700 stems/ha in the fenced plots and 1,983 stems/ha in the unfenced plots. Multiflora rose was by far the dominant sapling shrub species, accounting for 46% of the total sapling shrub density. It occurred mostly in the Bushman Hill, Cobean, and Slyder woodlots, with densities greater in the fenced plots than in the unfenced plots. Tartarian honeysuckle was the second most prevalent species, but was only growing in two woodlots. Smooth blackhaw accounted for 15% of the total density, but was only growing in two woodlots. There were no sapling-sized shrubs in Biesecker woodlot. In Pitzer woodlot, there was a single smooth blackhaw stem recorded between both fence treatments. Slyder woodlot had the greatest density of sapling shrubs of all the woodlots, and there were three times as many stems in the fenced plot than in the unfenced plot. Sapling shrub density was consistently greater in the fenced plots than in the unfenced plots across all the woodlots (Figure 32).

Non-native shrub species in the sapling-sized category had densities one to six times greater than the most abundant sapling tree species among all the Demonstration Plots. Certain non-native shrubs, such as Japanese barberry, multiflora rose, and Tartarian honeysuckle, usually grew better in one of the fence treatments. Japanese barberry density was greater in unfenced plots, whereas multiflora rose density was much greater in fenced plots. The same trend was evident in the Japanese barberry and multiflora rose seedling data. Tartarian honeysuckle sapling densities were greater within the Cobean woodlot unfenced plot than in the fenced plot, and within Slyder woodlot, densities were greater in the fenced plot than in the unfenced plot. Tartarian honeysuckle seedling densities were generally greater in unfenced plots than in fenced plots.

The 60% stocking level goals for seedling (16,834 stems/ha), small sapling (2,806 stems/ha), and large sapling tree species (935 stems/ha) represent the number of tree species stems needed to maintain an uneven-aged distribution. Seedling tree densities were adequate in four of the Demonstration Plots in 2002. Bushman Hill woodlot fenced and unfenced plots (21,700 and 19,800 stems/ha, respectively), Cobean woodlot unfenced plot (22,000 stems/ha), and Spangler fenced plot (20,700 stems/ha) densities exceeded the 60% stocking level goal (Figure 31). The Bushman Hill woodlot fenced plot (4,200 stems/ha) was the only Demonstration Plot to have a small sapling tree density that met or exceeded the 60% stocking level goal in 2002. The remaining 11 plots had small sapling tree densities that ranged from 0 to 900 stems/ha (Figure 33). Only one of the 12 Demonstration Plots had a large sapling tree density that met or exceeded the stocking level goal in 2002. The Biesecker woodlot unfenced plot had a large sapling tree density of 1,000 stems/ha (Figure 34). The other 11 plots had densities that ranged from 0 to 900 stems/ha.

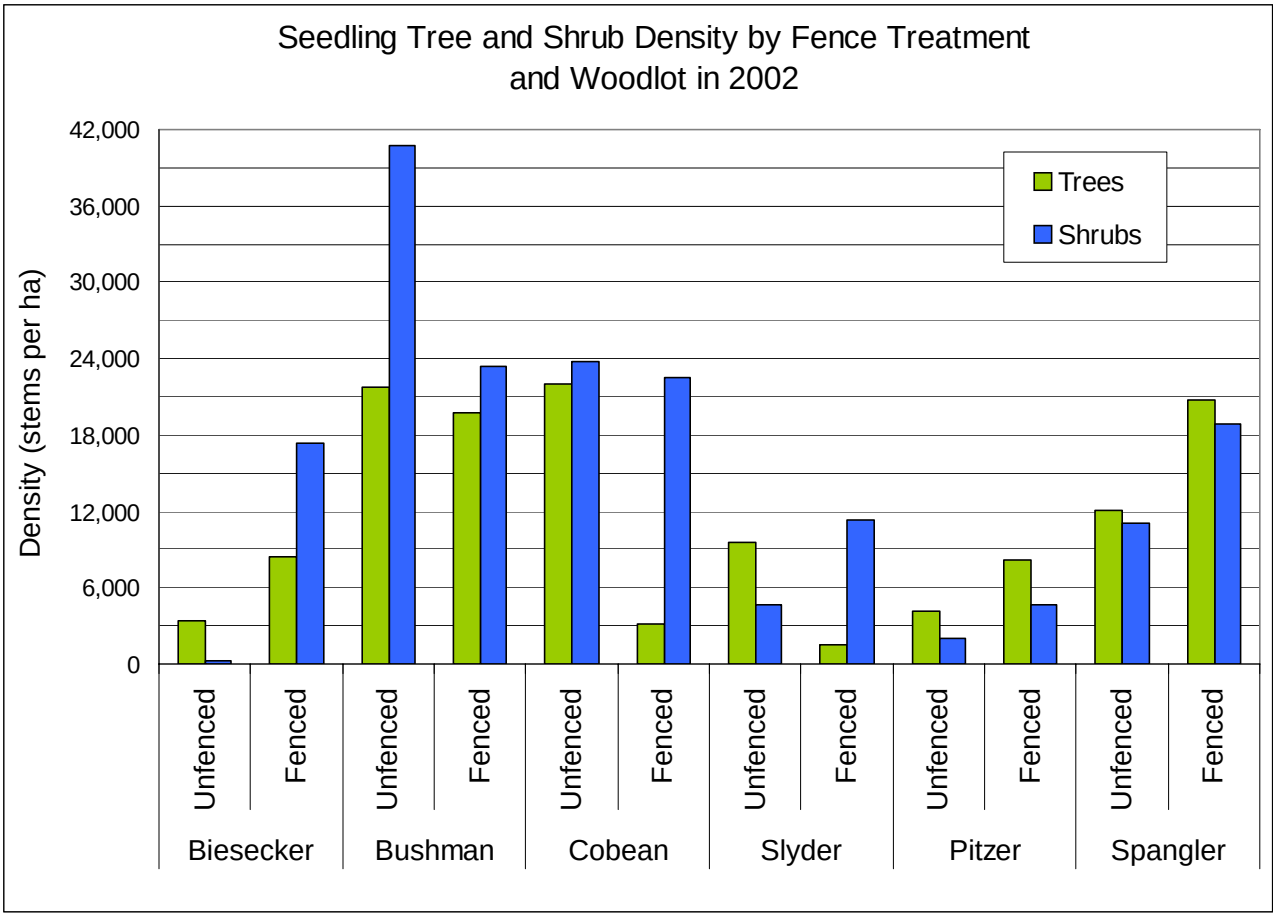


Figure 31. Density of seedling (≤150 cm in height) tree and shrub species by fence treatment in the 10 x 10 m Demonstration Plots in Biesecker, Bushman Hill, Cobean, Slyder, Pitzer, and Spangler woodlots, Gettysburg National Military Park, 2002.

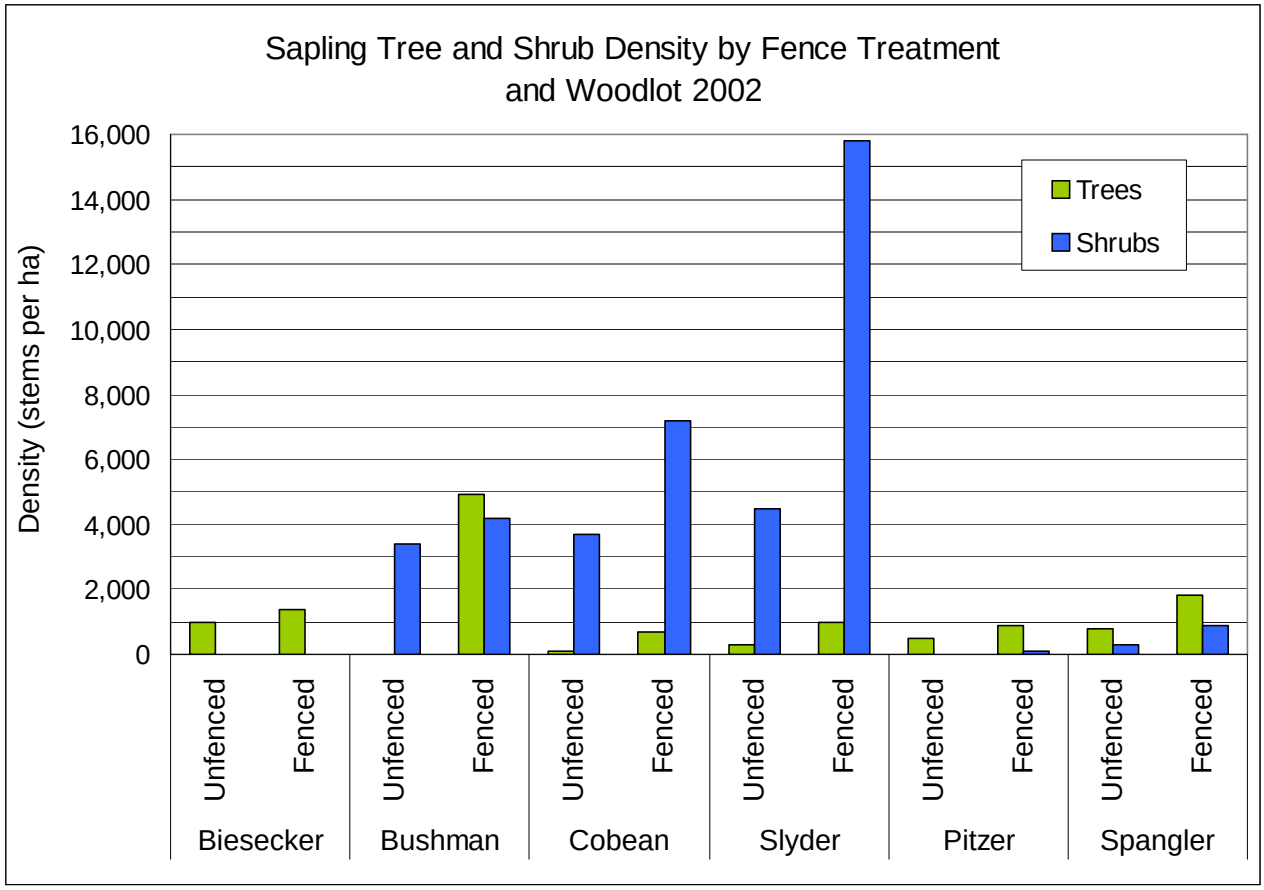


Figure 32. Density of sapling (>1.5 m in height and <12 cm dbh) tree and shrub species by fence treatment in the 10 x 10 m Demonstration Plots in Biesecker, Bushman Hill, Cobean, Slyder, Pitzer, and Spangler woodlots, Gettysburg National Military Park, 2002.

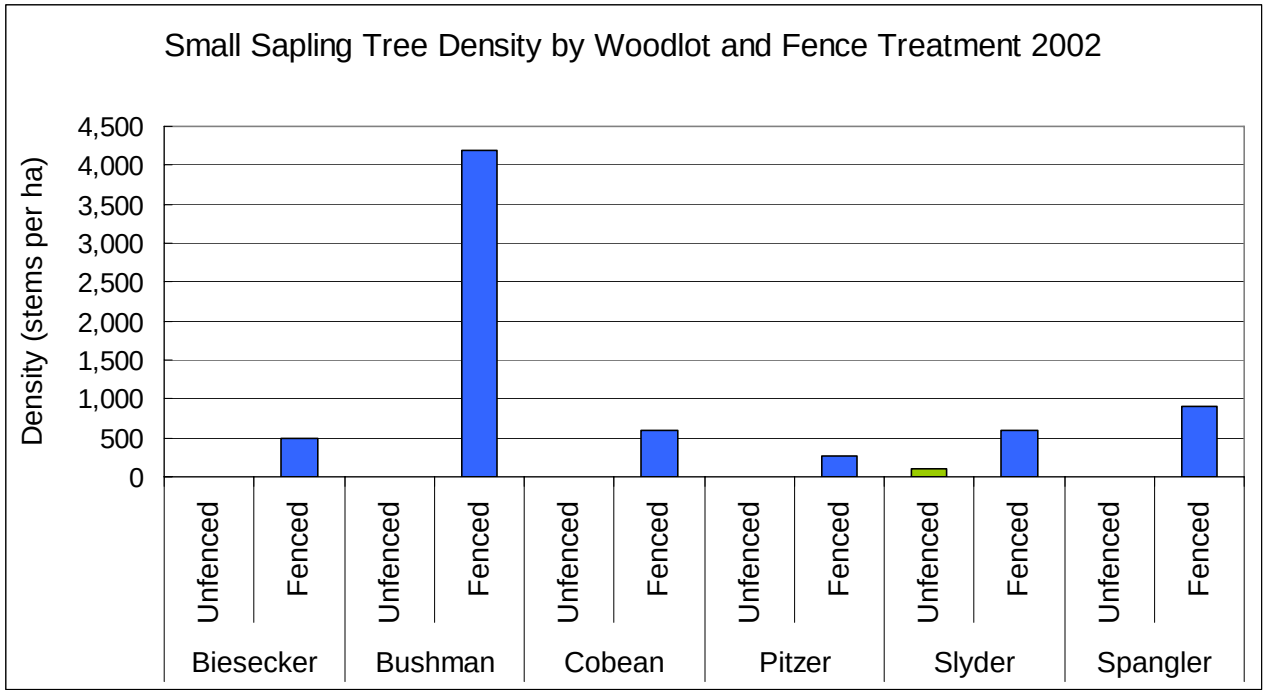


Figure 33. Density of small sapling (>1.5 m in height and <2 cm dbh) tree species by fence treatment in the 10 x 10 m Demonstration Plots in Biesecker, Bushman Hill, Cobean, Pitzer, Slyder, and Spangler woodlots, Gettysburg National Military Park, 2002.

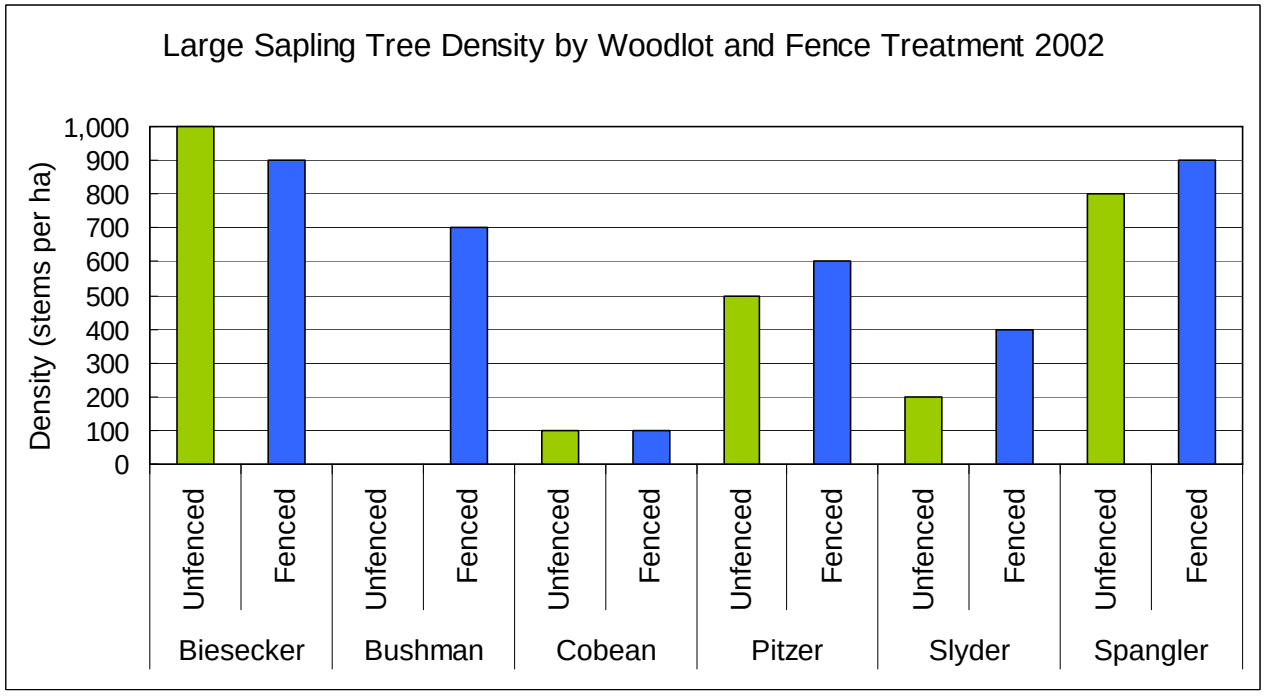


Figure 34. Density of large sapling (>1.5 m in height and 2-11.9 cm dbh) tree species by fence treatment in the 10 x 10 m Demonstration Plots in Biesecker, Bushman Hill, Cobean, Pitzer, Slyder, and Spangler woodlots, Gettysburg National Military Park, 2002.

Comparison of Inventories Among All Woodlots from 1986/87 to 2002

Over all woodlots and fence treatments, the trend was a decline in seedling tree density from 1986/87 to 2002 (Figure 35). Among all the fenced Demonstration Plots, the density of seedling trees decreased from 56,167 to 10,283 stems/ha from 1986/87 to 2002. Among the unfenced plots, the density of seedling trees decreased from 39,167 stems/ha in 1986/87 to 1,150 stems/ha in 1996, but then increased again to 12,150 stems/ha in 2002 (Figure 35). The reason for the increase in seedling tree density in the unfenced plots between 1996 and 2002 was probably due to the reduced deer browse after the implementation of the Deer Management Program. In the fenced plots from 1989 to 2002, the density of seedling trees <26 cm in height decreased from 44,433 to 3,983 stems/ha. The density of fenced seedlings ≥26 cm varied slightly over time from 7,450 stems/ha in 1989, peaking at 12,546 stems/ha in 1991, and then decreasing to 6,300 stems/ha in 2002 (Figure 36). Seedling tree density in the unfenced plots followed a similar trend as in the fenced plots, with the exception of an increase in density from 1996 to 2002. The density of seedling trees <26 cm in height in the unfenced plots decreased from 36,233 stems/ha in 1989 to 1,083 stems/ha in 1996, then increased to 8,467 stems/ha in 2002 (Figure 36). The density of seedling trees ≥26 cm in height was consistently lower in the unfenced plots compared to the fenced plots, but showed an increase between 1996 and 2002 (67 and 3,683 stems/ha, respectively).

The diversity of seedling tree species increased over time. The following species were recorded from 1986/87 through 2002 in at least one of the Demonstration Plots: ash, eastern red cedar, sweet cherry, black cherry, elm, mockernut hickory, pignut hickory, shagbark hickory, red maple, black oak, and white oak. Blackgum and Norway maple were recorded from 1994 on to 2002. Chestnut oak was recorded in 1989 and in 2002, but not in the 1990's. Red oak was recorded from 1989 on to 2002. Pin oak and black walnut were first recorded in 2002.

Over all the woodlots and both fence treatments, the density of seedling shrubs increased over time. Among all the fenced plots, the density increased from 2,667 to 16,350 stems/ha between 1986/87 and 2002, with peak densities in 1991 (21,221 stems/ha) when *Rubus* and multiflora rose were first recorded in the woodlots. Between 1986/87 and 2002, the overall density in the unfenced plots increased from 1,958 to 13,750 stems/ha (Figure 37). The density of seedling shrubs <26 cm in height in the fenced plots changed over time from 3,733 stems/ha in 1989, to a maximum of 9,683 stems/ha in 1994, then decreased to 4,167 stems/ha in 1996, and then increased to 6,833 stems/ha in 2002 (Figure 37). The density of seedling shrubs ≥26 cm in height in the fenced plots increased greatly between 1989 and 1991 (2,167 and 15,392 stems/ha, respectively), and then decreased to 9,517 stems/ha in 2002. There was a similar trend for unfenced seedling shrubs <26 cm in height. The density undulated slightly over time, but basically increased between 1989 and 2002 from 2,700 to 4,450 stems/ha (Figure 38). The density of unfenced seedling shrubs ≥26 cm in height increased consistently between the 1989 and 2002 inventories from 617 to 9,300 stems/ha.

Seedling shrub species diversity also increased over time. The following species were recorded from 1986/87 through 2002 in at least one of the Demonstration Plots: smooth blackhaw, sassafras, serviceberry, spicebush, eastern redbud, and greenbriar. Japanese barberry and flowering dogwood were recorded from 1989 through 2002. Multiflora rose, *Rubus*, and Tartarian honeysuckle were recorded from 1994 through 2002. Autumn olive, *Euonymus*, witch hazel, and *Ribes* were first recorded in 2002. *Rubus* was the predominant shrub species in 1991. There appeared to be a correlation between when *Rubus* became very abundant, deer density peaked (Appendix A), and seedling tree density declined.

After the implementation of the Deer Management Program, there was a noticeable increase in seedling tree densities in the unfenced Demonstration Plots. From 1986/87 to 1996 there was a consistent trend of decreasing seedling tree densities in both the fenced and unfenced plots, with the unfenced plot always having fewer seedling tree stems. However, in 2002 there was a shift in that trend with an increase in seedling tree density in the unfenced plots (Figure 35). Between 1996 and 2002, the seedling tree density in the unfenced plots increased from 1,150 to 12,150 stems/ha. The densities increased in both the <26 and ≥26 cm height classes (Figure 36). Seedling shrub density increased in both the fenced and unfenced plots from 1986/87 to 2002. From 1996 to 2002, there were increases in seedling shrub density in the unfenced plots for both height classes (Figures 37 and 38).

Non-native plant species invasion had a deleterious effect on seedling tree recruitment. Non-native species tended to invade the fenced Demonstration Plots sooner than the unfenced plots. Japanese barberry was first recorded in Biesecker, Cobean, and Spangler woodlots in 1989, in Slyder woodlot in 1994, and in Pitzer and Bushman Hill woodlots in 1996. Tartarian honeysuckle was first recorded in Cobean and Pitzer woodlots in 1994 and in Bushman Hill, Slyder, and Spangler woodlots in 2002. Autumn olive was first recorded in Bushman Hill woodlot in 2002. Multiflora rose was first recorded in Biesecker, Bushman Hill, Cobean, and Slyder woodlots in 1991 and in Pitzer woodlot in 1994 (Bowersox et al. 2003). Norway maple was recorded in Slyder woodlot from 1994 through 2002, in Spangler woodlot only in 1994, and in Biesecker and Bushman Hill woodlots only in 1996 and 2002. *Ailanthus* was only recorded in Bushman Hill woodlot in 1994.

In the fenced plots, the density of seedling shrubs >26 cm in height was greater than the density of seedling trees >26 cm in height in 1991, 1996, and 2002 (Figures 36 and 38). In 2002, the density of sapling trees and shrubs was greater in the fenced plots than in the unfenced plots (Figure 32). Thus, competition with seedling and sapling shrubs was probably not the reason for the lack of seedling trees in the upper height classes in the unfenced plots (Figures 36 and 38). In the unfenced plots, deer herbivory was probably the cause for the decline in seedling tree density in the upper height classes over time. The 2002 inventory results showed the seedling tree densities in the unfenced and fenced plots were equal (Figure 35). This would indicate that the Deer Management Program was having a beneficial effect, even though the deer population had not been reduced to the goal density of 25 deer/259 forested ha during any of the inventory years (Appendix A). In 2002, the seedling tree densities appeared to be rebounding, but were still below the preferred density for regenerating the sapling and overstory size trees needed for historic forest conditions.

One trend indicated by the comparison between the fenced Demonstration subplot and unfenced-control subplot herbaceous and vine inventory data was the dominating presence of Virginia-creeper in the fenced subplots in Biesecker and Bushman Hill woodlots and its absence or minimal growth in those woodlots' unfenced-control subplots. In the Biesecker woodlot fenced subplot, Virginia-creeper dominated the herbaceous and vine species present in the transects by 1.5 to 6.5 times during the three inventories. Virginia creeper was not present in either the line transects or quadrants in the unfenced-control subplots during all three inventories. In the Bushman Hill woodlot fenced subplot, Virginia-creeper progressively increased in Importance Value (IV) over time with its IV two and a half times the next most abundant species in 2002. It did not appear in the Bushman Hill woodlot unfenced-control subplot in 1992, in either the line transects or quadrants. It was present with at least one percent cover in the quadrants in 1995, but not present in the line transects. Virginia-creeper increased to seventh rank in IV in the unfenced-control subplot line transects in 2002. In Pitzer woodlot, it was not present in quadrants of either the fenced or unfenced-control subplots in 1995. In 2002, it was not present in the fenced subplot, but was present in the unfenced-control subplot quadrants, covering approximately one percent of the area.

Sources in Wisconsin, Maryland, and Virginia indicated Virginia-creeper was commonly browsed by white-tailed deer and occasionally severely damaged (Christoffel 2003; Kays 1997; Total Tree Health Care 2002). Protection from white-tailed deer browse may account for the increased presence of Virginia-creeper in the fenced subplots.

Cinquefoil was another species that was present during all three inventories in the Biesecker woodlot fenced subplot, but was absent in the unfenced quadrants and transects. Its presence, however, was at a much lower value than that of the Virginia-creeper. In Bushman Hill woodlot, it appeared in the unfenced-control subplot in 1992 and 1995, but not in 2002. It was not present in the Bushman Hill woodlot fenced subplot quadrants in 1992, 1995, or 2002. Cinquefoil was not present in any of the fenced or unfenced-control subplots in Pitzer woodlot during the three inventories. Sources from Virginia and Maryland indicate that Cinquefoil species are seldom damaged by white-tailed deer (Kays 1997; Total Tree Health Care 2002).

The Shannon Diversity Index values for herbaceous and vine species were consistently low in the Demonstration Plots in both the Biesecker and Pitzer woodlots. The Evenness Index values were much higher indicating that even though there were few species present, the number of individuals present was not heavily skewed toward one species. The indices generally were greater for the fenced Demonstration subplots in both Biesecker and Pitzer woodlots than the unfenced-control subplots, which may reflect some impact of the white-tailed deer. However, it is the reverse for the Bushman Hill woodlot. This difference may be due to the greater browse pressure on the herbaceous and vine species in Biesecker and Pitzer woodlots as there is much less total browse available in comparison to that in Bushman Hill woodlot.

No other trend was evident when comparing the changes for herbaceous and vine species over the ten-year period. Coefficients of Similarity between the same woodlot over time and between fenced and unfenced subplots at a particular time do not show any consistent trends (Table 21). However, in Bushman Hill woodlot, the diversity of species was much greater in the unfenced-control subplot than in the fenced subplot. A Friedman F_r test for randomized block design showed no significant difference at the 95% level in makeup of the plant communities over time in all three woodlots. The same test showed no significant difference between the plant communities in the fenced and unfenced-control subplots in the three woodlots during the three inventories, except for the Pitzer woodlot in 2002. At that time, no species were present in the line transects. The effect of white-tailed deer on the herbaceous and vine species near the fenced Demonstration Plots in the three woodlots was problematic. The increased diversity in the unfenced-control subplot at Bushman Hill would argue against white-tailed deer having an impact, unless they reduced the dominant species to the point that other species could survive in the area. The total lack of herbaceous and vine species in the unfenced-control subplot at Pitzer woodlot might be partially due to white-tailed deer.

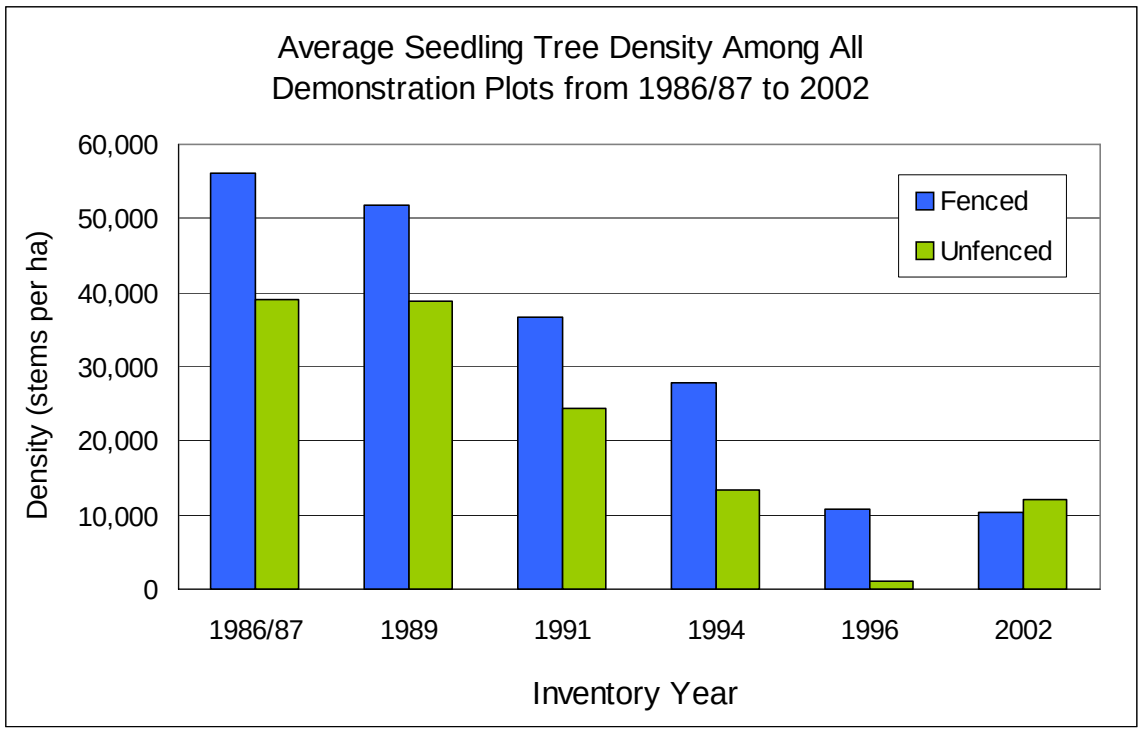


Figure 35. Average seedling (≤150 cm in height) tree species density by inventory year and fence treatment among all the Demonstration Plots in Gettysburg National Military Park, 1986/87 to 2002.

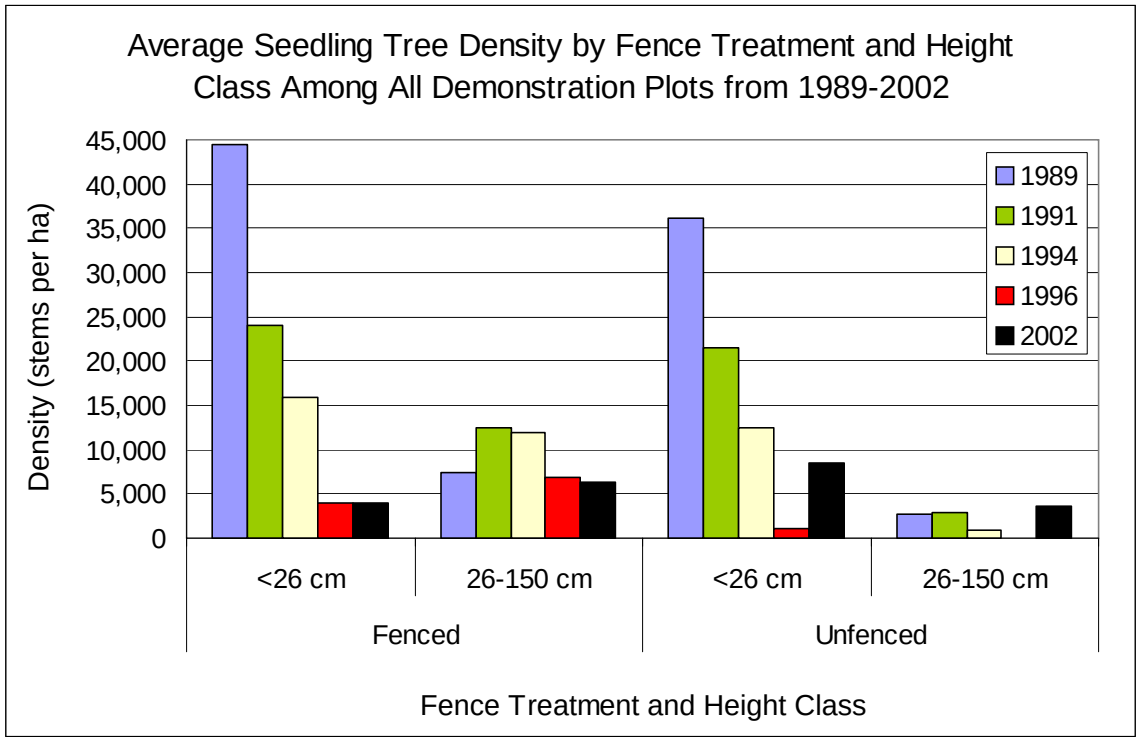


Figure 36. Average seedling (≤150 cm in height) tree species density by fence treatment and height class among all the Demonstration Plots in Gettysburg National Military Park, 1989 to 2002.

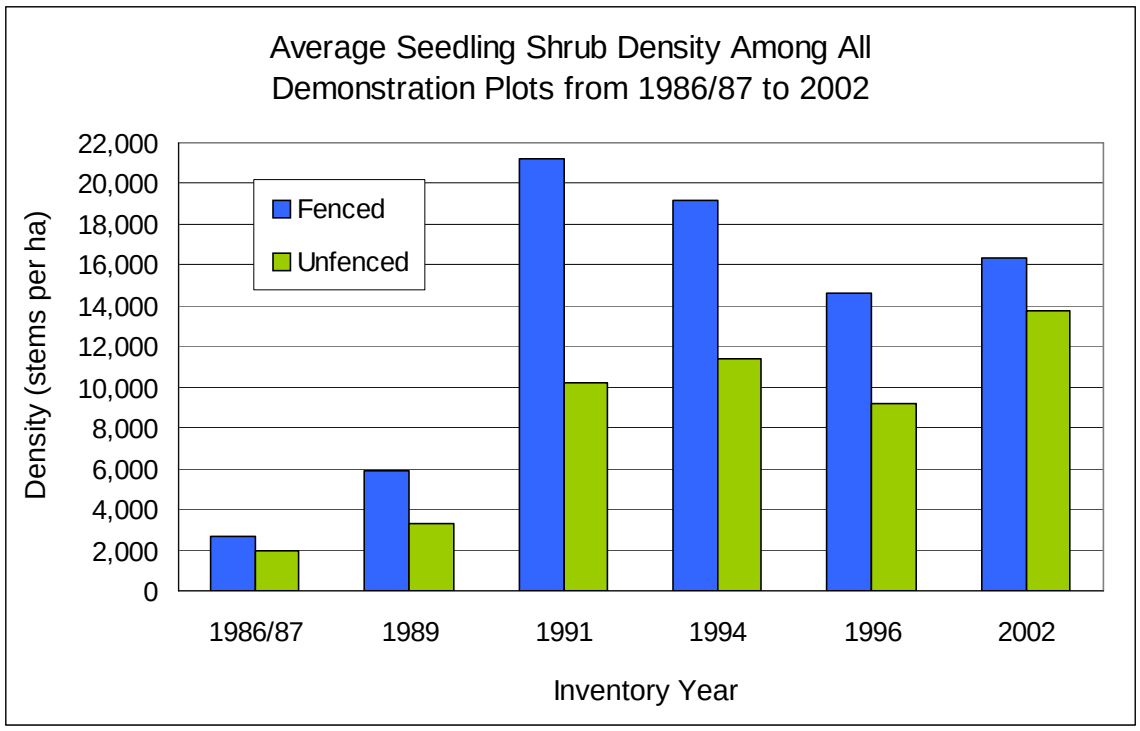


Figure 37. Average seedling (≤150 cm in height) shrub species density by inventory year and fence treatment among all the Demonstration Plots in Gettysburg National Military Park, 1986/87 to 2002.

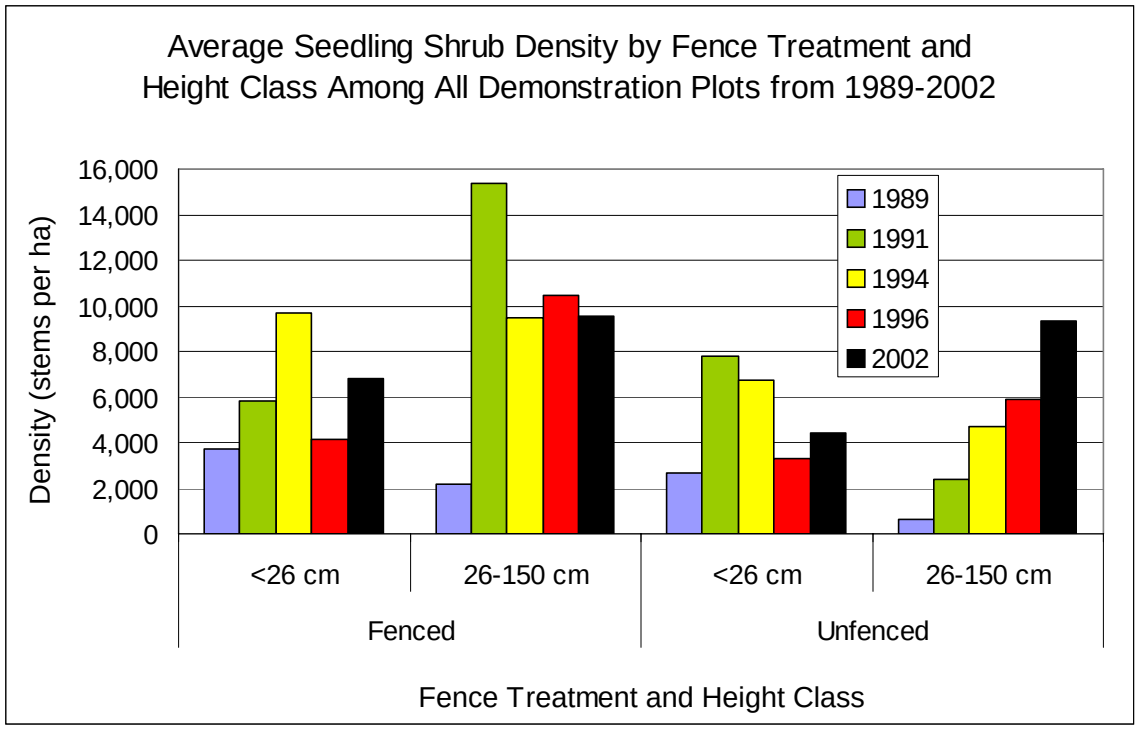


Figure 38. Average seedling (≤150 cm in height) shrub species density by fence treatment and height class among all the Demonstration Plots in Gettysburg National Military Park, 1989 to 2002.

Table 21. Coefficients of Community Similarity for herbaceous and vine species present in subplots of the fenced 10 x 10 m Demonstration Plot and the unfenced-control 40 x 40 m plot in Biesecker, Bushman Hill, and Pitzer woodlots, Gettysburg National Military Park, based on herbaceous and vine species in line transects and 0.0001 ha quadrants.

	Biesecker			Bushman Hill			Pitzer		
	1992	1995	2002	1992	1995	2002	1992	1995	2002
Transect Data									
Fenced vs. Unfenced-control	0.40	0.40	0.00	0.98	0.25	0.50	—	0.33	0.00
Quadrant Data									
Fenced vs. Unfenced-control	0.29	0.33	0.00	0.12	0.29	0.56	—	0.25	0.00

Comparison of Inventories for Individual Woodlots from 1986/87 to 2002

Biesecker Woodlot: The general trend over time was a reduction in seedling tree density with the lowest numbers recorded in 2002. Density in the fenced plot decreased from 102,000 stems/ha in 1986/87 to 8,400 stems/ha in 2002. Similarly, in the unfenced plot the density decreased from 49,000 stems/ha in 1986/87 to 3,400 stems/ha in 2002 (Figure 39). The density of seedling trees in the <26 and ≥26 cm height classes decreased over time in both the fenced and unfenced plot (Figure 40). The density of seedling trees <26 cm in height in the fenced plot decreased from 22,100 stems/ha in 1989 to 3,100 stems/ha in 2002. Similarly, the density of seedling trees <26 cm in height in the unfenced plot went from 26,100 stems/ha in 1989 to 2,400 stems/ha in 2002 (Figure 40). Densities of <26 cm seedling trees peaked in the fenced plot in 1991 and in the unfenced plot in 1994. Both plots experienced substantial density decreases in <26 cm seedling trees between 1994 and 1996. A similar trend was seen in the ≥26 cm seedling tree data. From 1989 to 2002, the density of ≥26 cm seedling trees in the fenced plot decreased from 14,700 to 5,300 stems/ha, and in the unfenced plot the density went from 3,000 to 1,000 stems/ha. The greatest densities of ≥26 cm seedling trees were recorded in 1991 in both plots (Figure 40). From 1989 to 2002, the diversity of seedling tree species increased slightly over time (nine to twelve species, respectively) in the fenced plot, but remained the same (four species) within the unfenced plot (Figure 39).

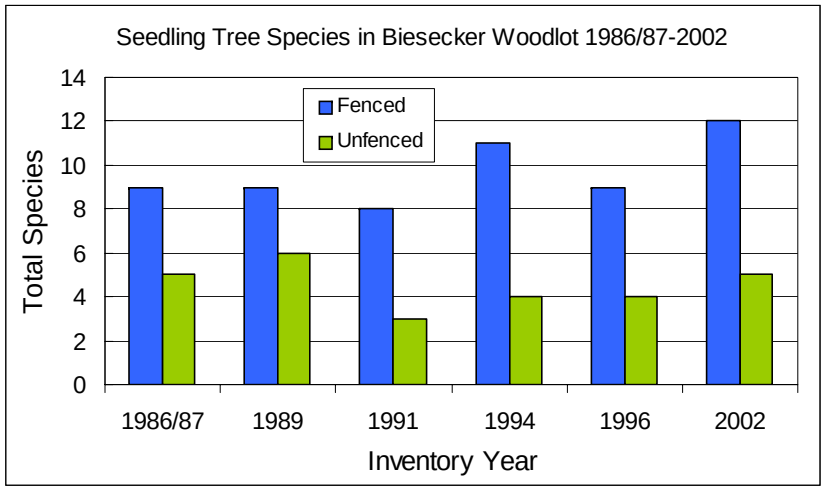
The general trend over time was an increase in seedling shrub density in the fenced plot and a decrease in the unfenced plot. The density of seedling shrubs in the fenced plot increased from 1,000 stems/ha in 1986/87 to 17,400 stems/ha in 2002. The opposite occurred in the unfenced plot where the density seedling shrubs increased from 1,000 stems/ha in 1986/87, peaked at 5,600 in 1991, and then decreased to 200 stems/ha in 2002 (Figure 39). The density of seedling shrubs <26 cm and ≥26 cm in height was consistently greater in the fenced plot than in the unfenced plot (Figure 41). From 1989 to 2002, the density of seedling shrubs <26 cm in height in the fenced plot increased from 2,900 to 6,700 stems/ha, with the greatest density recorded in 1991 (8,750 stems/ha). The density of seedling shrubs ≥26 cm in height in the fenced plot increased from 1,300 to 10,700 stems/ha between 1989 and 2002 (Figure 41). In the unfenced plot the number of species oscillated from one in 1986/87 to four in 1989 and 1994 to one in 2002 (Figure 39).

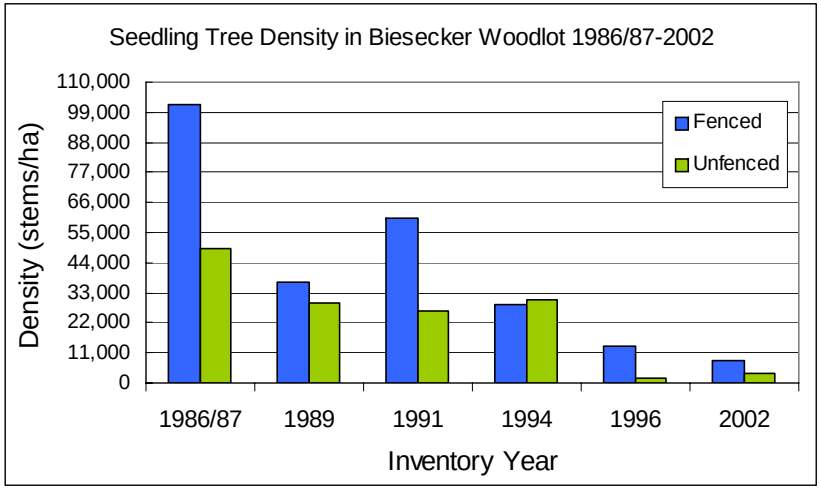
After the implementation of the Deer Management Program in 1995, the density of seedling trees in the unfenced plot increased slightly. From 1996 to 2002, the density of seedling trees <26 cm in height went from 1,600 to 2,400 stems/ha, and the density of ≥26 cm seedlings increased from 0 to 1,000 stems/ha (Figure 40). The number of seedling tree species present hardly changed (four to five species) during this time. An opposite trend was evident in the seedling shrub data. From 1996 to 2002, the density of seedling shrubs <26 cm in height in the unfenced plot went from 500 to 200 stems/ha, and the density of seedling shrubs ≥26 cm in the unfenced plot remained at zero stems/ha (Figure 41). The number of seedling shrub species in the unfenced plot decreased from three species in 1996 to one species in 2002 (Figure 39).

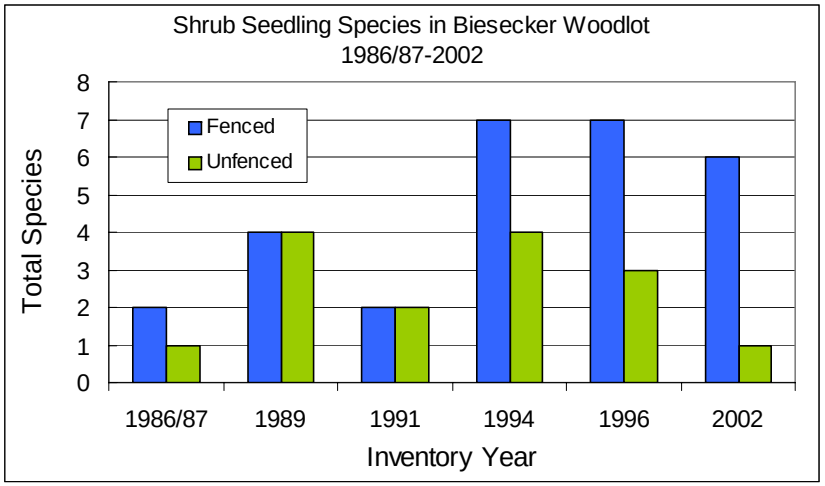
Between 1996 and 2002, the density of seedling trees in the fenced plot decreased, but the density in the unfenced plot increased. In contrast, the density of seedling shrubs in the fenced plot increased between 1996 and 2002, but the density of seedling shrubs in the unfenced plot decreased. The substantial increase in seedling shrubs in the fenced plot may have been the reason for the decrease in seedling trees in the fenced plot. Competition within the fenced plot, especially with the ≥26 cm shrub stems, was probably a deterrent for seedling tree recruitment.
In the fenced subplot, Virginia-creeper had the greatest IV in 2002, which was 3.5 times greater than the second-ranked species (Table 3). Spring-beauty was second-ranked in 1992, but was not present in

either the line transects or quadrants in 1995 or 2002. Cinquefoil (*Pontentilla canadensis*), which was third-ranked in 1992, was second-ranked in 1995 and 2002. The Shannon Diversity Indices were 0.58, 0.30, and 0.52 for 1992, 1995, and 2002, respectively. The Evenness Indices were 0.96, 0.64, and 0.86 for the same years, respectively (Tables 4 and 5).

In the unfenced-control subplot, only spring-beauty was present in the line transects in 1992, but cut-leaved toothwort (*Cardamine concatenata*) was also present in the quadrants (Table 6). In 1995, cut-leaved toothwort was present at a slightly greater IV than spring-beauty. In 2002, the IV of spring-beauty was two times that of wild licorice, the only other species found in the line transects. Cut-leaved toothwort was again present in the quadrants. The Shannon Diversity Indices were 0.0, 0.30, and 0.22 for 1992, 1995, and 2002, respectively. The Evenness Indices were 0, 1.00, and 0.72 during the same years, respectively (Tables 4 and 5).







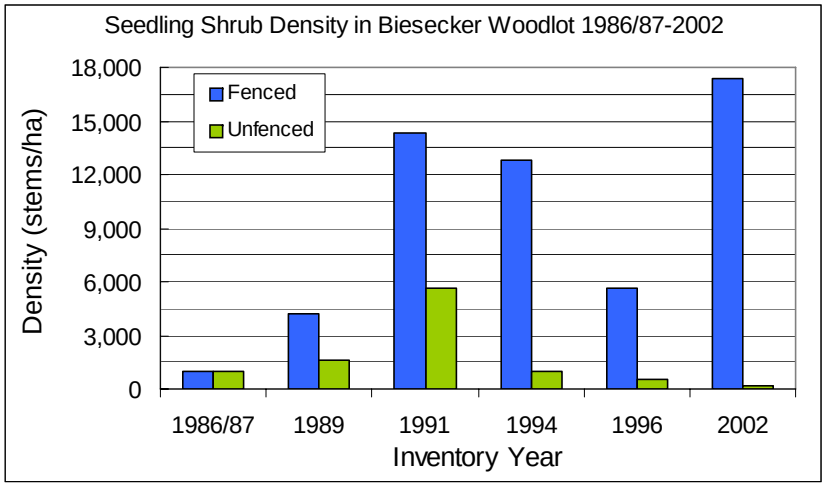


Figure 39. Number of species and density of seedling (≤150 cm in height) tree and shrub species by inventory year in the fenced and unfenced 10 x 10 m Demonstration Plots in Biesecker woodlot, Gettysburg National Military Park, 1986/87 to 2002.

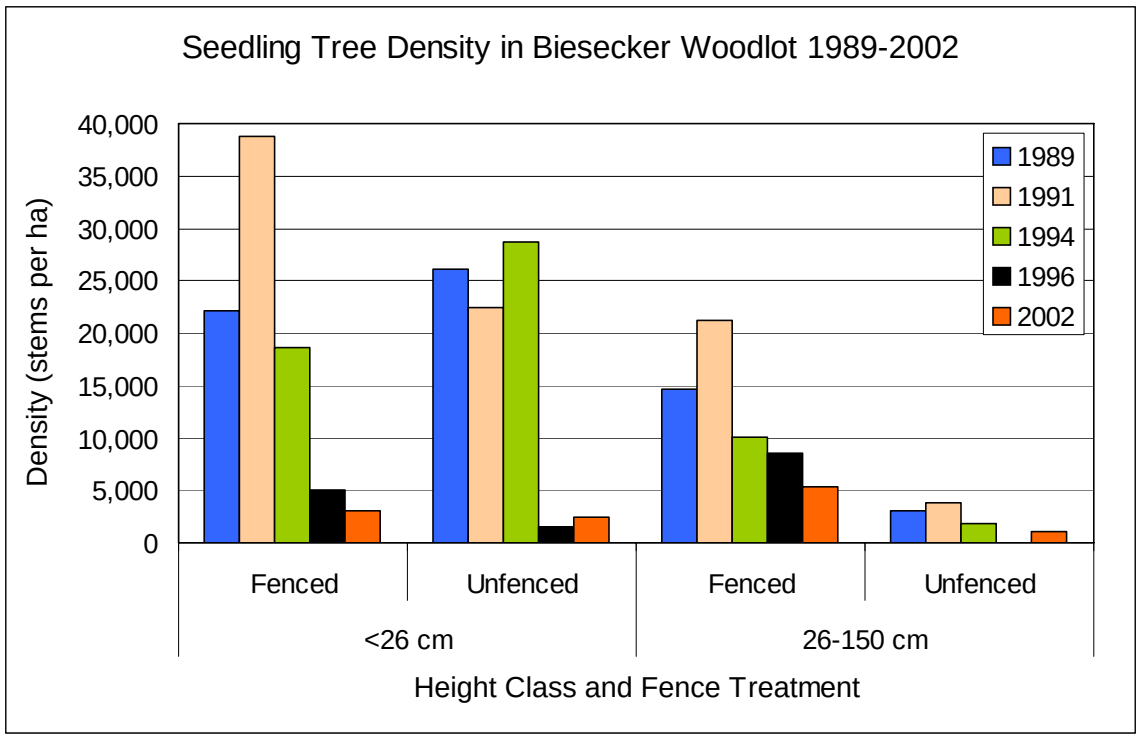


Figure 40. Density of seedling (≤150 cm in height) tree species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Biesecker woodlot, Gettysburg National Military Park, 1989 to 2002.

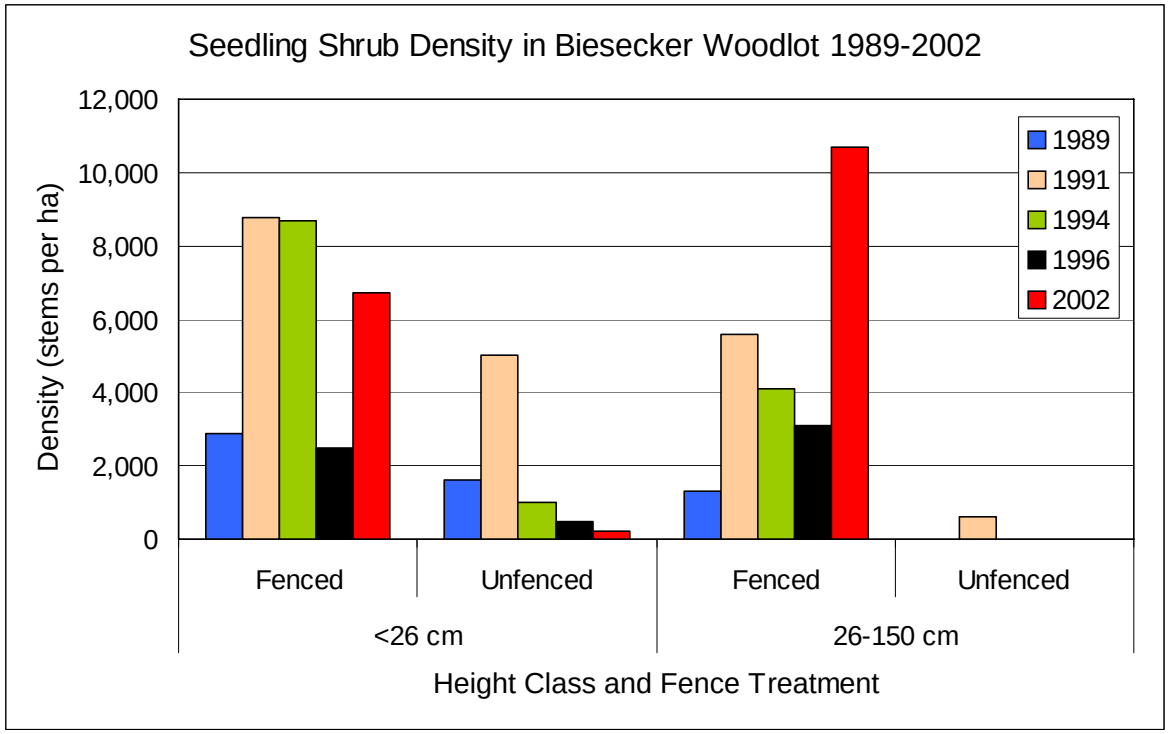


Figure 41. Density of seedling (≤150 cm in height) shrub species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Biesecker woodlot, Gettysburg National Military Park, 1989 to 2002.

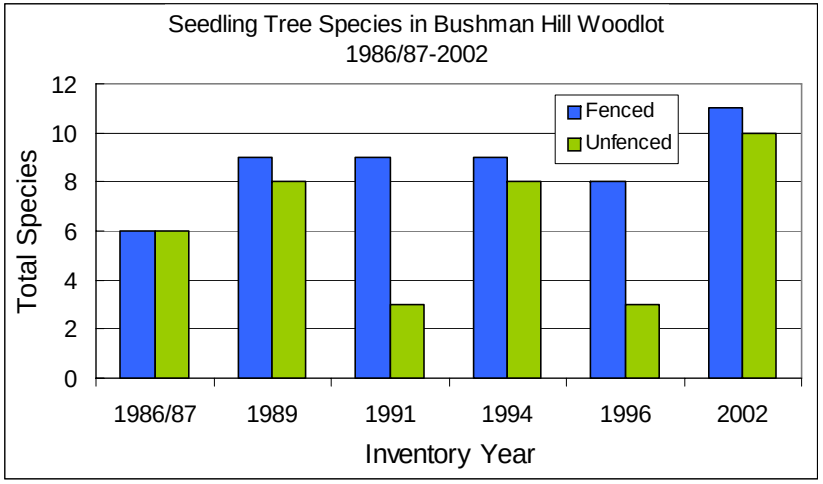
Bushman Hill Woodlot: The general trend over time was a reduction in seedling tree density with the lowest numbers recorded in 2002. The density of seedling trees in the fenced plot decreased from 133,000 stems/ha in 1986/87 to 19,800 stems/ha in 2002. Similarly, the density of seedling trees in the unfenced plot decreased from 98,000 stems/ha to 21,700 stems/ha in 2002 (Figure 42). The density of seedling trees <26 cm in height decreased over time in both the fenced and unfenced plot (Figure 43). The density of seedling trees <26 cm in height in the fenced plot decreased from 49,700 stems/ha in 1989 to 5,900 stems/ha in 2002. Similarly, the density of seedling trees <26 cm in height in the unfenced plot went from 60,500 stems/ha in 1989 to 12,600 stems/ha in 2002 (Figure 43). Both plots experienced steady decreases in <26 cm seedling trees from 1989 to 1996. The density of seedling trees ≥26 cm in height in the fenced plot increased from 16,400 stems/ha in 1989 to 34,500 stems/ha in 1994, then decreased to 13,900 stems/ha in 2002. From 1989 to 1996, the density of seedling trees ≥26 cm in height in the unfenced plot went from 12,100 to 100 stems/ha, then increased to 9,100 stems/ha in 2002 (Figure 43). The diversity of seedling tree species had a similar increasing trend over time in both the fenced and unfenced plots (Figure 42). The trend was more consistent in the fenced plot than in the unfenced plot. Between 1996 and 2002, the density of seedling trees in the fenced plot decreased, but the density in the unfenced plot increased. In contrast, the density of seedling shrubs in both the fenced and unfenced plots increased from 1996 to 2002. Competition between tree and shrub species in the fenced plot was probably a deterrent for seedling tree recruitment.

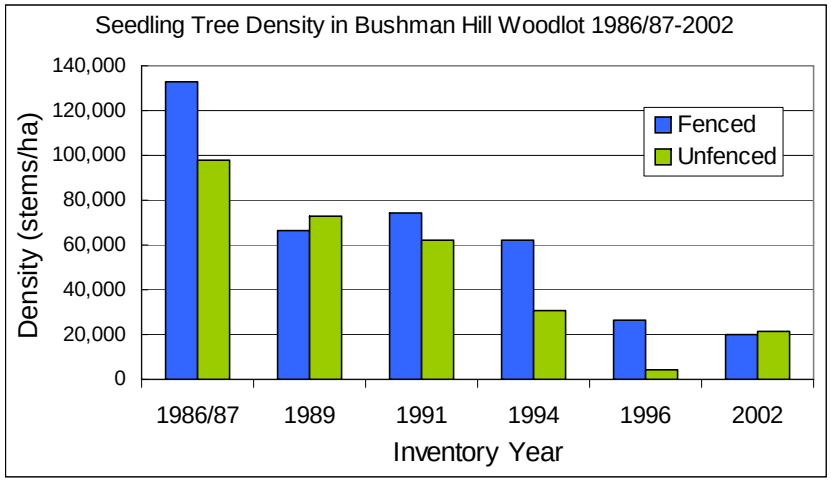
The general trend over time was an increase in seedling shrub density. The density of seedling shrubs in the fenced plot increased from 8,000 stems/ha in 1986/87 to 41,225 stems/ha in 1991, then decreased to 17,000 stems/ha in 1996, and increased again to 23,400 stems/ha in 2002 (Figure 42). A similar oscillating trend occurred in the unfenced plot where the density increased from 2,000 stems/ha in 1986/87, peaked at 38,300 stems/ha in 1994, then decreased to 14,400 stems/ha in 1996, and increased again to 40,700 stems/ha in 2002 (Figure 42). In 1989, 1991, 1994, and 2002, the density of seedling shrubs <26 cm in height in the fenced plot hardly changed, with ranges between 10,800 to 14,400 stems/ha, but there was a decrease in seedling shrub density in 1996 to only 4,300 stems/ha. The density of seedling shrubs <26 cm in height in the unfenced plot increased between 1989 and 2002 from 7,500 to 11,800 stems/ha, with peak densities recorded in 1994 (26,400 stems/ha) (Figure 44). From 1989 to 2002, the density of seedling shrubs ≥26 cm in height in the fenced plot increased from 7,100 to 12,600 stems/ha, with a peak density of 28,725 stems/ha recorded in 1991. The density of seedling shrubs ≥26 cm in height in the unfenced plot increased from 3,600 stems/ha in 1989 to 28,900 stems/ha in 2002 (Figure 44). From 1986/87 to 2002, the diversity of seedling shrub species increased from three to eight species in the fenced plot, and from one to ten species in the unfenced plot (Figure 42).

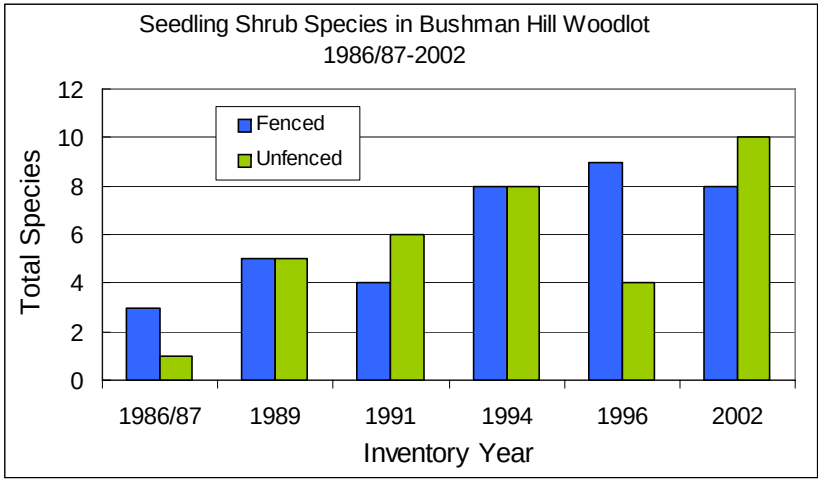
After the implementation of the Deer Management Program in 1995, the density of seedling trees in the unfenced plot increased greatly. From 1996 to 2002, the density of seedling trees <26 cm in height went from 4,100 to 12,600 stems/ha, and the density of seedlings ≥26 cm in height increased from 100 to 9,100 stems/ha (Figure 43). Between 1996 and 2002, the number of seedling tree species increased from three to ten species and the number of seedling shrub species increased from four to ten (Figure 42). From 1996 to 2002, the density of seedling shrubs <26 cm in height in the unfenced plot went from 7,400 to 11,800 stems/ha, and the density of seedling shrubs ≥26 cm in height in the unfenced plot increased substantially from 7,000 to 28,900 stems/ha (Figure 44). This indicates that the reduction in deer herbivory, even with an increase in shrub species competition, was beneficial for the presence and growth of seedling trees. In the unfenced plot, both tree and shrub species experienced increases in seedling densities between 1996 and 2002, with seedling shrubs ≥26 cm in height yielding the greatest increases.

In the fenced subplot, rough bedstraw had the greatest IV in 1992 (Table 9). It dropped to fourth rank in 1995 and was absent from the quadrants in 2002. Virginia-creeper increased from fourth rank to number one in 1995 and 2002. Its IV increased approximately 50 units during each of the two intervals between the inventories. Jack-in-the-pulpit (*Arisaema triphyllum*) was third-ranked in 1992. It was not present in the line transects in 1995, but was present at less than one percent of cover in the quadrants in 1995. It was third-ranked in the transects in 2002. The Shannon Diversity Indices were 0.56, 0.66, and 0.57 for 1992, 1995, and 2002, respectively, and the Evenness Indices were 0.94, 0.95, and 0.73 during the same years, respectively (Tables 4 and 5).

In the unfenced-control subplot, cinquefoil had the greatest IV in 1992 and 1995, but was absent from the quadrants in 2002 (Table 10). Wild licorice was second-ranked in 1992, dropped to fifth rank in l995 and was absent from the quadrants in 2002. Jack-in-the-pulpit was third-ranked in 1992, tied for tenth rank in 1995, and second-ranked in 2002. Japanese honeysuckle, which was not present in the quadrants in 1992, increased to sixth rank in 1995 and to first rank in 2002. Enchanter's-nightshade increased from fifth rank in 1992, to third rank in 1995 and 2002. The Shannon Diversity Indices were 0.83, 0.77, and 0.91 for 1992, 1995, and 2002, respectively, and the Evenness Indices were 0.92, 0.74, and 0.87 during the same years, respectively (Tables 4 and 5).







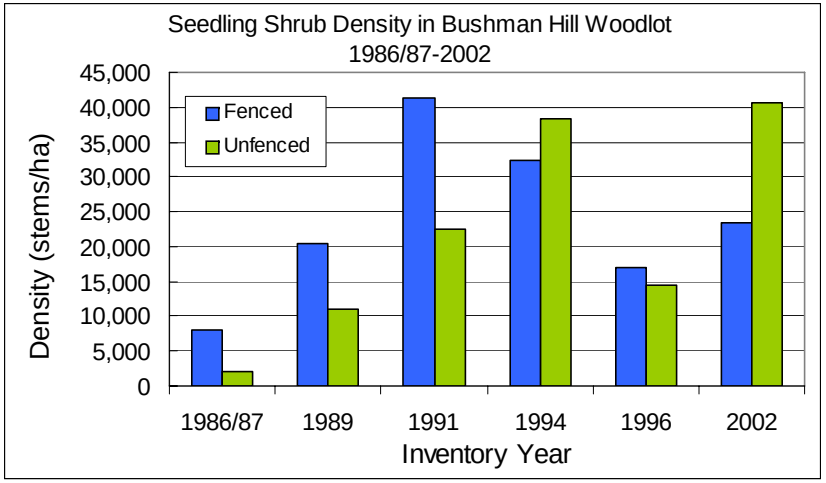


Figure 42. Number of species and density of seedling (≤150 cm in height) tree and shrub species by inventory year in the fenced and unfenced 10 x 10 m Demonstration Plots in Bushman Hill woodlot, Gettysburg National Military Park, 1986/87 to 2002.

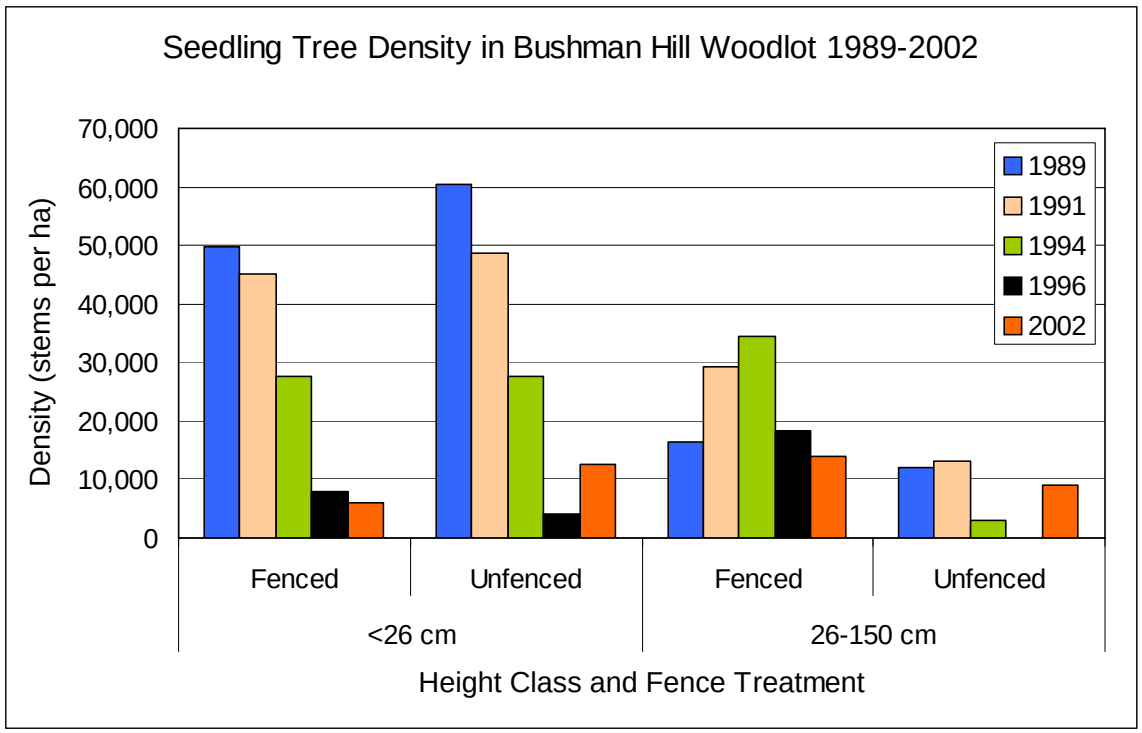


Figure 43. Density of seedling (≤150 cm in height) tree species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Bushman Hill woodlot, Gettysburg National Military Park, 1989 to 2002.

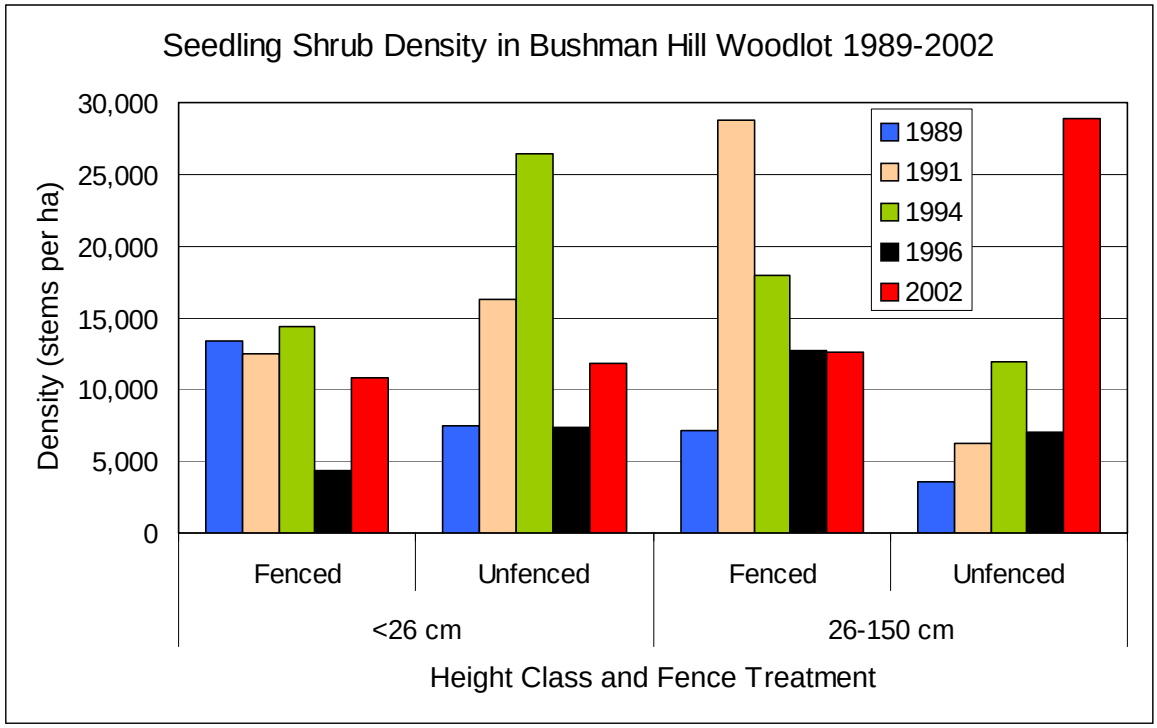
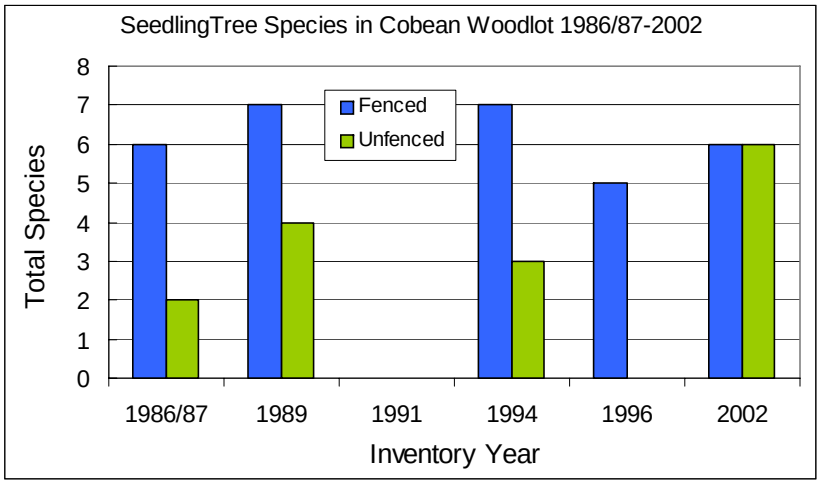


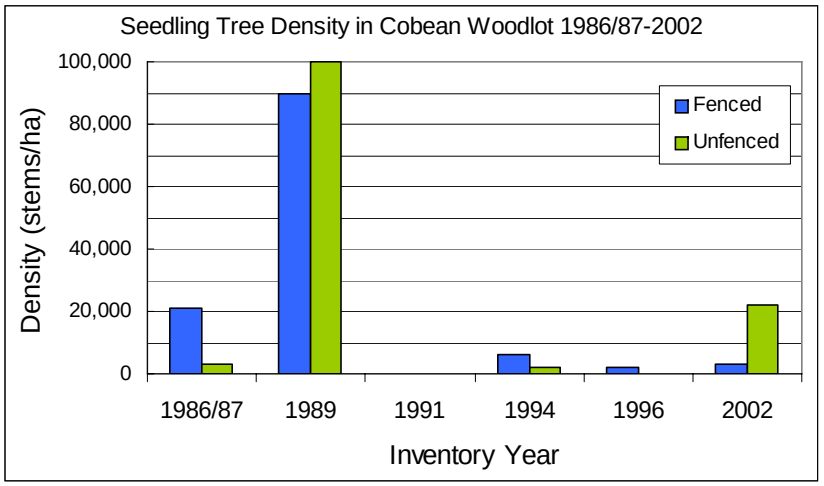
Figure 44. Density of seedling (≤150 cm in height) shrub species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Bushman Hill woodlot, Gettysburg National Military Park, 1989 to 2002.

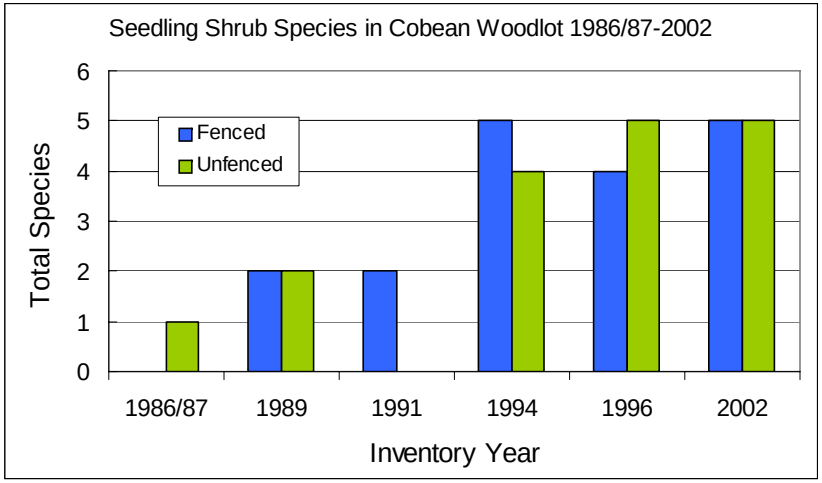
Cobean Woodlot: There was a sharp increase in seedling tree density between 1986/87 and 1989, then a drastic decrease in densities during the 1990's. Density in the fenced plot went from 21,000 stems/ha in 1986/87, to 90,000 stems/ha in 1989, to only 3,100 stems/ha in 2002. The same trend occurred in the unfenced plot when the density increased from 3,000 stems/ha in 1986/87, to 100,000 stems/ha in 1989, then decreased to 22,000 stems/ha in 2002 (Figure 45). From 1989 to 1991, the density of seedling trees <26 cm in height decreased substantially in the fenced (88,400 to 0 stems/ha) and unfenced (99,100 to 0 stems/ha) plots (Figure 46). The density of seedling trees <26 cm in height in the unfenced plot (20,600 stems/ha) was greater than in the fenced plot (1,300 stems/ha) in 2002. The density of seedling trees ≥26 cm in height was fairly consistent over time, ranging from 0 to 3,500 stems/ha in the fenced plot and 0 to 1,400 stems/ha in the unfenced plot (Figure 46). The diversity of seedling tree species remained the same over time in the fenced plot with six species in both 1986/87 and 2002. The seedling tree species diversity in the unfenced plot increased over the same time period from two to six species (Figure 45).

The general trend over time was an increase in seedling shrub density. Between 1986/87 and 2002, seedling shrub density in the fenced plot increased from 0 to 22,500 stems/ha, with the greatest density (40,000 stems/ha) recorded in 1996. A similar trend was seen in the unfenced plot, where the seedling shrub density went from 1,000 stems/ha in 1986/87, to 23,800 stems/ha in 2002, with the peak density (31,000 stems/ha) recorded in 1996 (Figure 45). The seedling shrub densities in fenced and unfenced plots were equal in 2002. The density of seedling shrubs <26 cm in height in fenced plot increased from 700 stems/ha in 1989, to 11,250 stems/ha in 1991, but then gradually increased to 12,900 stems/ha in 2002. Seedling shrub density of stems <26 cm in height in the unfenced plot also increased over time, but with the greatest change occurring between 1994 and 1996. There were 200 stems/ha recorded in the unfenced plot in 1989 and 10,400 stems/ha in 2002 (Figure 47). The density of seedling shrubs ≥26 cm in height increased over the fourteen-year inventory period, with the greatest densities recorded in 1996. In the fenced plot, the density of seedling shrubs 26-150 cm in height increased substantially from 2,400 to 24,600 stems/ha between 1989 and 1996, then decreased to 9,600 stems/ha in 2002 (Figure 47). Similarly, the seedling shrub density for the same height ranges in the unfenced plot increased from 200 to 10,400 stems/ha between 1989 and 2002. From 1986/87 to 2002, the diversity of seedling shrub species increased from zero to five species in the fenced plot, and from one to five species in the unfenced plot (Figure 45). The intense competition between tree and shrub species was probably the reason for the low seedling tree densities in the fenced and unfenced plots.

From 1996 to 2002, there was an increase in seedling tree density in the unfenced plot. The density of seedling trees <26 cm in height went from 0 to 20,600 stems/ha in the six-year period. However, there was not as strong a response in the ≥26 cm height class category for seedling tree density. Densities from 1996 to 2002 only increased from 0 to 1,400 stems/ha. From 1996 to 2002, seedling shrub densities in the unfenced plot decreased in the <26 cm (10,900 to 10,400 stems/ha, respectively) and ≥26 cm (33,296 to 26,802 stems/ha, respectively) height classes. Competition with shrub species was probably the primary factor in the low seedling tree densities.







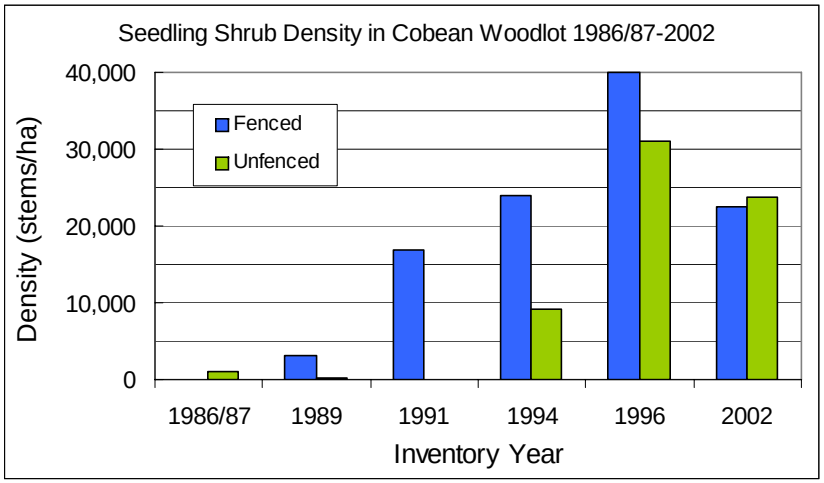


Figure 45. Number of species and density of seedling (≤150 cm in height) tree and shrub species by inventory year in the fenced and unfenced 10 x 10 m Demonstration Plots in Cobean woodlot, Gettysburg National Military Park, 1986/87 to 2002.

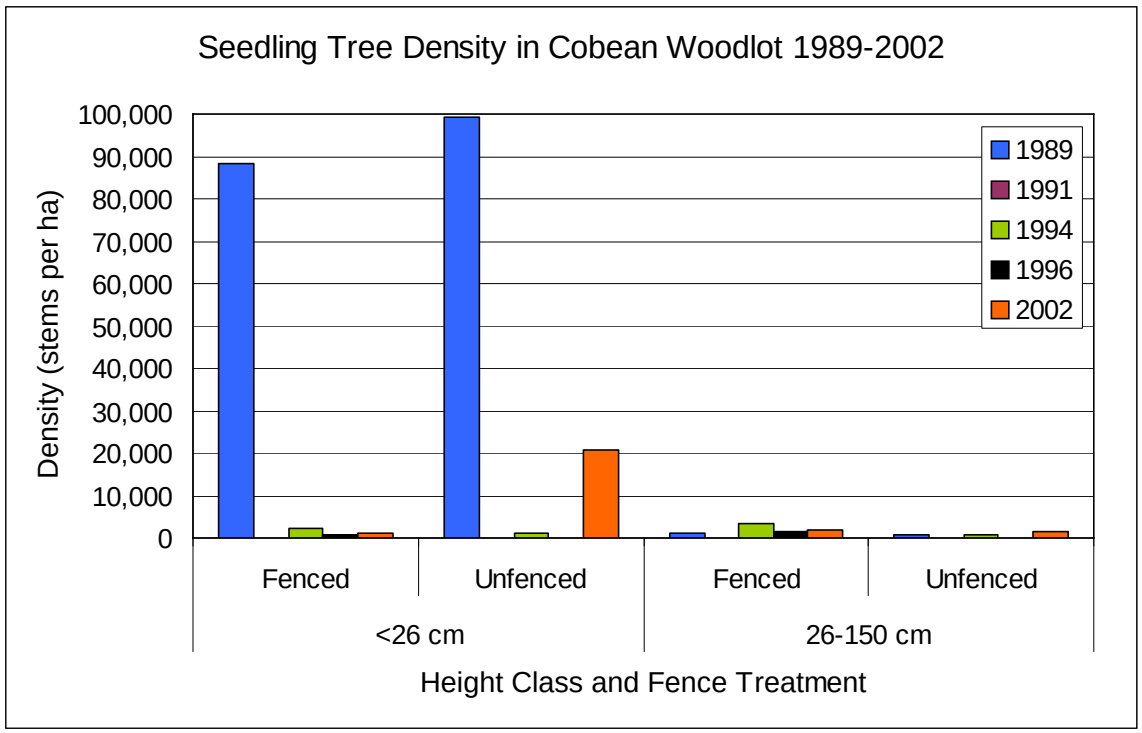


Figure 46. Density of seedling (≤150 cm in height) tree species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Cobean woodlot, Gettysburg National Military Park, 1989 to 2002.

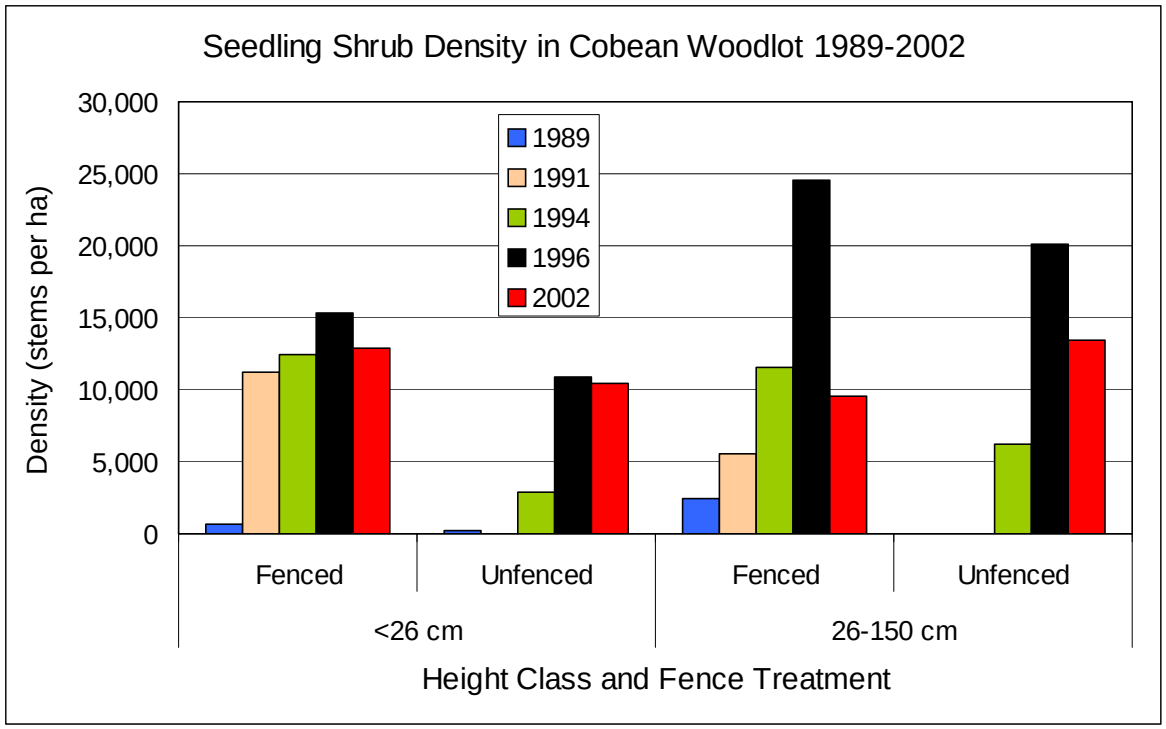


Figure 47. Density of seedling (≤150 cm in height) shrub species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Cobean woodlot, Gettysburg National Military Park, 1989 to 2002.

Pitzer Woodlot: From 1986/87 to 2002 there was an overall decrease in seedling tree density in Pitzer woodlot. The density of seedling trees in the fenced plot was 23,000 stems/ha in 1986/87, peaked at 28,000 stems/ha in 1991, and decreased over time to 8,200 stems/ha in 2002. In the unfenced plot, the density oscillated between the inventories, starting with 16,000 stems/ha in 1986/87, decreasing to 7,000 stems/ha in 1991, increasing to 12,000 stems/ha in 1994, decreasing to 1,000 stems/ha in 1996, and increasing to 4,100 stems/ha in 2002 (Figure 48).

Between 1989 and 2002, the density of seedling trees <26 cm in height in the fenced plot decreased from 18,000 to 4,500 stems/ha, with the greatest density recorded in 1991 (24,375 stems/ha) (Figure 49). From 1989 to 1994, there was an increasing trend in the seedling tree density for stems <26 cm in height in the unfenced plot (6,300 to 11,900 stems/ha), but then the density decreased greatly to only 500 stems/ha in 1996, then it increased to 2,700 stems/ha in 2002 (Figure 49). From 1989 to 2002, the density of seedling tree stems ≥26 cm in height in the fenced plot increased from 1,300 to 3,700 stems/ha, with the greatest density recorded in 1996 (5,900 stems/ha) (Figure 49). Similarly, the density of seedling trees ≥26 cm in height in the unfenced plot increased slightly from 300 stems/ha in 1989 to 1,400 stems/ha in 2002. Seedling tree species diversity increased over time. From 1989 to 2002, the diversity of seedling tree species in the fenced plot went from four to eleven species, and in the unfenced plot went from five to nine species (Figure 48).

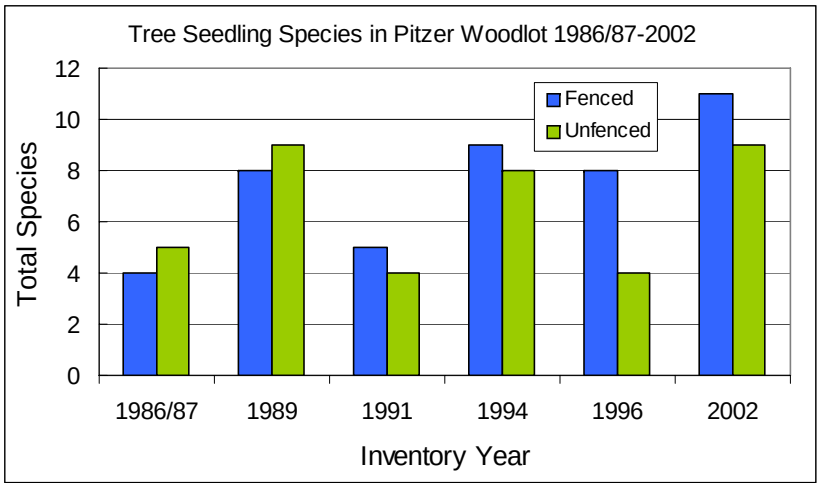
Seedling shrub density varied over time in a way that was unlike any other woodlot inventoried. The seedling shrub density in the fenced plot gradually increased from 1,000 to 3,125 stems/ha between 1986/87 and 1991, then peaked at 8,700 stems/ha in 1994, decreased to 3,000 stems/ha 1996, and increased again to 4,600 stems/ha in 2002. A similar up-down trend was seen in the unfenced plot data, but the density peaked at 6,875 stems/ha in 1991 (Figure 48). The density of seedling shrubs <26 cm in height in the fenced plot increased from 1,800 stems/ha in 1989, to a maximum of 4,300 stems/ha in 1994, then decreased to 2,700 stems/ha in 2002 (Figure 50). Similarly, the density of seedling shrubs ≥26 cm in height in the fenced plot increased between 1989 and 2002 from 300 to 1,900 stems/ha, with peak densities recorded at 4,400 stems/ha in 1994. There was no consistent trend in seedling shrub density in the <26 cm height class in the unfenced plot between 1989 and 2002. The density ranged between 100 in 1996 to 6,875 stems/ha in1991 (Figure 50). Although the density of seedling shrubs ≥26 cm in height in the unfenced plot varied over time, the general trend was an increase from 100 to 1,100 stems/ha from 1989 to 2002. The diversity of seedling shrub species in the fenced plot increased from one species in 1986/87 to six species in 1994, and then decreased to three species in 2002. Diversity within the unfenced plot varied over time also, but three species were recorded in the plot in both 1986/87 and 2002 (Figure 48).

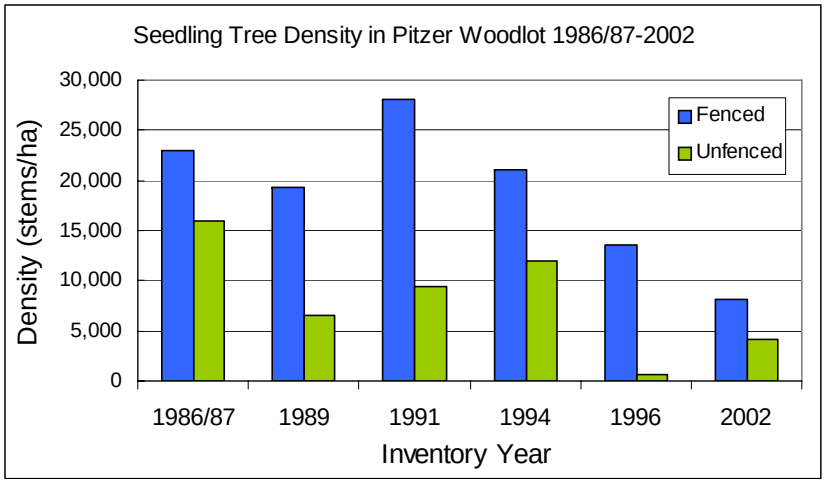
From 1996 to 2002, after the implementation of the Deer Management Program, there were increases in seedling tree and shrub densities in the unfenced plot for both height classes. The density of seedling trees in both the <26 cm and ≥26 cm height categories was greater than that of seedling shrubs in the unfenced plot during both inventories (Figures 49 and 50). Also, seedling tree densities in each of the two height categories were greater than seedling shrub densities in the fenced plot during every inventory.

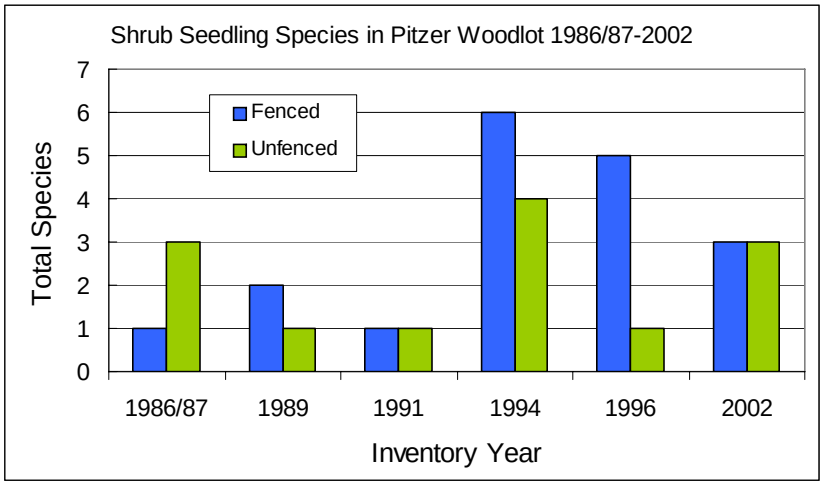
In the fenced plot, transects of the Pitzer woodlot Demonstration Plots were only performed in 1995 and 2002. Japanese honeysuckle dominated the transects in 1995 and 2002, having an IV 7.5 and 2.8 times greater than the next highest value for those time periods (Table 15). Grass spp. increased from fourth rank to second rank by a factor of four between 1995 and 2002. False solomon's-seal (*Simlacina racemosa*) was the only other species found in the line transects both years. It ranked third both years, with a slight increase in IV in 2002. The number of species increased by two in the line

transects and by three in the quadrants between 1995 and 2002. The Shannon Diversity Indices were 0.30 and 0.47 for 1995 and 2002, respectively, and the Evenness Indices were 0.50 and 0.60 during the same years, respectively (Tables 4 and 5).

In the unfenced-control plot, only two species were present in the line transects in 1995 and none were present in 2002 (Table 16). Japanese honeysuckle and wild licorice were about equally represented, with Japanese honeysuckle having the greater IV. Three species were present in the quadrants in 1995 and only one in 2002. The Shannon Diversity Indices were 0.30 and 0 for 1995 and 2002, respectively, and the Evenness Indices were 0.99 and 0 during the same years, respectively (Tables 4 and 5).







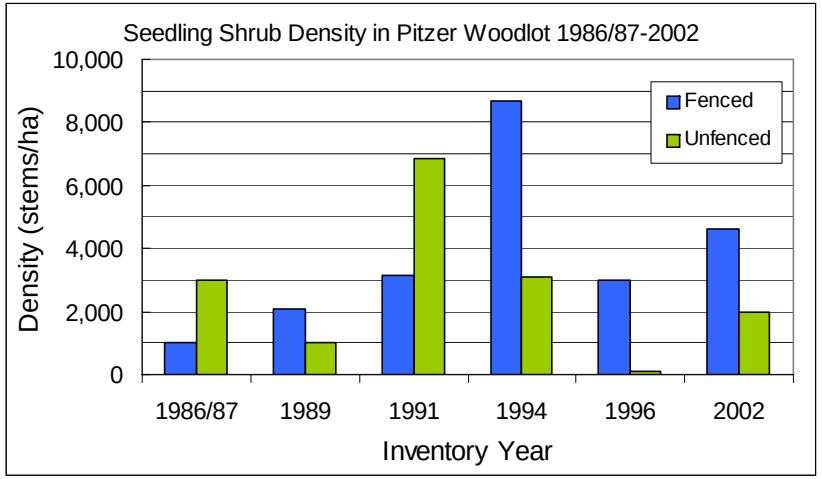


Figure 48. Number of species and density of seedling (≤150 cm in height) tree and shrub species by inventory year in the fenced and unfenced 10 x 10 m Demonstration Plots in Pitzer woodlot, Gettysburg National Military Park, 1986/87 to 2002.

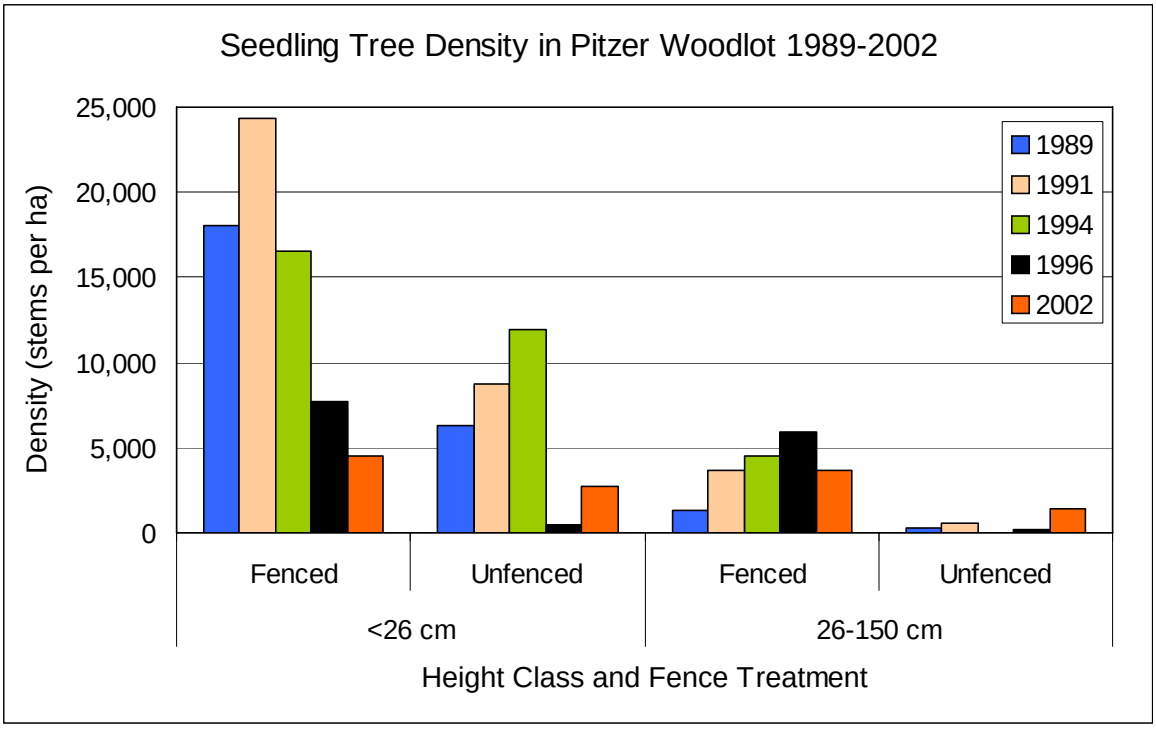


Figure 49. Density of seedling (≤150 cm in height) tree species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Pitzer woodlot, Gettysburg National Military Park, 1989 to 2002.

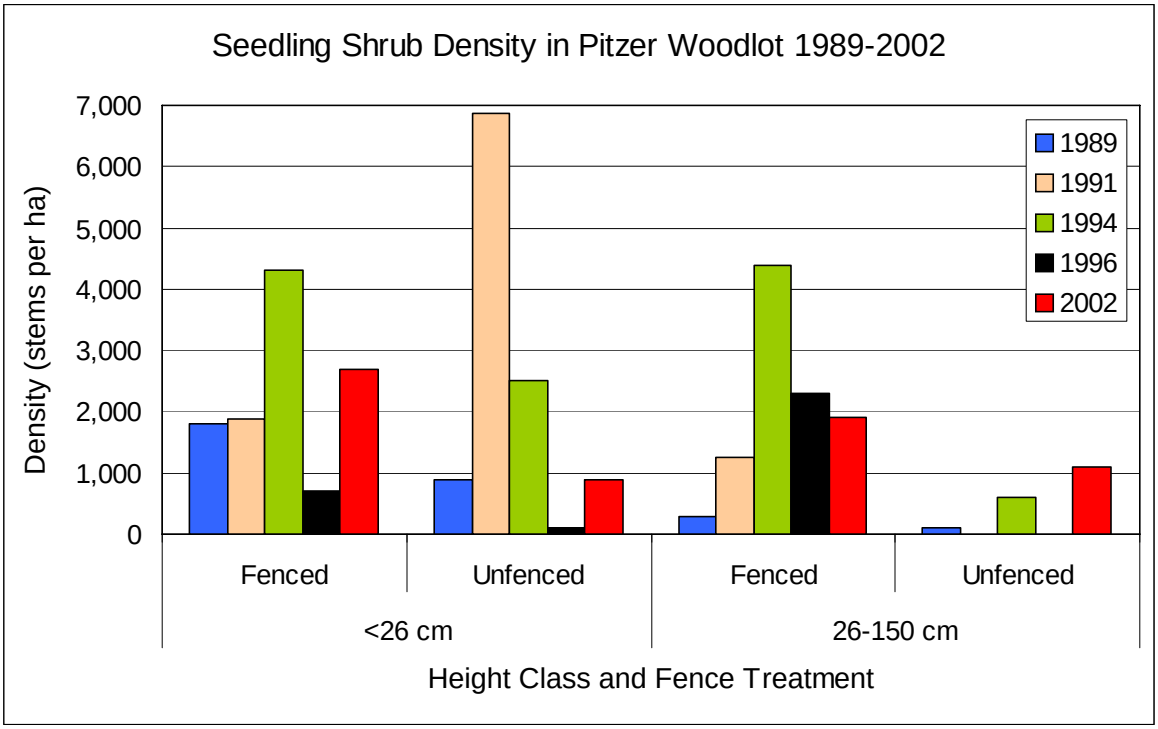
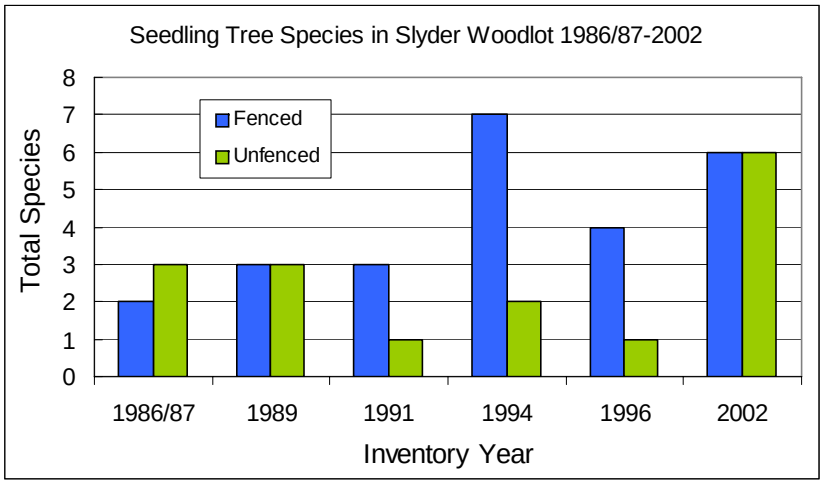


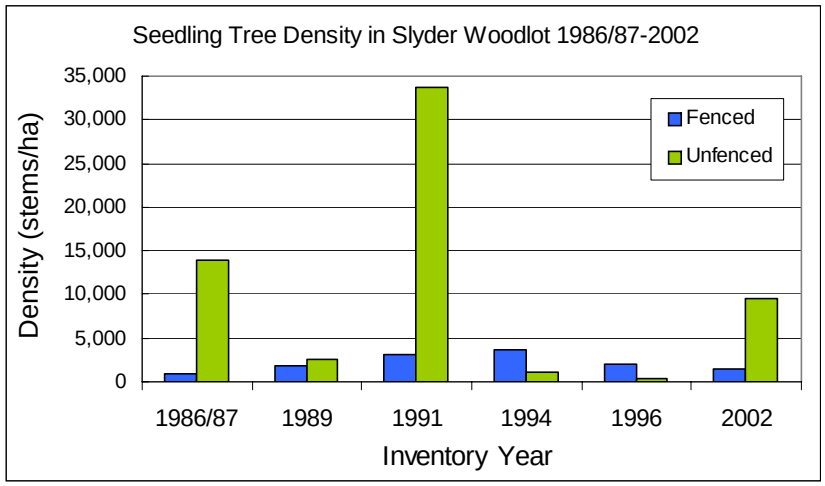
Figure 50. Density of seedling (≤150 cm in height) shrub species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Pitzer woodlot, Gettysburg National Military Park, 1989 to 2002.

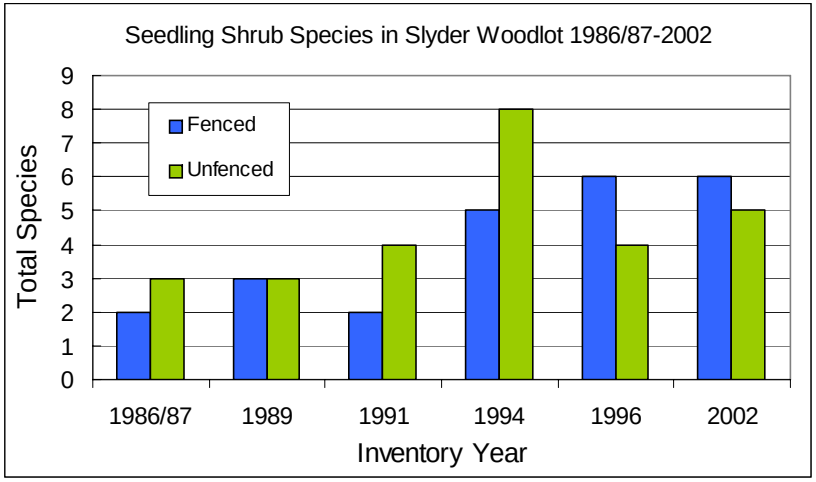
Slyder Woodlot: There was no consistent change in seedling tree density between 1986/87 and 2002. Seedling tree density in the fenced plot increased from 1,000 stems/ha in 1986/87 to 3,600 stems/ha in 1994, then decreased to 1,500 stems/ha in 2002. In the unfenced plot, the density decreased from 14,000 stems/ha in 1986/87 to 2,600 stems/ha in 1989, then increased substantially to 33,750 stems/ha in 1991, then decreased to 400 stems/ha in 1996, and then increased again to 9,600 stems/ha in 2002. The density of seedling trees in the unfenced plot was greater than in the fenced plot in 2002 (Figure 51). In the unfenced plot, there was a surge in the density of seeding trees <26 cm in height in 1991 (33,750 stems/ha), but it dropped back down in 1994 (1,100 stems/ha), and remained low through 2002 (2,200 stems/ha) (Figure 52). In the fenced plot, the density of seedling trees <26 cm in height remained constant over time, ranging from 900 to 200 stems/ha from 1989 to 2002. The same trend was evident for seedling trees ≥26 cm in height in the fenced plot. Between 1989 and 2002, the density ranged from 1,000 to 2,450 stems/ha. In the unfenced plot, there were no seedling trees ≥26 cm in height recorded until 1996. Between 1996 and 2002, the density increased from 100 to 7,400 stems/ha (Figure 52). The seedling tree species diversity increased over time from two to six species in the fenced plot, and from three to six species in the unfenced plot (Figure 51).

There was no consistent trend in seedling shrub density between 1986/87 and 2002. The fenced plot density increased from 2,000 stems/ha in 1986/87 to a peak of 43,125 stems/ha in 1991, then gradually decreased to 11,300 stems/ha in 2002. A similar trend was seen in the unfenced plot data. The seedling shrub density in the unfenced plot went from 4,000 stems/ha in 1986/87, to 22,450 stems/ha in 1991, then decreased to 4,700 stems/ha in 2002 (Figure 51). Seedling shrubs <26 cm in height exhibited the same trends in density over time in both fence treatments. The density of seedling shrubs <26 cm in height in the fenced plot increased from 400 to 13,000 stems/ha from 1989 to 1994, then decreased to 500 stems/ha in 2002 (Figure 53). Similarly, the density of seedling shrubs <26 cm in height in the unfenced plot went from 3,800 to 16,250 stems/ha between 1989 and 1991, then decreased to 500 stems/ha in 2002. The density of seedling shrubs ≥26 cm in height in the fenced plot increased substantially from 1,200 to 43,125 stems/ha between 1989 and 1991, then decreased to 10,400 stems/ha in 2002 (Figure 53). However, the density of seedling shrubs ≥26 cm in height in the unfenced plot was more consistent over time, with an overall increase in density from 0 to 4,200 between 1989 and 2002. The diversity of seedling shrub species increased over time from two to six species in the fenced plot, and from three to five species in the unfenced plot (Figure 51).

After the implementation of the Deer Management Program in 1995, there was an increase in the abundance of seedling trees. Seedling tree densities in the unfenced plot increased between 1996 and 2002. The density of seedling trees <26 cm in height went from 300 in 1996 to 2,200 stems/ha in 2002. The density of seedling tree stems ≥26 cm in height went from 100 to 7,400 stems/ha between 1996 and 2002 (Figure 52). Surprisingly, the density of seedling shrubs decreased in the unfenced plot between 1996 and 2002. The density of seedling shrubs <26 cm in height decreased from 2,200 to 900 stems/ha, and stems ≥26 cm in height decreased from 7,400 to 4,200 stems/ha between 1996 and 2002 (Figure 53).







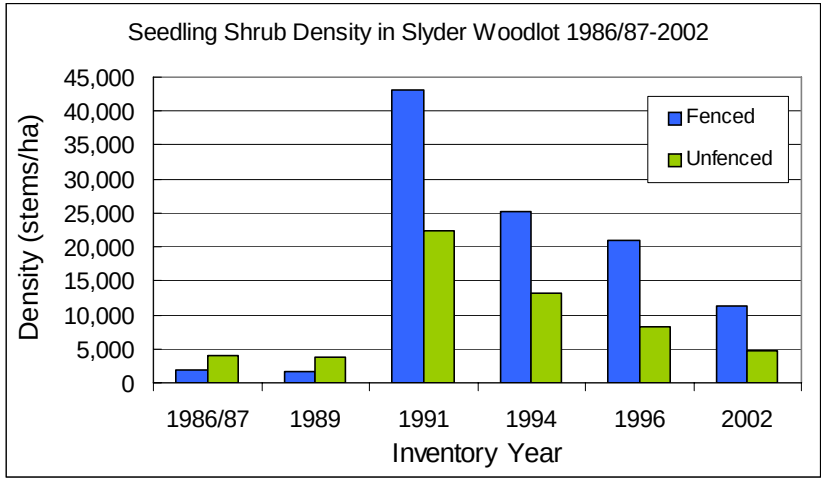


Figure 51. Number of species and density of seedling (≤150 cm in height) tree and shrub species by inventory year in the fenced and unfenced 10 x 10 m Demonstration Plots in Slyder woodlot, Gettysburg National Military Park, 1986/87 to 2002.

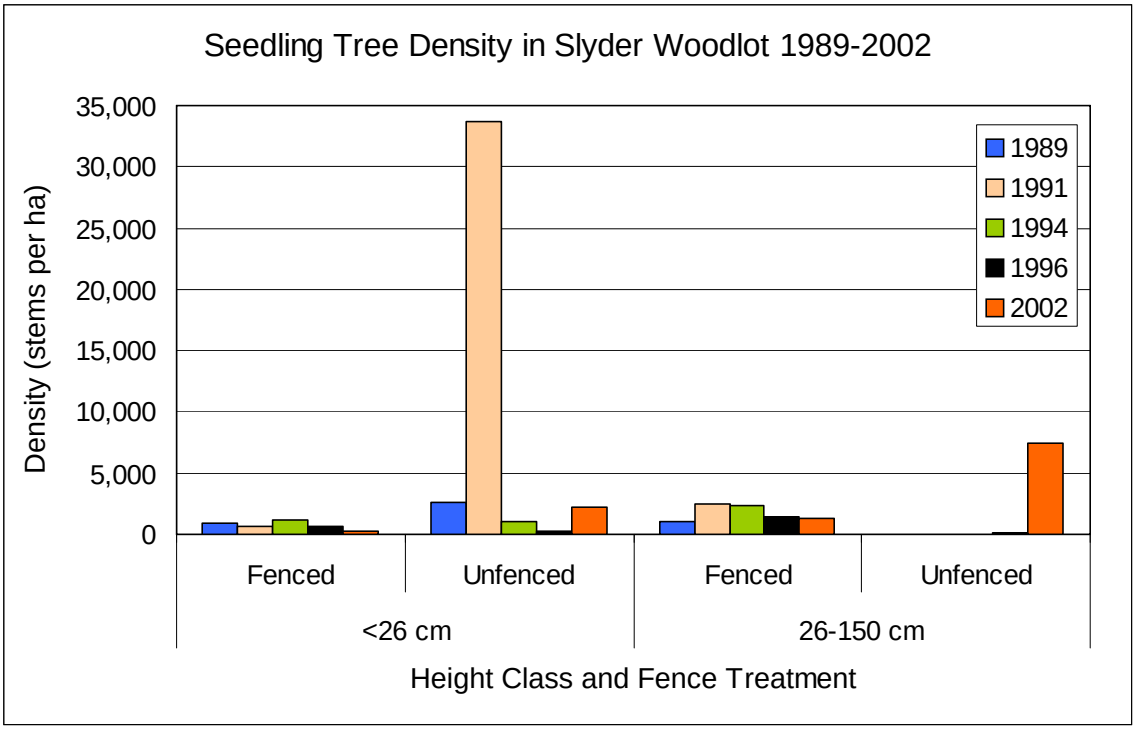


Figure 52. Density of seedling (≤150 cm in height) tree species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Slyder woodlot, Gettysburg National Military Park, 1989 to 2002.

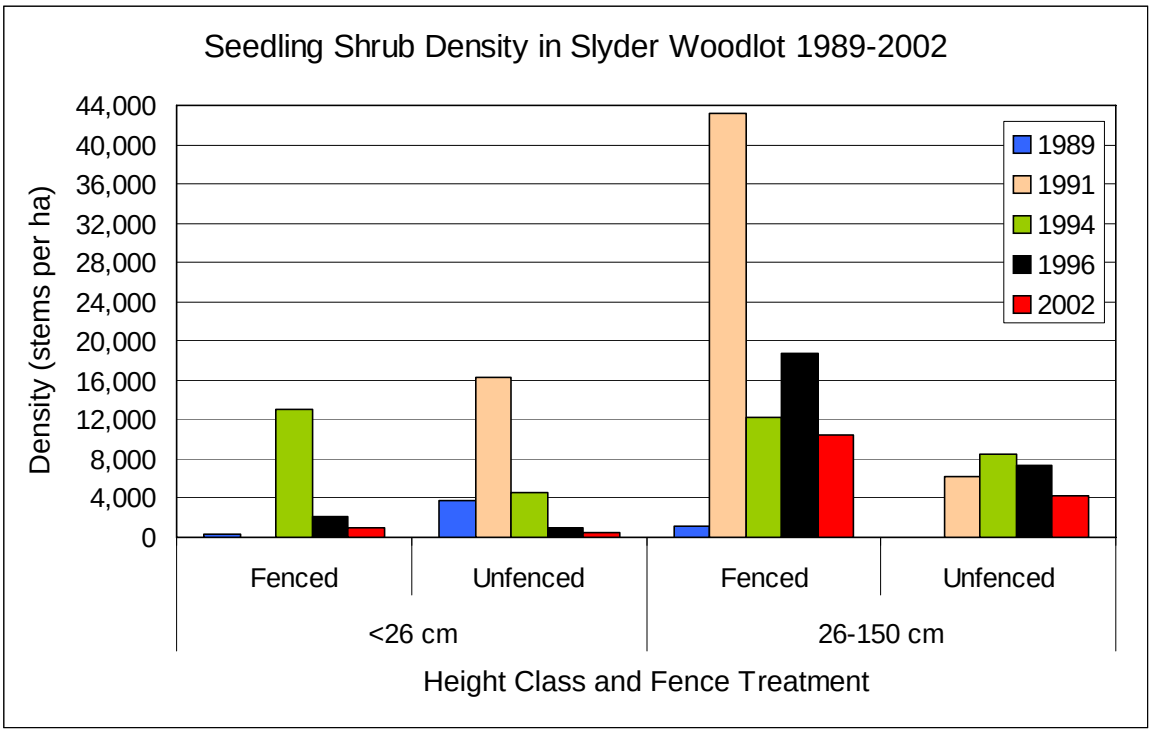
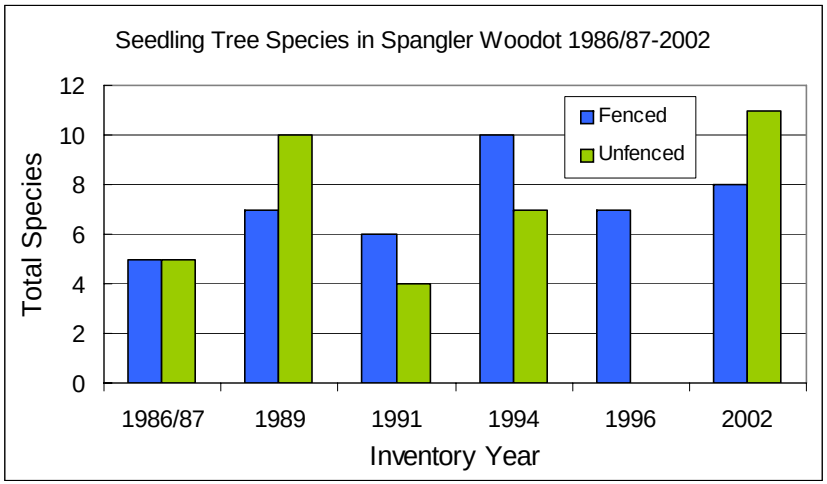


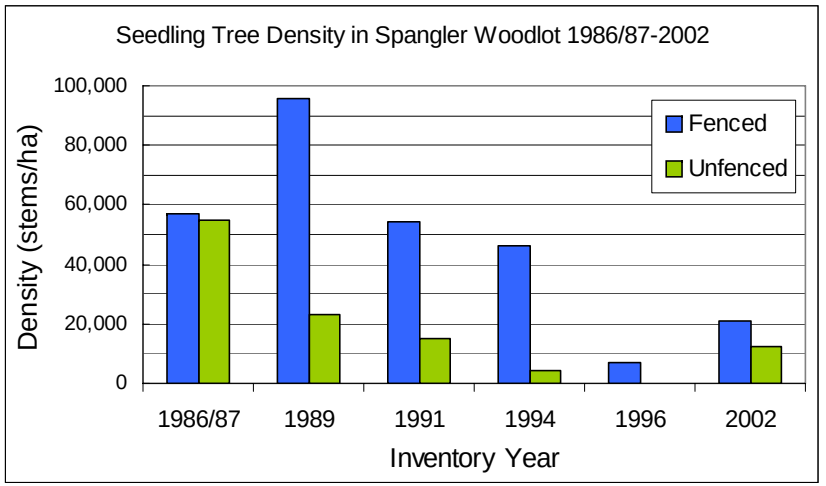
Figure 53. Density of seedling (≤150 cm in height) shrub species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Slyder woodlot, Gettysburg National Military Park, 1989 to 2002.

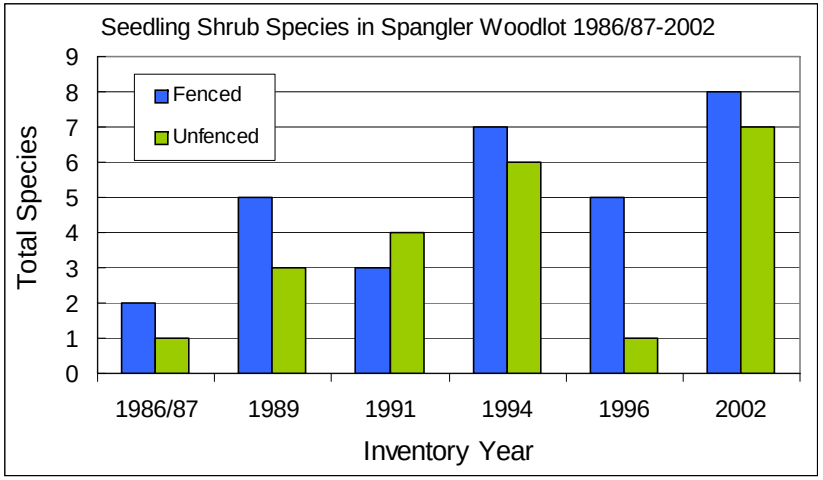
Spangler Woodlot: From 1986/87 to 2002 there was an overall decrease in seedling tree density in Spangler woodlot. Seedling tree density in the fenced plot was 57,000 stems/ha in 1986/87, peaked at 95,800 stems/ha in 1989, and then decreased to 20,700 stems/ha in 2002 (Figure 54). The lowest density (7,000 stems/ha) was recorded in 1996. In the unfenced plot, seedling tree density decreased steadily over time from 55,000 stems/ha in 1986/87 to 12,100 stems/ha in 2002. There were no seedling trees recorded in the unfenced plot in 1996. The density of seedling trees <26 cm in height in the fenced plot decreased substantially over time, from 85,700 stems/ha in 1989 to 8,900 stems/ha in 2002, with the lowest density recorded at 1,600 stems/ha in 1996 (Figure 55). The density of seedling trees <26 cm in height in the unfenced plot exhibited a similar trend, with densities that decreased from 22,800 stems/ha in 1989 to 0 stems/ha in 1996, and then increased to 10,300 stems/ha in 2002. For seedling trees ≥26 cm in height in the fenced plot, the density remained fairly consistent between the 1989 to 2002 inventories, with 10,100 and 11,800 stems/ha. There were no seedling trees ≥26 cm in height recorded in the unfenced plot in 1991, 1994, or 1996, but there were 1,800 stems/ha in 2002 (Figure 55). Seedling tree diversity increased over time, unlike the density. Between 1986/87 and 2002, the seedling tree diversity went from five to eight species in the fenced plot and from five to eleven species in the unfenced plot (Figure 54).

The general trend from 1986/87 to 2002 was an increase in seedling shrub density. The seedling shrub density increased from 4,000 to 18,900 stems/ha in the fenced plot between 1986/87 and 2002, with the lowest density (1,200 stems/ha) recorded in 1996. A similar trend was evident in the unfenced plot data, where the seedling shrub density went increased from 750 to 11,100 stems/ha between 1986/87 and 2002 (Figure 54). Unlike any other woodlot, the 2002 seedling shrub densities in both the fenced and unfenced plots were greater than in any other inventory year (Figure 56). In the fenced plot, the density of seedling shrubs <26 cm in height oscillated between inventories, but there was an overall increase in density from 3,200 to 7,000 stems/ha between 1989 and 2002 (Figure 56). Similarly, the density of seedling shrubs ≥26 cm in height in the fenced plot increased from 700 to 11,900 stems/ha between 1989 and 2002. There was a more subtle increase in the density of seedling shrubs <26 cm in height in the unfenced plot from 2,200 to 2,900 stems/ha between 1989 and 2002 (Figure 56). However, the density of seedling shrubs ≥26 cm in height in the unfenced plot increased from zero to 8,200 stems/ha between 1989 and 2002. From 1986/87 to 2002, the diversity of seedling shrub species increased from two to eight species in the fenced plot, and from one to seven species in the unfenced plot (Figure 54).

From 1996 to 2002, there were increases in seedling tree and shrub densities in the fenced and unfenced plots. After the implementation of the Deer Management Program in 1995, the density of seedling trees <26 cm in height in the unfenced plot increased substantially from 0 to 10,300 stems/ha between 1996 and 2002 (Figure 55). The density of seedling trees ≥26 cm in height in the unfenced plot increased from 0 to 1,800 stems/ha during the same time period. The Spangler woodlot is an area where the Deer Management Program has been noticeably effective. Seedling shrub densities for the <26 cm and ≥26 cm height classes in the unfenced plot increased from 0 and 1,000 stems/ha, respectively, in 1996, to 2,900 and 8,200 stems/ha, respectively, in 2002 (Figure 56).







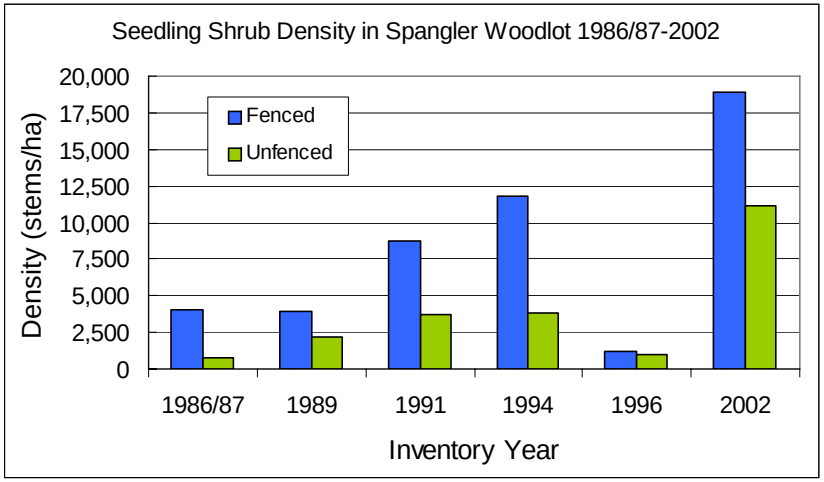


Figure 54. Number of species and density of seedling (≤150 cm in height) tree and shrub species by inventory year in the fenced and unfenced 10 x 10 m Demonstration Plots in Spangler woodlot, Gettysburg National Military Park, 1986/87 to 2002.

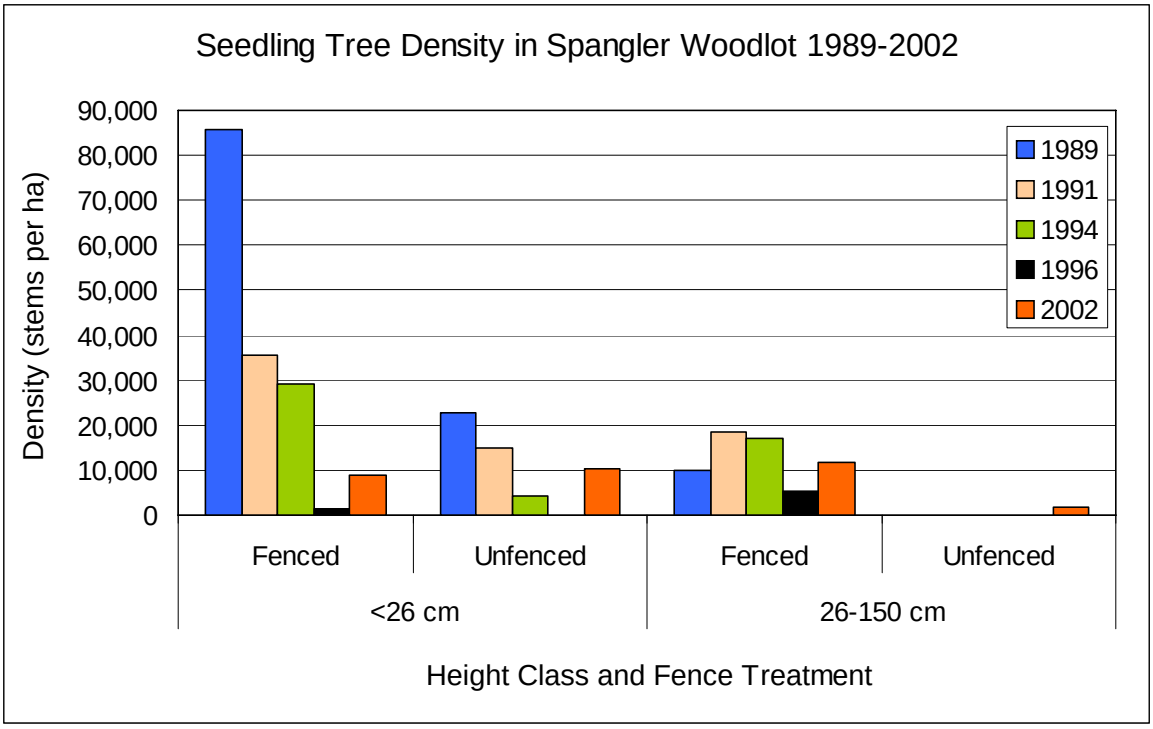


Figure 55. Density of seedling (≤150 cm in height) tree species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Spangler woodlot, Gettysburg National Military Park, 1989 to 2002.

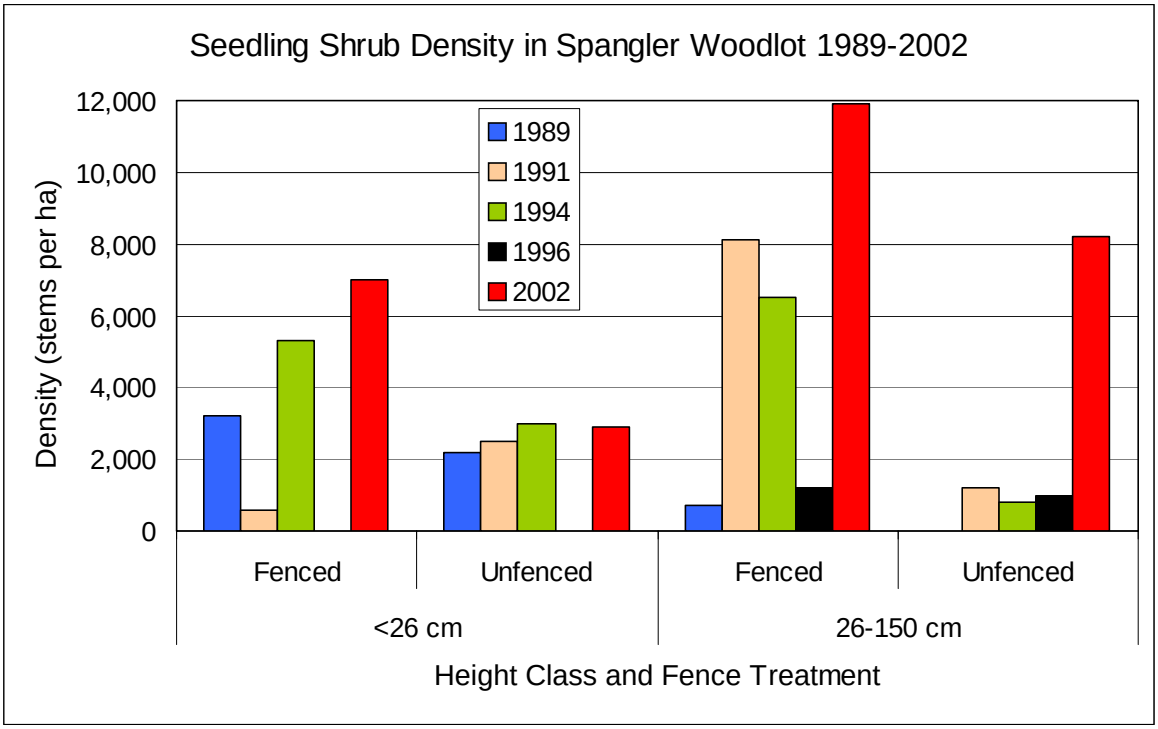


Figure 56. Density of seedling (≤150 cm in height) shrub species by height class and fence treatment in the 10 x 10 m Demonstration Plots in Spangler woodlot, Gettysburg National Military Park, 1989 to 2002.

Results

Biesecker Woodlot (Combined Fenced and Unfenced Data)

The combined data results were based on data from 30 plots. None of the overstory plots and none of the sapling plots were fenced to exclude white-tailed deer. However, 15 of the plots had seedling subplots unfenced and 15 of the plots had seedling subplots fenced to exclude white-tailed deer.

Tree Species:
Overstory: In 2002, twenty tree species were inventoried in the overstory (>1.5 m in height and ≥12 cm dbh) with a density of 328 stems/ha, an average dbh of 22.7 cm, and a basal area of 26.48 m^2 per ha (Table 22). Overstory trees accounted for 37% of all tree stems >1.5 m height (Figure 57). The species with the greatest density (represented by percent of total overstory density) were white oak (21%), northern red oak (20%), shagbark hickory (18%), pignut hickory (13%), and sweet cherry (7%) (Figure 58, Table 23). The species with the greatest basal area were white oak (54%), northern red oak (20%), shagbark hickory (9%), pignut hickory (7%), and black cherry (2%) (Table 23). The remaining fifteen species of trees accounted for 8% of the total basal area. The overstory density and basal area values would place the Biesecker woodlot in the 94% stocking level (Roach and Gingrich 1962).

Large Sapling: In 2002, fourteen tree species were inventoried in the large sapling (>1.5 m in height and 2-11.9 cm dbh) category. The density was 552 stems/ha, with an average dbh of 7.3 cm, and a basal area of 2.24 m^2 per ha (Table 22). Large sapling density was mostly comprised of pignut hickory (37%), shagbark hickory (26%), black cherry (10%), white oak (9%), and sweet cherry (7%) (Table 24, Figure 58). The remaining nine species of trees accounted for 10% of the total density.

Small Sapling: Six tree species were inventoried in the small sapling (>1.5 m in height and <2 cm dbh) category in 2002. The density was 15 stems/ha, with an average dbh of 1.3 cm, and a basal area of 0.0021 m^2 per ha (Table 22). Small sapling density was comprised of black cherry (27%), pignut hickory (20%), shagbark hickory (20%), mockernut hickory (13%), ash (13%), and sweet cherry (7%) (Table 25, Figure 58). No oaks were recorded in the 2002 inventory.

Seedling: Thirteen species of trees were inventoried in the seedling (≤150 cm in height) category in 2002. The seedling tree density was 18,892 stems/ha (Table 26). Combined black cherry and sweet cherry density was 8,889 stems/ha or 47% of the total density (Figure 59). Oaks totaled 5,695 stems/ha or 30% of the total seedling tree density. Hickory accounted for 7% of the total density, while the remaining six trees accounted for 16% combined.

Shrub Species:
Overstory: There were no overstory-size species of shrubs inventoried in 2002.

Large Sapling: In 2002, three shrub species were inventoried in the large sapling category. Their combined density was 57 stems/ha, with an average dbh of 5.7 cm, and a basal area of 0.18 m^2 per ha (Tables 22 and 24). Large sapling density was comprised of smooth blackhaw (54%), serviceberry (40%), and flowering dogwood (6%) (Figure 60).

Small Sapling: Four shrub species were inventoried in the small sapling category in 2002. The density was 136 stems/ha, with an average dbh of 0.8 cm, and a basal area of 0.0053 m^2 per ha (Tables 22 and 25). Small sapling density was comprised of multiflora rose (57%), *Rubus* (27%), Japanese barberry (10%), and smooth blackhaw (6%) (Figure 60).

Seedling: Six species of shrubs were inventoried in the seedling category. In 2002, the seedling shrub density was 27,222 stems/ha (Table 26). *Rubus* were dominant, comprising 59% of the total, while smooth blackhaw and Japanese barberry were 18% and 14%, respectively, of the total seedling shrub density. Serviceberry, flowering dogwood, and multiflora rose collectively accounted for 8% of the total seedling shrub density (Figure 61).

Herbaceous and Vine Vegetation: Herbaceous plant and vine data showed an average total herbaceous coverage of 20% (Table 27). Forb coverage was greatest (15%), followed by vine and grass coverages (4% and 1%, respectively).

Table 22. Density, average diameter, and basal area for small sapling, large sapling, and overstory tree and shrub species in thirty 20 x 20 m Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.[a]

	Small Sapling[b]	Large Sapling[b]	Overstory[b]
Tree Species			
Density (stems/ha)	15.0	552.0	328.0
Average DBH (cm)	1.3	7.3	22.7
Basal Area (m^2/ha)	0.0021	2.24	26.48
Shrub Species			
Density (stems/ha)	136.0	57.0	0.0
Average DBH (cm)	0.8	5.7	0.0
Basal Area (m^2/ha)	0.0053	0.18	0.000

[a] Total area of 30 plots was 1.2 ha.
[b] Small saplings were stems >1.5 m in height and <2 cm dbh; large saplings were stems >1.5 m in height and 2-11.9 cm dbh; overstory were stems >1.5 m in height and ≥12 cm dbh.

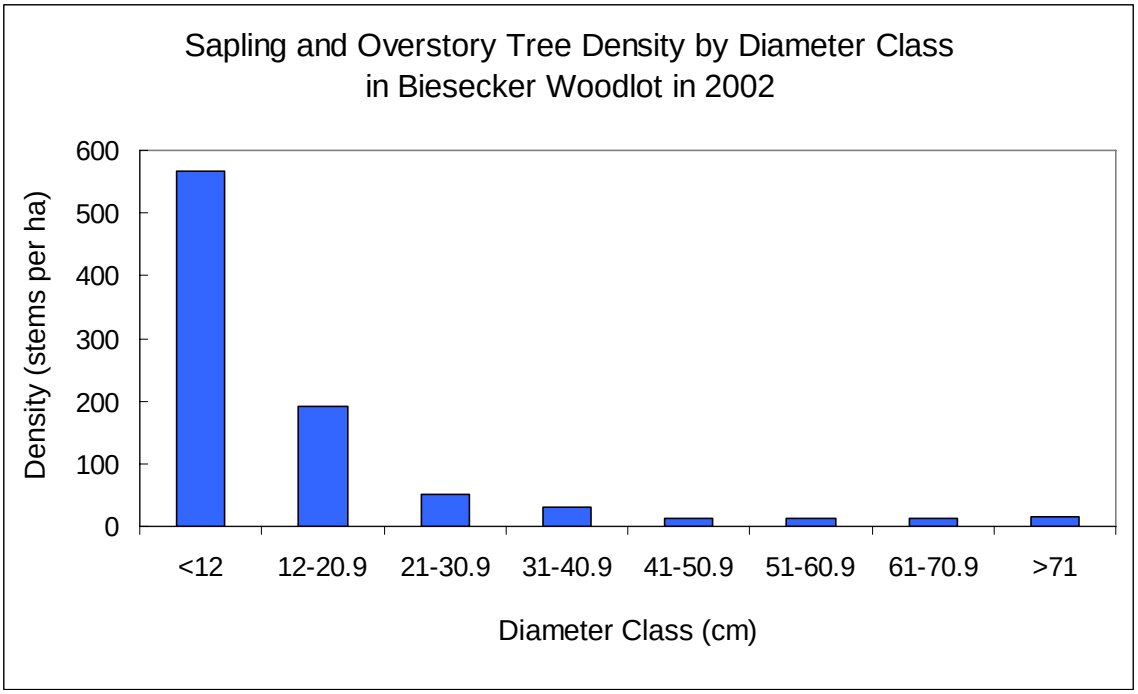


Figure 57. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) tree species by diameter class in thirty 20 x 20 m Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

Table 23. Density, average diameter, and basal area for overstory[a] tree and shrub species in thirty 20 x 20 m Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	4	21.6	0.17
Blackgum	1	12.4	0.01
Catalpa	3	18.4	0.09
Cedar, eastern red	4	16.9	0.10
Cherry, sweet	23	15.3	0.40
Cherry, black	21	17.2	0.56
Elm, American	5	15.7	0.10
Elm, slippery	4	26.9	0.28
Hickory, mockernut	14	16.9	0.28
Hickory, pignut	43	21.8	1.79
Hickory, shagbark	58	19.9	2.38
Maple, red	3	17.3	0.09
Maple, sugar	1	22.9	0.04
Oak, black	2	38.6	0.20
Oak, northern red	67	29.6	5.84
Oak, scarlet	3	22.5	0.12
Oak, white	68	43.7	13.90
Pine, eastern white	1	25.1	0.04
Pine, Virginia	1	37.6	0.09
Walnut, black	2	17.9	0.05
Total	328	22.7	26.48
Shrub Species – none			

[a] Overstory were stems >1.5 m in height and ≥12 cm dbh.
[b] Total area of 30 plots was 1.2 ha.

Table 24. Density, average diameter, and basal area for large sapling[a] tree and shrub species in thirty 20 x 20 m Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	4	3.5	0.01
Blackgum	2	7.1	0.01
Catalpa	3	5.9	0.01
Cedar, eastern red	6	8.0	0.04
Cherry, sweet	39	8.5	0.26
Cherry, black	54	7.4	0.26
Elm, American	6	7.2	0.03
Elm, slippery	3	7.1	0.01
Hickory, mockernut	29	7.9	0.17
Hickory, pignut	203	6.1	0.70
Hickory, shagbark	142	6.1	0.48
Maple, red	2	10.5	0.02
Oak, northern red	8	8.9	0.06
Oak, white	51	7.5	0.23
Total	552	7.3	2.24
Shrub Species			
Blackhaw, smooth	31	5.1	0.07
Dogwood, flowering	3	4.8	0.01
Serviceberry	23	7.3	0.11
Total	57	5.7	0.18

[a] Large saplings were stems >1.5 m in height and 2-11.9 cm dbh.
[b] Total area of 30 plots was 1.2 ha.

Table 25. Density, average diameter, and basal area for small sapling[a] tree and shrub species in thirty 20 x 20 m Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	2	1.2	0.0003
Cherry, sweet	1	1.0	0.0001
Cherry, black	4	1.3	0.0006
Hickory, mockernut	2	1.4	0.0003
Hickory, pignut	3	1.7	0.0004
Hickory, shagbark	3	1.0	0.0005
Total	15	1.3	0.0021
Shrub Species			
Barberry, Japanese	13	0.9	0.0008
Blackhaw, smooth	8	1.1	0.0008
Rose, multiflora	78	0.7	0.0031
Rubus	37	0.5	0.0007
Total	136	0.8	0.0053

[a] Small saplings were stems >1.5 m in height and <2 cm dbh.
[b] Total area of 30 plots was 1.2 ha.

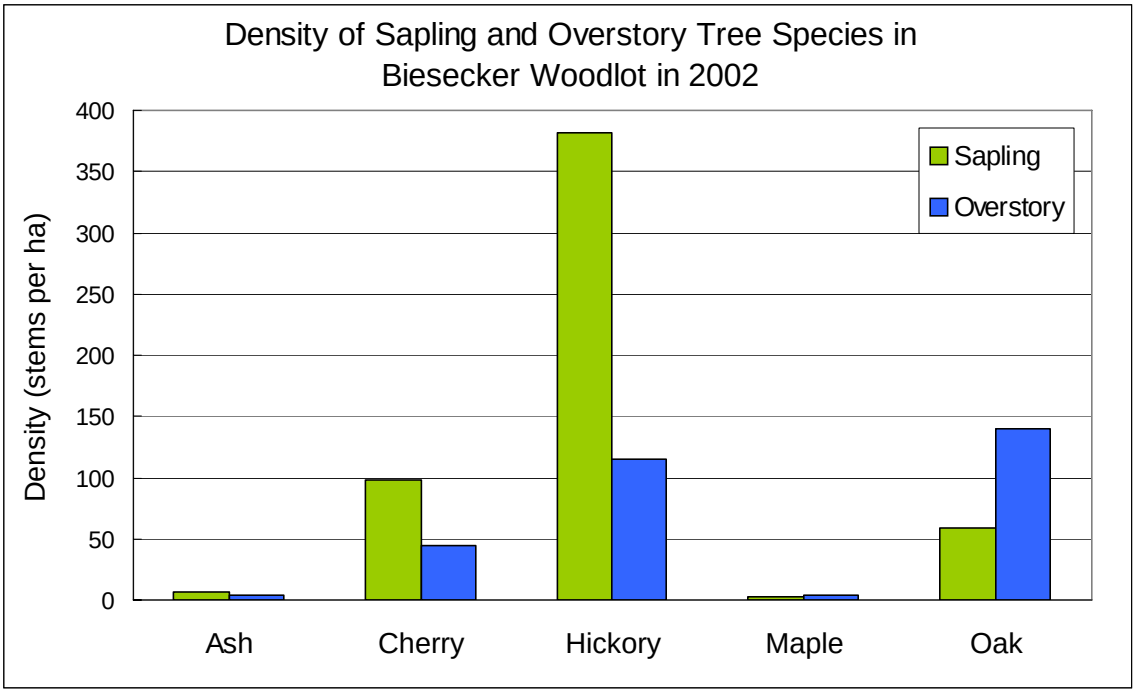


Figure 58. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) selected tree species in thirty 20 x 20 m Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

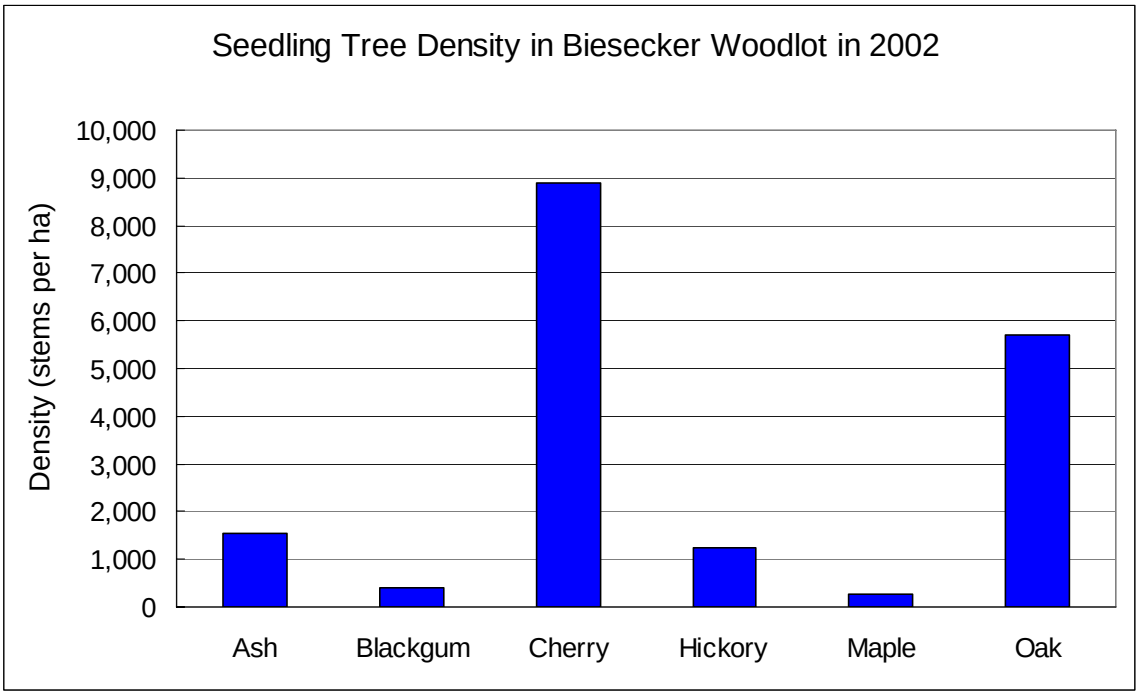


Figure 59. Density of seedling (≤150 cm height) selected tree species in eighteen 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

Table 26. Density of seedling[a] tree and shrub species in eighteen 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)
Tree Species	
Ash	1,528
Blackgum	417
Cedar, eastern red	556
Cherry, sweet	2,083
Cherry, black	6,806
Elm, American	139
Hickory, mockernut	556
Hickory, pignut	139
Hickory, shagbark	556
Maple, red	278
Oak, northern red	278
Oak, white	5,417
Yew	139
Total	18,892
Shrub Species	
Barberry, Japanese	3,888
Blackhaw, smooth	5,000
Dogwood, flowering	139
Rose, multiflora	278
Rubus	16,111
Serviceberry	1,806
Total	27,222

[a] Seedlings with stems ≤150 cm in height.
[b] Total area of 18 subplots was 0.0072 ha.

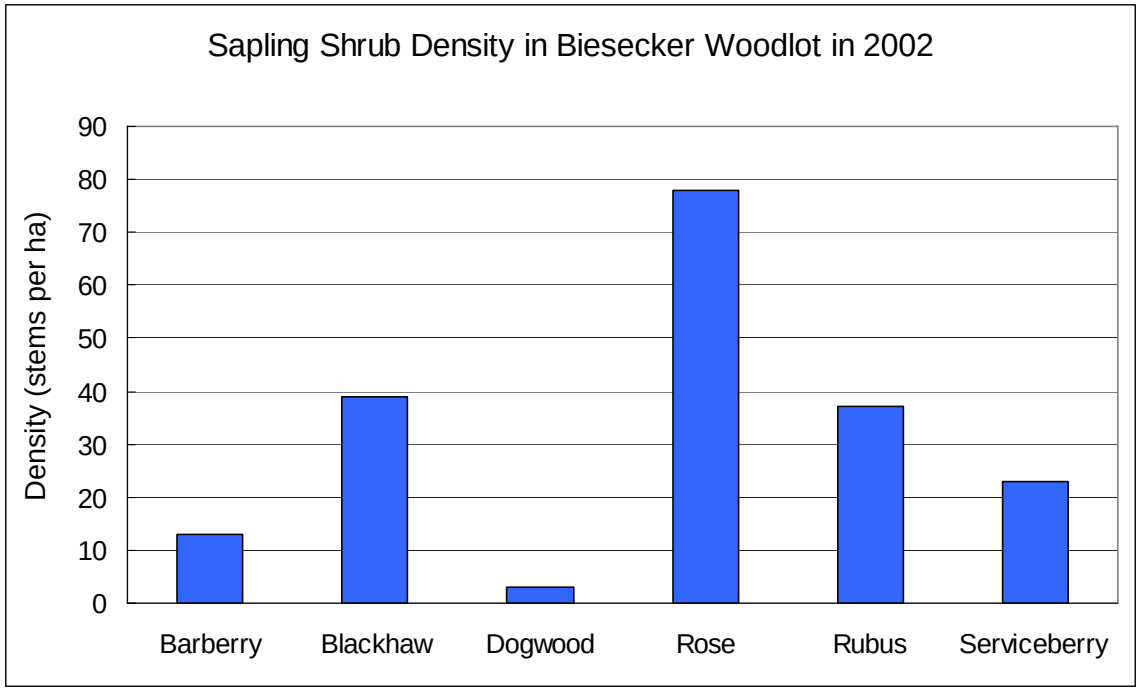


Figure 60. Density of sapling (>1.5 m in height and <12 cm dbh) shrub species in thirty 20 x 20 m Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

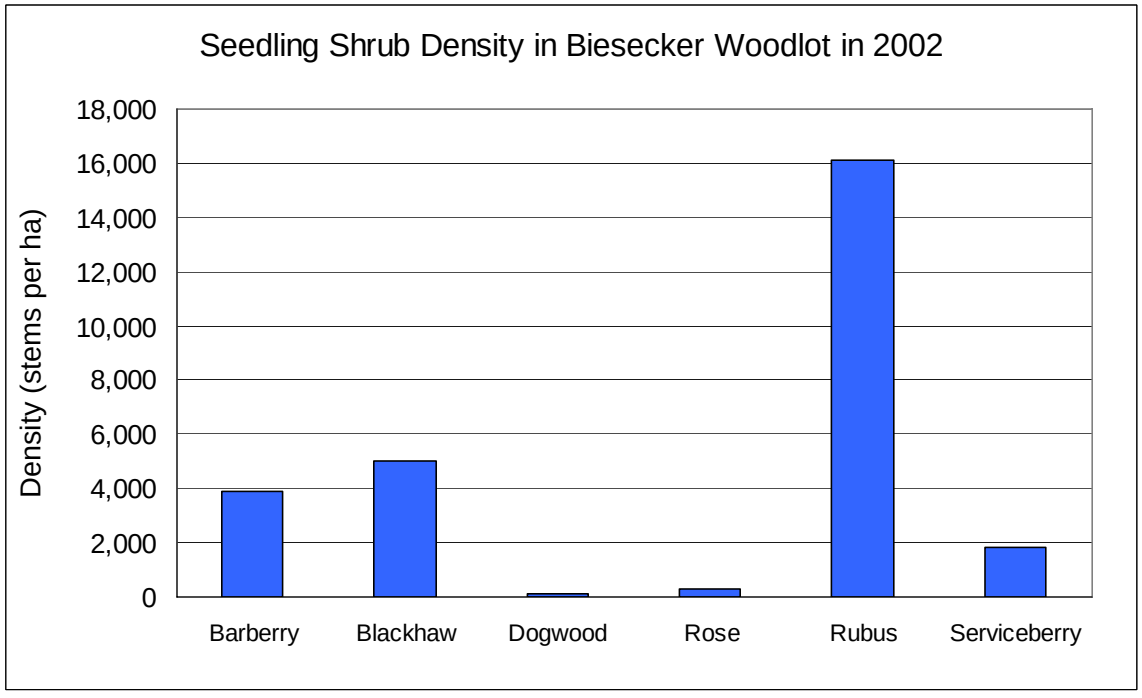


Figure 61. Density of seedling (≤150 cm height) shrub species in eighteen 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

Table 27. Average coverage for grass, forb, vine, and total species in thirty 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.[a]

	Average Coverage (%)
Grass	1
Forb	15
Vine	4
Total	20

[a] Total area of 30 subplots was 0.012 ha.

Biesecker Woodlot (Fenced and Unfenced Seedling and Herbaceous Comparisons)

Tree Species:
Seedling: In 2002, the density of seedling trees in the fenced subplots (24,791 stems/ha) was 3.5 times greater than in the unfenced subplots (7,084 stems/ha) (Table 28). Species diversity was also substantially greater in fenced subplots (13 species) than in the unfenced subplots (4 species). Analysis indicated that seedling tree density was significantly different between fence treatments and that there was a significant interaction between woodlot and fence treatment. Overall, the density of seedling trees in fenced subplots was significantly different that in the unfenced subplots. The density of seedling trees in Biesecker fenced subplots was significantly different than in Biesecker unfenced subplots.

Blackgum, eastern red cedar, American elm, pignut hickory, shagbark hickory, northern red oak, white oak, red maple, and yew were recorded in the fenced subplots, but were not present in any unfenced subplots. White oak and black cherry were the dominant trees in the fenced subplots, accounting for 33 and 32%, respectively, of total seedling density (Figure 62, Table 28). Sweet cherry (9%) and ash (8%) contributed greater numbers of seedlings to the total density than the remaining nine species of trees. In the unfenced subplots, black cherry was the dominant species, accounting for 65% of the total seedling density, while sweet cherry comprised 24% of the density.

Shrub Species:
Seedling: The seedling shrub density in the fenced subplots was 33,124 stems/ha for six species, and in the unfenced subplots was 15,417 stems/ha for four species (Table 28). *Rubus* were dominant (20,625 stems/ha) in the fenced subplots, accounting for 62% of the seedling shrub density (Figure 63). Smooth blackhaw was also prevalent (7,291 stems/ha) comprising 22% of the density. Flowering dogwood and multiflora rose were present in the fenced subplots, but were absent in the unfenced subplots. Japanese barberry (7,500 stems/ha) and *Rubus* (7,083 stems/ha) were co-dominant in the unfenced subplots. Analysis of all the seedling shrub data indicated a significant interaction between woodlot and fence treatment. The density of seedling shrubs in the Biesecker fenced subplots was significantly different than in the Biesecker unfenced subplots.

Herbaceous and Vine Vegetation: In Biesecker woodlot, the average total herbaceous coverage in the fenced subplots was 25%, compared to 14% in the unfenced subplots (Table 29). Forb and vine coverages in the fenced subplots (20 and 4%, respectively) were greater than in the unfenced subplots (9 and 3%, respectively). Grass coverage was slightly greater in the unfenced subplots (2%) than in the fenced subplots (1%).

Analysis indicated that fence treatment was a significant predictor of total average herbaceous coverage in 2002. In Biesecker woodlot, the percent total coverage in the fenced subplots was significantly different than in the unfenced subplots. Analysis also indicated that woodlot, fence treatment, and the interaction between woodlot and fence treatment were significant predictors of average forb coverage. Biesecker fenced subplots had significantly different average forb coverage (20%) than in the unfenced subplots (9%) (Table 29).

Biesecker Fenced: Japanese honeysuckle (*Lonicera japonica*) had the greatest Importance Value (IV) in the 2002 survey with an IV of 128.0 (Table 30). Virginia-creeper (*Parthenocissus quinquefolia*) ranked second, and Enchanter's-nightshade (*Circaea lutetiana*) ranked third in IV in 2002. The Shannon Index value was 0.80 and the Evenness Index value was 0.65 in 2002 (Table 31).

Biesecker Unfenced-Control: Japanese honeysuckle had the greatest IV in 2002. Grass spp. (*Poaceae*) were ranked second, and spring-beauty was ranked third in 2002 (Table 32). The Shannon Index value was 0.78 in 2002, and the Evenness Index value was 0.65 (Table 31).

Biesecker Unfenced: Whereas Japanese honeysuckle dominated in the fenced and unfenced-control subplots, there was no dominant species in the unfenced subplots. Grass spp. was first rank IV in 2002. Japanese honeysuckle ranked second and sheep sorrel (*Rumex arcetosella*) ranked third in IV in 2002 (Table 33). The Shannon Index value was 1.06, and the Evenness Index value was 0.80 in 2002 (Table 31).

Table 28. Density of seedling[a] tree and shrub species by fence treatment[b] in eighteen 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.[c]

	Fenced Treatment Density (stems/ha)	Unfenced Treatment Density (stems/ha)
Tree Species		
Ash	2,083	417
Blackgum	625	0
Cedar, eastern red	833	0
Cherry, sweet	2,292	1,667
Cherry, black	7,917	4,583
Elm, American	208	0
Hickory, mockernut	625	417
Hickory, pignut	208	0
Hickory, shagbark	833	0
Oak, northern red	417	0
Oak, white	8,125	0
Maple, red	417	0
Yew	208	0
Total	24,791	7,084
Shrub Species		
Barberry, Japanese	2,083	7,500
Blackhaw, smooth	7,291	417
Dogwood, flowering	208	0
Rose, multiflora	417	0
Rubus	20,625	7,083
Serviceberry	2,500	417
Total	33,124	15,417

[a] Seedlings were stems ≤150 cm in height.
[b] Twelve plots contained a 3 x 3 m square and 1.8 m high fence, enclosing the 2 x 2 m subplot.
[c] Total area of 18 subplots was 0.0072 ha.; fenced treatment had 0.0048 ha and the unfenced treatment had 0.0024 ha.

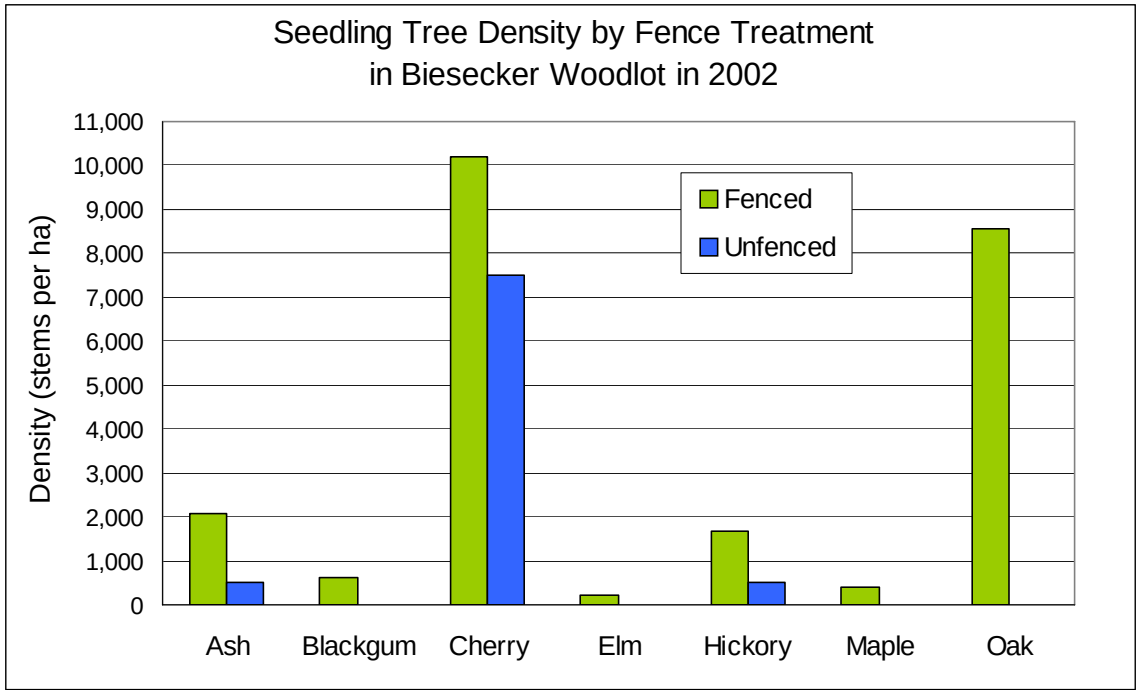


Figure 62. Density of seedling (≤150 cm height) tree species in twelve fenced and six unfenced 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

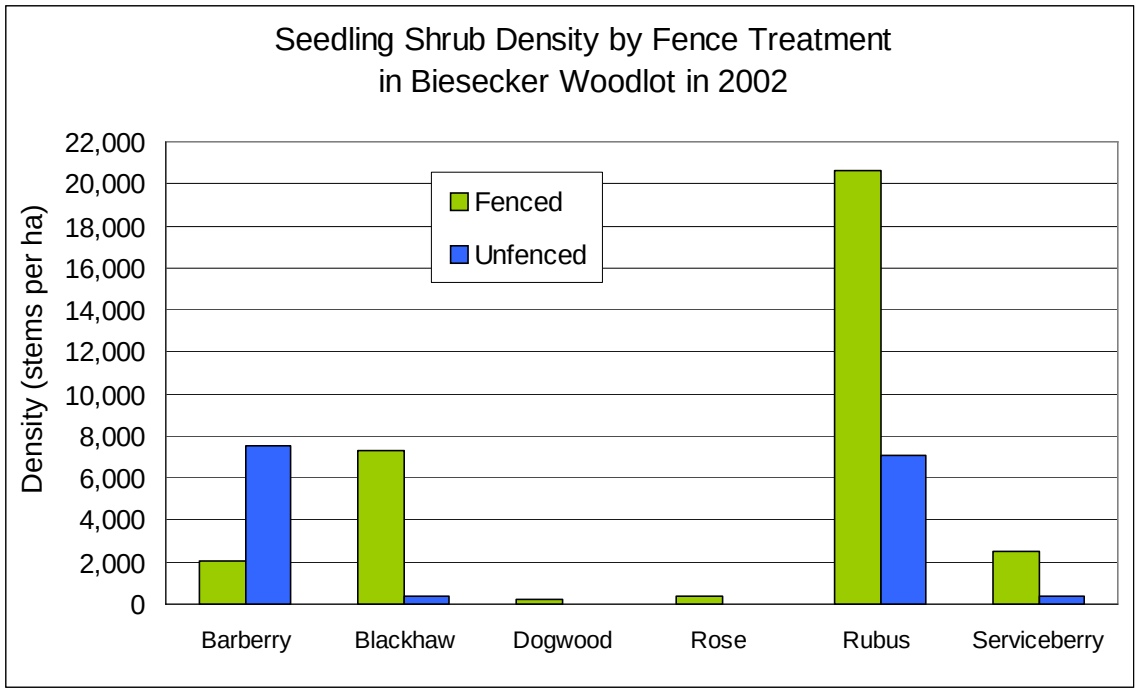


Figure 63. Density of seedling (≤150 cm height) shrub species in twelve fenced and six unfenced 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.

Table 29. Average coverage for grass, forb, vine, and total species by fence treatment[a] in thirty 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 2002.[b]

	Fenced Treatment Average Coverage (%)	Unfenced Treatment Average Coverage(%)
Grass	1	2
Forb	20	9
Vine	4	3
Total	25	14

[a] Fifteen plots in the fenced treatment contained a 3 x 3 m square 1.8 m high fence, enclosing the 2 x 2 m subplot.
[b] Total area of 30 subplots was 0.012 ha, each fence treatment having 0.006 ha.

Table 30. Comparison of the Importance Values (IV) of herbaceous and vine species with the ten greatest IVs in the fenced 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 1992 to 2002. The IVs were calculated from line transect data[a].

1992		1995		2002	
Species	IV	Species	IV	Species	IV
Japanese honeysuckle	76.5	Japanese honeysuckle	86.4	Japanese honeysuckle	128.0
Spring-beauty	58.7	Spring-beauty	58.9	Virginia-creeper	42.7
Cinquefoil	32.2	Grass spp.	30.9	Enchanter's-nightshade	33.6
Sedge spp.	31.4	Jewelweed	28.7	Spring-beauty	22.7
Composite spp.	22.3	Enchanter's-nightshade	17.1	Grass spp.	20.2
Jewelweed	14.0	Virginia-creeper	14.6	Garlic-mustard	16.0
Virginia-creeper	13.7	Composite spp.	13.4	Jewelweed	13.1
Grass spp.	11.4	Cut-leaved toothwort	8.4	Wild licorice	4.1
Wild onion spp.	7.9	Wild licorice	7.2	Cinquefoil	3.9
Garlic-mustard	6.9	Sedge spp.	6.0	Cleavers	3.9

[a] Data were collected in two 0.981 m2 quadrants in the 2 x 2 m subplot.

Table 31. Shannon Diversity Index and Evenness Index values for herbaceous and vine species in the fenced and unfenced 2 x 2 m subplots within the Long-term Monitoring Plots and unfenced-control 2 x 2 m subplots in Biesecker, Bushman Hill, Herr Ridge, Pitzer, and Powers Hill woodlots, Gettysburg National Military Park. Values were calculated from line transect data collected in 1992, 1995[a] and 2002 (Brower et al. 1990).

	Shannon Diversity Index			Evenness Index		
	1992	1995	2002	1992	1995	2002
Biesecker						
Fenced	1.02	0.96	0.80	0.76	0.74	0.65
Unfenced-controls	0.82	0.86	0.78	0.62	0.68	0.65
Unfenced	0.93	0.78	1.06	0.79	0.63	0.80
Bushman Hill						
Unfenced	1.12	1.07	1.14	0.74	0.70	0.77
Herr Ridge	0.91	0.93	0.81	0.77	0.73	0.69
Pitzer						
Fenced	—	1.11	1.09	—	0.80	0.78
Unfenced-controls	—	0.87	1.08	—	0.76	0.76
Unfenced	—	0.83	0.88	—	0.68	0.69
Powers Hill						
Unfenced	0.97	1.25	0.97	0.77	0.77	0.70

[a]All data were obtained during the spring season except for Pitzer 1995, which was collected during the summer.

Table 32. Comparison of Importance Values (IV) of the herbaceous and vine species with the ten greatest IVs in the unfenced-control 2 x 2 m subplots in Biesecker woodlot, Gettysburg National Military Park, 1992 to 2002. The IVs were calculated from line transect data[a].

1992		1995		2002	
Species	IV	Species	IV	Species	IV
Spring-beauty	89.6	Spring-beauty	86.0	Japanese honeysuckle	136.7
Japanese honeysuckle	86.5	Japanese honeysuckle	66.5	Grass spp.	39.3
Grass spp.	38.3	Garlic-mustard	31.2	Spring-beauty	29.8
Composite spp. 1	13.3	Wild licorice	25.4	Enchanter's-nightshade	23.3
Enchanter's-nightshade	9.9	Enchanter's-nightshade	25.2	Garlic-mustard	16.0
Wild licorice	9.1	Smartweed spp.	16.7	Wild licorice	15.6
False nettle	8.9	Composite spp. 1	15.9	Jewelweed	9.9
Smartweed spp.	7.6	Grass spp.	14.8	Virginia-creeper	9.0
Bedstraw spp.	7.5	White-snakeroot	4.8	Goldenrod spp.	4.8
Composite spp. 2	5.8	Cut-leaved toothwort	3.8	Cut-leaved toothwort	4.8

[a] Data were collected in two 0.981 m2 quadrants in the 2 x 2 m subplot.

Table 33. Comparison of the Importance Values (IV) of the herbaceous and vine species with the ten greatest IVs in the unfenced 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 1992 to 2002. The IVs were calculated from line transect data[a].

1992		1995		2002	
Species	IV	Species	IV	Species	IV
Sedge (C. complanata)	64.0	Spring-beauty	90.1	Grass spp.	59.0
Cinquefoil	44.6	Grass spp.	72.6	Japanese honeysuckle	39.8
Spring-beauty	30.9	Enchanter's-nightshade	34.4	Sheep sorrel	25.8
Japanese honeysuckle	29.7	Sedge spp.	26.9	Spring-beauty	24.7
Enchanter's-nightshade	26.2	Cinquefoil	14.4	Cut-leaved toothwort	23.6
Grass spp.	22.2	Composite spp. 1	9.4	Enchanter's-nightshade	23.4
Smartweed spp.	19.8	Sheep sorrel	9.3	Cinquefoil	18.0
Composite spp. 2	18.8	Wild licorice	9.1	Common blue violet	17.5
Wild licorice	15.7	Japanese honeysuckle	9.1	Violet wood-sorrel	12.4
Sheep sorrel	15.3	Cut-leaved toothwort	7.8	Field pussytoes	12.2

[a] Data were collected in two 0.981 m2 quadrants in the 2 x 2 m subplot.

Bushman Hill Woodlot

Tree Species:
Overstory: In 2002, sixteen tree species were inventoried in the overstory with a density of 264 stems/ha, an average dbh of 27.3, and a basal area of 26.93 m^2 per ha (Table 34). Overstory trees accounted for 56% of all stems >1.5 m height and ≥12 cm dbh (Figure 64). The trees with the greatest density were white oak (27%), northern red oak (11%), black oak (9%), ash (9%), and mockernut hickory (7%) (Figure 65). The tree species in the overstory with the greatest basal area were white oak (46%), black oak (13%), northern red oak (11%), yellow poplar (*Liriodendron tulipifera*) (10%), and mockernut hickory (5%) (Table 35). The remaining eleven species of trees accounted for 15% of the basal area. The overstory density and basal area values would place the Bushman Hill woodlot in the 93% stocking level (Roach and Gingrich 1962).

Large Sapling: In 2002, fifteen species of trees were inventoried in the large sapling (>1.5 m in height and 2-11.9 cm dbh) category. The density was 171 stems/ha, with an average dbh of 7.9 cm, and a basal area of 0.91 m^2 per ha (Table 36). Large sapling density was mostly comprised of mockernut hickory (18%), shagbark hickory (13%), ash (13%), pignut hickory (11%), and American elm (10%) (Figure 65). The remaining ten species of trees accounted for 36% of the total density.

Small Sapling: Six tree species were inventoried in the small sapling (>1.5 m in height and <2 cm dbh) category in 2002. The density was 41 stems/ha, with an average dbh of 0.9 cm, and a basal area of 0.0030 m^2 per ha (Table 37). Small sapling density was comprised of ash (29%), slippery elm (24%), American elm (20%), *Ailanthus* (17%), black cherry (5%), and shagbark hickory (5%) (Figure 65). No oak species were recorded in the small sapling category in 2002.

Seedling: Fifteen species of trees were inventoried in the seedling category (≤150 cm in height) in 2002 with a density of 41,166 stems/ha (Table 38). Ash were the dominant species with 18,000 stems/ha, representing 44% of the total seedling density. Oaks totaled 8,333 stems/ha or 20% of the total seedling tree density (Figure 66). Cherry, red maple, and hickory species densities were each 9% of the total seedling density. The density of elm species accounted for 7% of the total. The remaining three species of trees were 2% of the total seedling density (Table 38).

Shrub Species:
Overstory: There were five shrub species inventoried in the overstory category in 2002. Their combined density was 14 stems/ha, with an average dbh of 16.0 cm, and a basal area of 0.22 m^2 per ha (Table 34). Sassafras was the most abundant species with five stems/ha or 36% of the total overstory shrub density. Flowering dogwood, smooth blackhaw, eastern redbud, and serviceberry accounted for 22, 14, 14, and 14%, respectively, of the total density (Table 35).

Large Sapling: In 2002, eleven species of shrubs were inventoried in the large sapling category. The density was 428 stems/ha, with an average dbh of 4.4 cm, and a basal area of 0.78 m^2 per ha (Tables 34 and 36). The majority of the large sapling density was comprised of eastern redbud (40%), smooth blackhaw (18%), witch hazel (17%), flowering dogwood (8%), and spicebush (5%) (Figure 67). The remaining six species of shrubs combined accounted for 12% of the total density.

Small Sapling: Nine shrub species were inventoried in the small sapling category. Their combined density was 1,814 stems/ha, with an average dbh of 0.9 cm, and a basal area of 0.1273 m^2 per ha (Table 37). The small sapling shrub density was comprised of eastern redbud (23%), multiflora rose (23%), spicebush (20%), *Rubus* (14%), Japanese barberry (11%), and autumn olive (6%) (Figure 67).

Seedling: In 2002, fourteen species of shrubs were inventoried in the seedling category. The seedling shrub density was 74,167 stems/ha (Table 38). *Rubus* were the dominant species comprising 25% of the total seedling shrub density. The other abundant species were eastern redbud (14%), multiflora rose (10%), and spicebush (9%) (Figure 68). The remaining ten species of shrubs collectively accounted for 14% of the total density.

Herbaceous and Vine Vegetation: Herbaceous plant and vine data collected in the seedling subplots showed an average total herbaceous coverage of 45% (Table 39). Forb coverage was greatest (34%), followed by vine and grass coverages (10% and 1%, respectively).

In 2002, the species with the greatest IV was Virginia-creeper (Table 40). Japanese honeysuckle was second-ranked in 2002. Naked-flowered tick-seed (*Desmodium nudiflorum*) ranked third. The Shannon Index value was 1.14 and the Evenness Index value was 0.77 in 2002 (Table 31).

Table 34. Density, average diameter, and basal area of small sapling, large sapling, and overstory tree and shrub species in thirteen 20 x 20 m Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.[a]

	Small Sapling[b]	Large Sapling[b]	Overstory[b]
Tree Species			
Density (stems/ha)	41.0	171.0	264.0
Average DBH (cm)	0.9	7.9	27.3
Basal Area (m^2/ha)	0.0030	0.91	26.93
Shrub Species			
Density (stems/ha)	1,814.0	428.0	14.0
Average DBH (cm)	0.9	4.4	16.0
Basal Area (m^2/ha)	0.1273	0.78	0.22

[a] Total area of 15 plots was 0.6 ha.
[b] Small saplings were stems >1.5 m in height and <2 cm dbh; large saplings were stems >1.5 m in height and 2-11.9 cm dbh; overstory were stems >1.5 m in height and ≥12 cm dbh.

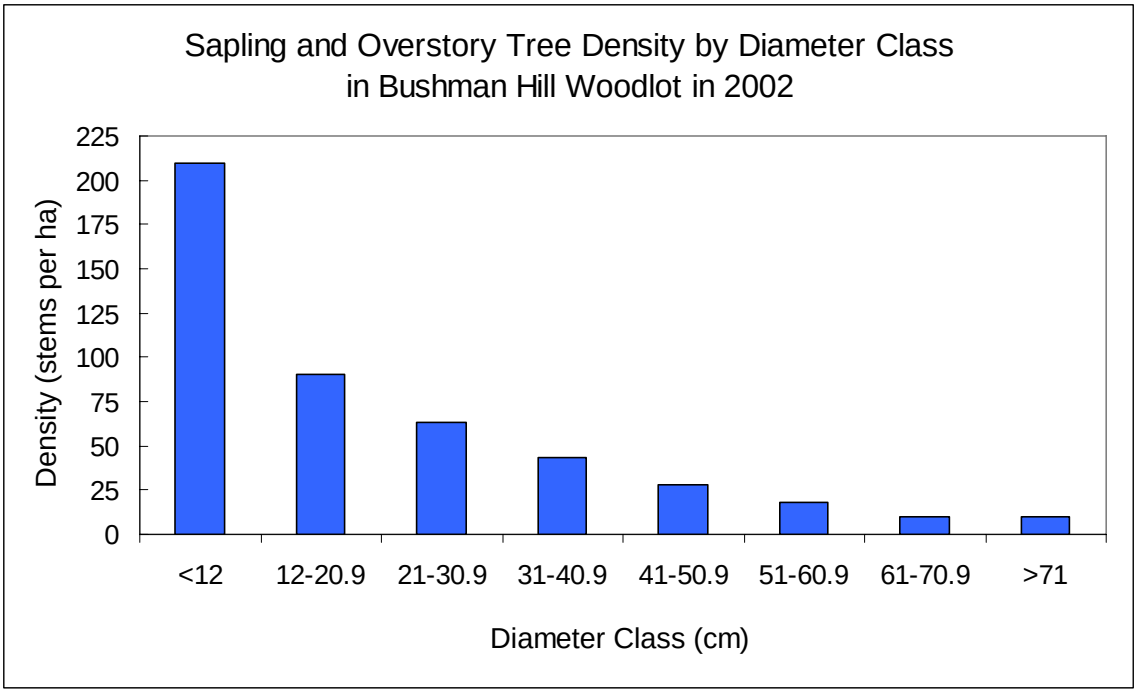


Figure 64. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) tree species by diameter class in fifteen 20 x 20 m Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

Table 35. Density, average diameter, and basal area of overstory[a] tree and shrub species in thirteen 20 x 20 m Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	23	18.3	0.60
Blackgum	15	25.6	0.81
Cedar, eastern red	10	18.3	0.28
Cherry, sweet	2	29.2	0.11
Elm, American	2	22.0	0.13
Hickory, mockernut	18	23.9	1.32
Hickory, pignut	12	27.3	0.78
Hickory, shagbark	10	20.6	0.26
Maple, red	8	16.3	0.14
Maple, sugar	12	17.5	0.25
Oak, black	23	42.1	3.57
Oak, chestnut	12	24.5	0.58
Oak, northern red	30	31.8	2.93
Oak, scarlet	2	31.8	0.13
Oak, white	70	44.4	12.41
Poplar, yellow	15	42.6	2.63
Total	264	27.3	26.93
Shrub Species			
Blackhaw, smooth	2	20.8	0.06
Dogwood, flowering	3	13.6	0.05
Redbud, eastern	2	13.5	0.02
Sassafras	5	14.4	0.05
Serviceberry	2	17.8	0.04
Total	14	16.0	0.22

[a] Overstory were stems >1.5 m in height and ≥12 cm dbh.
[b] Total area of 15 plots was 0.6 ha.

Table 36. Density, average diameter, and basal area of large sapling[a] tree and shrub species in thirteen 20 x 20 m Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	22	8.0	0.12
Blackgum	10	7.2	0.04
Cedar, eastern red	7	7.4	0.03
Cherry, sweet	10	8.9	0.07
Cherry, black	3	5.6	0.01
Elm, American	17	7.9	0.09
Elm, slippery	3	8.8	0.02
Hickory, mockernut	30	7.4	0.14
Hickory, pignut	18	7.3	0.08
Hickory, shagbark	22	6.9	0.10
Maple, red	12	8.3	0.08
Maple, sugar	8	8.7	0.07
Oak, chestnut	5	9.7	0.04
Oak, white	2	6.6	0.01
Walnut, black	2	9.1	0.01
Total	171	7.9	0.91
Shrub Species			
Autumn Olive	8	2.6	0.01
Barberry, Japanese	18	3.1	0.02
Blackhaw, smooth	78	5.3	0.20
Dogwood, flowering	35	5.8	0.11
Grape	8	2.7	0.01
Redbud, eastern	172	3.5	0.18
Rose, multiflora	3	2.5	0.02
Sassafras	3	10.2	0.03
Serviceberry	10	5.7	0.03
Spicebush	23	2.9	0.04
Witch hazel	72	4.5	0.13
Total	428	4.4	0.78

[a] Large saplings were stems >1.5 m in height and 2-11.9 cm dbh.
[b] Total area of 15 plots was 0.6 ha.

Table 37. Density, average diameter, and basal area of small sapling[a] tree and shrub species in thirteen 20 x 20 m Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ailanthus	7	1.0	0.0006
Ash	12	1.0	0.0009
Cherry, black	2	0.5	0.0000
Elm, American	8	1.0	0.0007
Elm, slippery	10	1.0	0.0007
Hickory, shagbark	2	1.0	0.0001
Total	41	0.9	0.0030
Shrub Species			
Autumn Olive	115	1.0	0.0099
Barberry, Japanese	208	0.9	0.0131
Blackhaw, smooth	7	0.8	0.0003
Honeysuckle, Tartarian	2	0.5	0.0000
Redbud, eastern	422	1.0	0.0392
Rose, multiflora	420	0.7	0.0176
Rubus	260	0.7	0.0133
Spicebush	357	1.1	0.0312
Witch hazel	23	1.2	0.0027
Total	1,814	0.9	0.1273

[a] Small saplings were stems >1.5 m in height and <2 cm dbh.
[b] Total area of 15 plots was 0.6 ha.

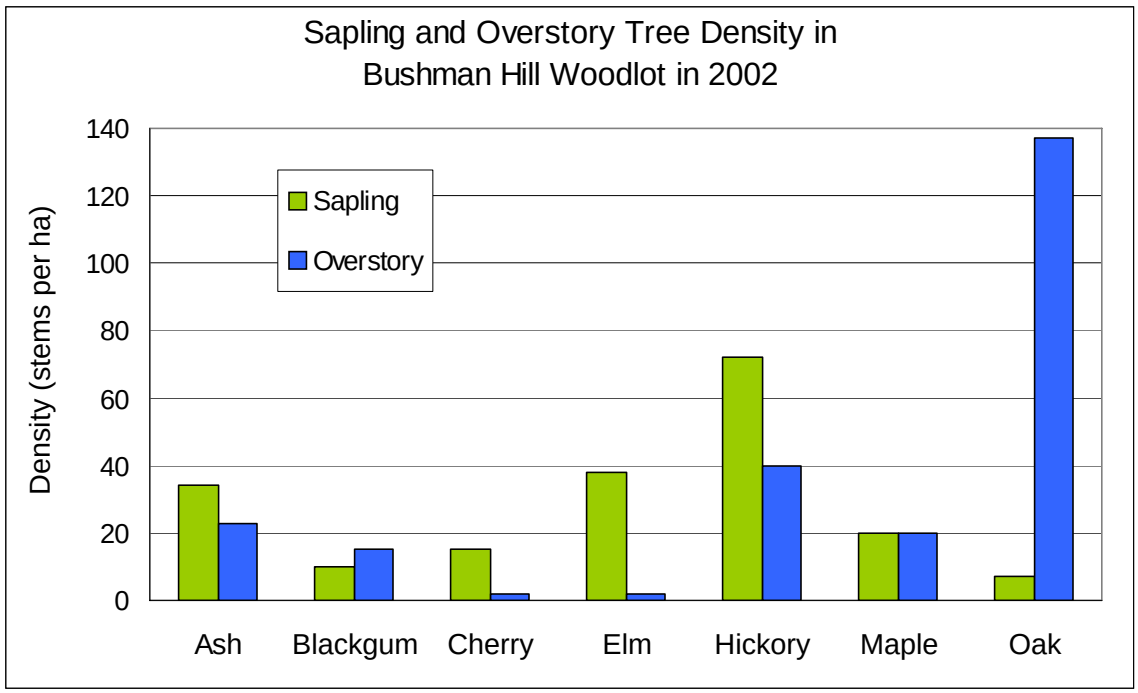


Figure 65. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) selected tree species in fifteen 20 x 20 m Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

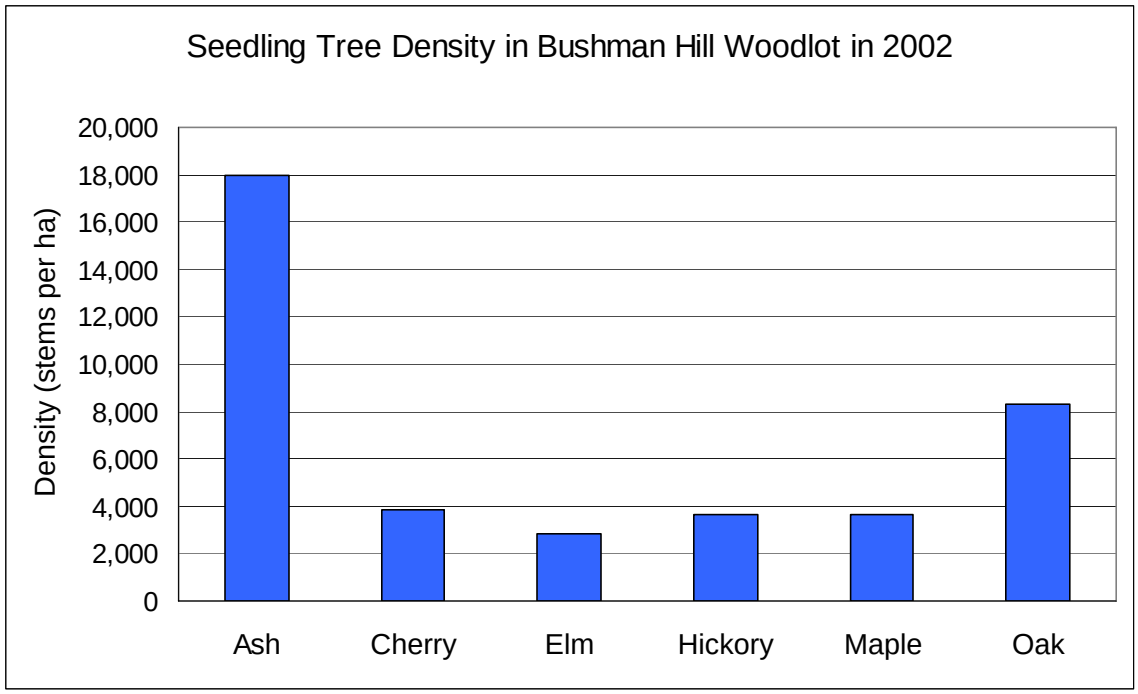


Figure 66. Density of seedling (≤150 cm in height) selected tree species in fifteen 2 x 2 m subplots within the Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

Table 38. Density of seedling[a] tree and shrub species in fifteen 2 x 2 m subplots within the Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)
Tree Species	
Ash	18,000
Birch	333
Blackgum	333
Cherry, black	2,667
Cherry, sweet	1,167
Elm, slippery	1,500
Elm, American	1,333
Hickory, mockernut	1,333
Hickory, pignut	1,833
Hickory, shagbark	500
Maple, red	3,667
Oak, black	1,000
Oak, northern red	333
Oak, white	7,000
Poplar, yellow	167
Total	41,166
Shrub Species	
Autumn olive	667
Barberry, Japanese	2,333
Blackhaw, smooth	2,333
Blueberry	1,167
Dogwood, flowering	667
Euonymus	1,333
Hazelnut	167
Redbud, eastern	10,333
Rose, multiflora	7,500
Rubus	18,500
Sassafras	667
Serviceberry	833
Spicebush	6,667
Witch hazel	167
Total	74,167

[a] Seedlings were stems ≤150 cm in height.
[b] Total area of 15 subplots was 0.006 ha.

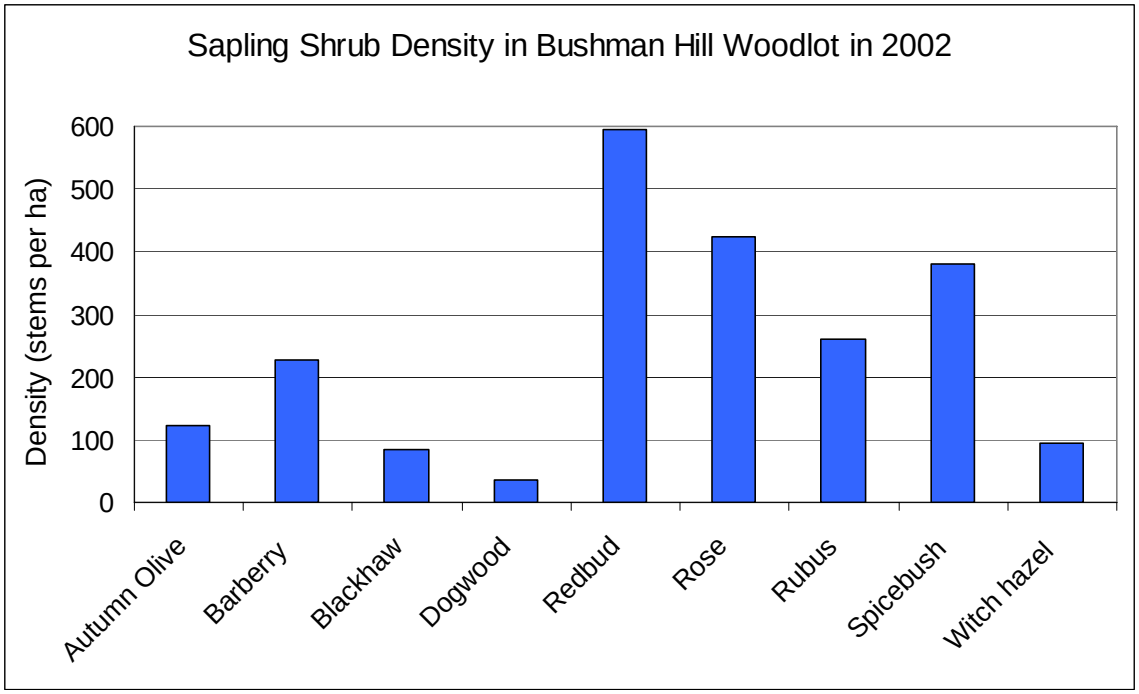


Figure 67. Density of sapling (>1.5 m in height and <12 cm dbh) shrub species in fifteen 20 x 20 m Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

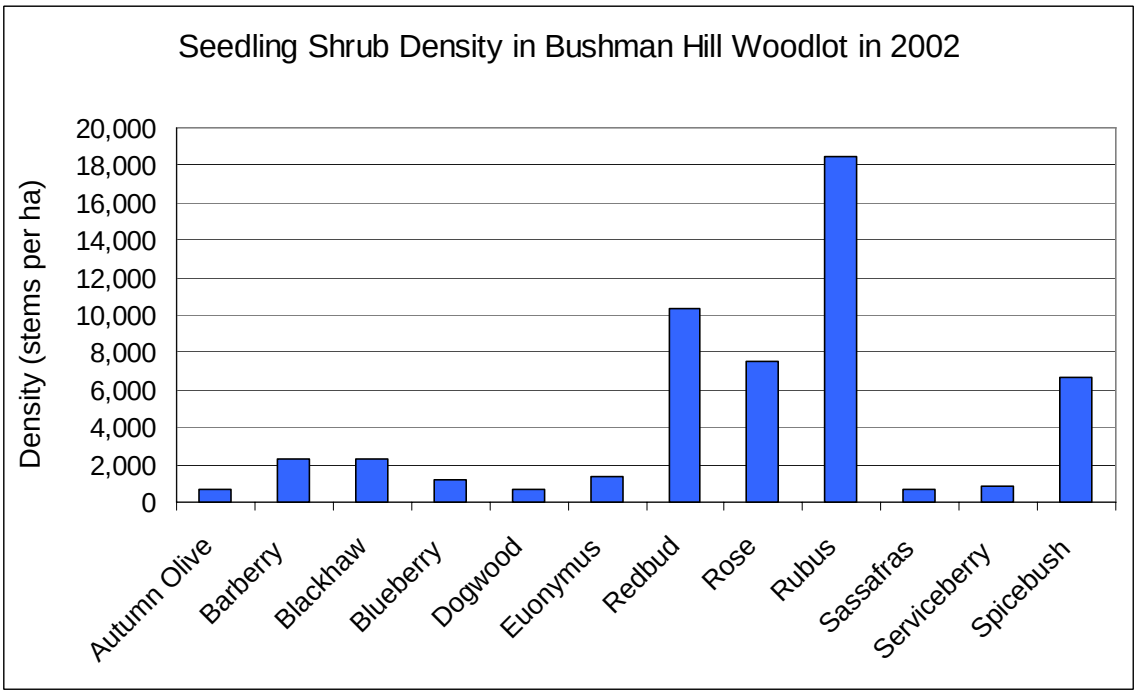


Figure 68. Density of seedling (≤150 cm in height) shrub species in fifteen 2 x 2 m subplots within the Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.

Table 39. Average coverage for grass, forb, vine, and total species in fifteen 2 x 2 m subplots within the Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 2002.[a]

	Average Coverage (%)
Grass	1
Forb	34
Vine	10
Total Species	45

[a] Total area of 15 subplots was 0.006 ha.

Table 40. Comparison of the Importance Values of herbaceous and vine species with the ten greatest IVs in the unfenced 2 x 2 m subplots within the Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 1992 to 2002. The IVs were calculated from line transect data[a].

1992		1995		2002	
Species	IV	Species	IV	Species	IV
Rough bedstraw	58.7	Grass spp.	49.1	Virginia-creeper	78.6
Japanese honeysuckle	43.7	Rough bedstraw	42.7	Japanese honeysuckle	56.9
Enchanter's-nightshade	20.8	Japanese honeysuckle	40.5	Naked-flowered tick-seed	20.4
Naked-flowered tick-seed	20.8	Naked-flowered tick-seed	22.5	Enchanter's-nightshade	16.0
Hog-peanut	17.1	Enchanter's-nightshade	22.0	Stiltgrass	15.1
Agrimony	17.0	Virginia-creeper	17.6	Poison-ivy	11.5
Virginia-creeper	15.5	Wild-comfrey	17.5	White-snakeroot	10.8
Cinquefoil	14.6	Jack-in-the-pulpit	16.7	Agrimony	10.8
Sedge spp.	14.3	Agrimony	13.9	Wild licorice	10.4
White-snakeroot	12.2	Wild licorice	11.0	Jack-in-the-pulpit	8.4

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

Herr Ridge Woodlot

Tree Species:
Overstory: In 2002, fourteen tree species were inventoried in the overstory category (>1.5 m in height and ≥12 cm dbh) with a density of 258 stems/ha, an average dbh of 23.5 cm, and a basal area of 23.38 m^2 per ha (Table 41). Twenty two percent of tree species >1.5 m in height were overstory trees (Figure 69). The species of trees with the greatest density were shagbark hickory (22%), white oak (17%), black cherry (14%), northern red oak (14%), and mockernut and pignut hickory (9% each) (Table 42). The remaining eight species of trees accounted for 17% of the total overstory density. Hickory, oak, cherry, and ash comprised 39, 31, 18, and 7%, respectively, of the total overstory density (Figure 70). The tree species with the greatest basal area were white oak and northern red oak, accounting for 42 and 32%, respectively, of the total basal area. Hickory and cherry represented 15% and 3%, respectively, of the total basal area. The remaining seven species of trees accounted for 8% of the basal area. The overstory density and basal area values would place the Herr Ridge woodlot in the 81% stocking level (Roach and Gingrich 1962).

Large Sapling: In 2002, fifteen tree species were inventoried in the large sapling (>1.5 m in height and 2-11.9 cm dbh) category. The density was 796 stems/ha, with an average dbh of 6.3 cm, and a basal area of 2.47 m^2 per ha (Tables 41 and 43). The large sapling density was comprised mostly of shagbark hickory (25%), black cherry (31%), pignut hickory (18%), mockernut hickory (11%), and ash (7%) (Figure 70). The remaining ten species of trees accounted for 8% of the total density. Oaks only accounted for 1% of the density.

Small Sapling: Nine species were inventoried in the small sapling (>1.5 m in height and <2 cm dbh) category in 2002. The density was 127 stems/ha, with an average dbh of 1.3 cm, and a basal area of 0.0171 m^2 per ha (Table 41). Cherry were the dominant species comprising 45% of the total density. The remaining density was disbursed between ash (21%), hickory (20%), and oak (14%) species (Table 44, Figure 70).

Seedling: Nine species of tree were recorded in the seedling category in 2002 with a density of 17,692 stems/ha (Table 45). Ash were the dominant species in the seedling category with a density of 10,962 stems/ha, representing 62% of the total seedling tree density (Figure 71). Cherry species density was 2,885 stems/ha, or 16% of the total density. The hickory species density was 2,308 stems/ha or 13% of the total. The remaining three species of trees, including white oak, accounted for 9% of the total seedling density.

Shrub Species:
Overstory: No shrub species were recorded in the overstory in Herr Ridge woodlot in the 2002 inventory (Table 41).

Large Sapling: In 2002, eight species of shrubs were inventoried in the large sapling category. Their combined density was 393 stems/ha, with an average dbh of 4.0 cm, and a basal area of 0.66 m^2 per ha (Tables 41 and 43). The majority of the large sapling density was comprised of smooth blackhaw (54%), eastern redbud (29%), serviceberry (8%), and flowering dogwood (4%) (Figure 72). The remaining four species of shrubs combined accounted for 5% of the total density.

Small Sapling: Nine shrub species were inventoried in the small sapling category in 2002. The density was 179 stems/ha, with an average dbh of 1.1 cm, and a basal area of 0.0022 m^2 per ha (Table 44). Smooth blackhaw was the dominant species, accounting for 65% of the total small sapling shrub

density (Figure 72). Multiflora rose and eastern redbud were 15 and 7%, respectively, of the total density. The remaining six species of shrubs comprised 13% of the total small sapling density.

Seedling: In 2002, eight species of shrubs were inventoried in the seedling category with a total density of 45,961 stems/ha (Table 45). *Rubus* were the dominant component of the seedling category, comprising 75% of the total density. The other abundant species were smooth blackhaw and eastern redbud with 18% and 2%, respectively, of the total seedling shrub density (Figure 73). Japanese barberry, *Euonymus*, grape, *Ribes*, and multiflora rose collectively accounted for 5% of the total seedling density.

Herbaceous and Vine Vegetation: Herbaceous and vine plant inventories showed an average total herbaceous coverage of 20% (Table 46). Forb coverage was greatest (17%), followed by vine and grass coverage (3 and 0%, respectively).

Enchanter's-nightshade had the greatest IV in 2002 (Table 47). Virginia-creeper was second-ranked and Japanese honeysuckle was third-ranked in 2002. The Shannon Index value was 0.81, and the Evenness Index value was 0.69 in 2002 (Table 31).

Table 41. Density, average diameter, and basal area of small sapling, large sapling, and overstory tree and shrub species in fifteen 20 x 20 m Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 2002.[a]

	Small Sapling[b]	Large Sapling[b]	Overstory[b]
Tree Species			
Density (stems/ha)	127.0	796.0	258.0
Average DBH (cm)	1.3	6.3	23.5
Basal Area (m^2/ha)	0.017	2.47	23.38
Shrub Species			
Density (stems/ha)	179.0	393.0	0.0
Average DBH (cm)	1.1	4.0	0.0
Basal Area (m^2/ha)	0.019	0.66	0.00

[a] Total area of 15 plots was 0.6 ha.
[b] Small saplings were stems >1.5 m in height and <2 cm dbh; large saplings were stems >1.5 m in height and 2-11.9 cm dbh; overstory were stems >1.5 m in height and ≥12 cm dbh.

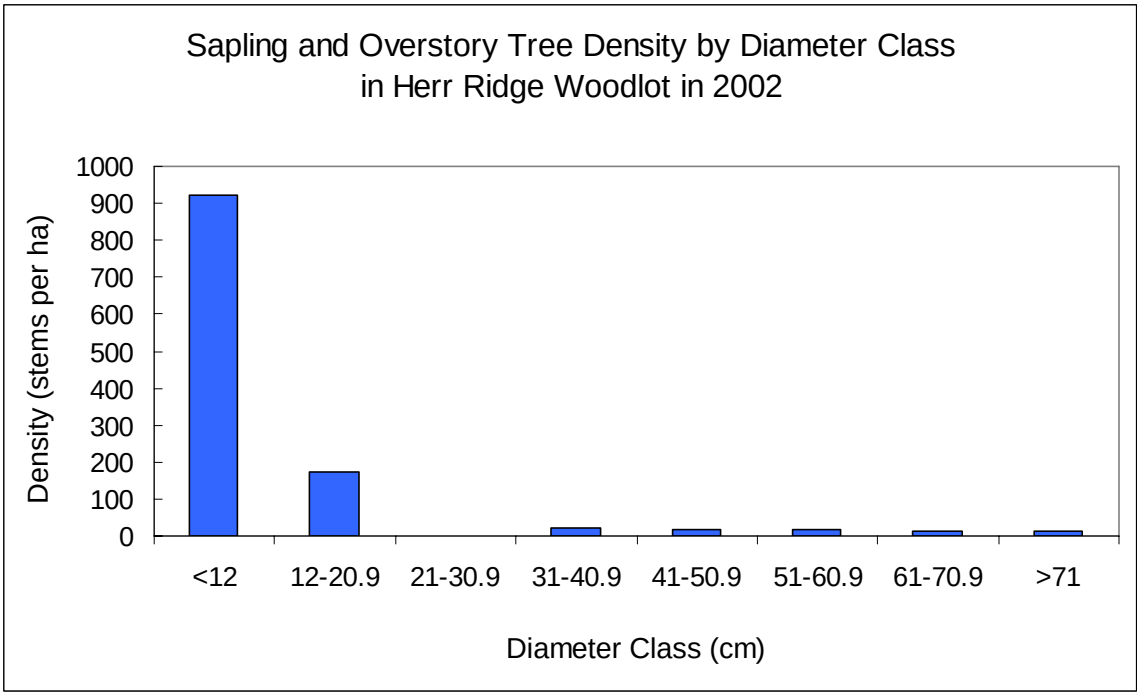


Figure 69. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) tree species by diameter class in fifteen 20 x 20 m Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 2002.

Table 42. Density, average diameter, and basal area of overstory[a] tree species in fifteen 20 x 20 m Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	17	19.4	0.72
Blackgum	2	14.0	0.03
Cherry, sweet	12	16.4	0.29
Cherry, black	35	14.9	0.52
Elm, American	2	19.6	0.11
Hickory, mockernut	22	19.2	0.56
Hickory, pignut	22	21.8	1.20
Hickory, shagbark	57	18.4	1.72
Maple, Norway	3	18.7	0.16
Maple, red	2	12.4	0.01
Oak, black	3	42.1	0.75
Oak, northern red	35	45.7	7.41
Oak, white	43	49.1	9.82
Walnut, black	3	17.3	0.08
Total	258	23.5	23.38
Shrub Species - none			

[a] Overstory were stems >1.5 m in height and ≥12 cm dbh.
[b] Total area of 15 plots was 0.6 ha.

Table 43. Density, average diameter, and basal area of large sapling[a] tree and shrub species in fifteen 20 x 20 m Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	52	5.0	0.12
Apple	2	2.3	0.001
Blackgum	5	7.7	0.02
Cherry, sweet	12	6.8	0.04
Cherry, black	250	5.0	0.60
Elm, American	23	7.0	0.10
Hackberry	2	3.8	0.002
Hickory, mockernut	90	6.3	0.35
Hickory, pignut	142	5.6	0.44
Hickory, shagbark	197	6.0	0.69
Maple, Norway	8	7.3	0.04
Maple, red	2	10.4	0.01
Oak, black	2	4.6	0.003
Oak, northern red	7	7.2	0.04
Oak, white	2	9.1	0.01
Total	796	6.3	2.47
Shrub Species			
Blackhaw, smooth	213	3.5	0.25
Dogwood, flowering	17	3.6	0.02
Grape	8	2.6	0.005
Hawthorn	7	4.1	0.01
Privet	2	3.0	0.001
Redbud, eastern	113	5.2	0.29
Serviceberry	30	5.2	0.08
Witch hazel	3	4.4	0.01
Total	393	4.0	0.66

[a] Large saplings were stems >1.5 m in height and 2-11.9 cm dbh.
[b] Total area of 15 plots was 0.6 ha.

Table 44. Density, average diameter, and basal area of small sapling[a] tree and shrub species in fifteen 20 x 20 m Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	27	1.1	0.0029
Cherry, sweet	2	1.3	0.0004
Cherry, black	55	1.2	0.0071
Hickory, mockernut	5	1.7	0.0011
Hickory, pignut	7	1.6	0.0013
Hickory, shagbark	13	1.3	0.0021
Oak, black	2	1.0	0.0001
Oak, northern red	13	1.3	0.0018
Oak, swamp white	3	1.0	0.0003
Total	127	1.3	0.0171
Shrub Species			
Blackhaw, smooth	117	1.2	0.0136
Dogwood, flowering	2	0.8	0.0001
Hawthorn	7	1.1	0.0005
Privet	2	1.0	0.0001
Redbud, eastern	12	1.5	0.0022
Rose, multiflora	27	0.8	0.0015
Serviceberry	7	1.4	0.0011
Honeysuckle, Tartarian	3	1.3	0.0004
Witch hazel	2	1.0	0.0001
Total	179	1.1	0.0022

[a] Small saplings were stems >1.5 m in height and <2 cm dbh.
[b] Total area of 15 plots was 0.6 ha.

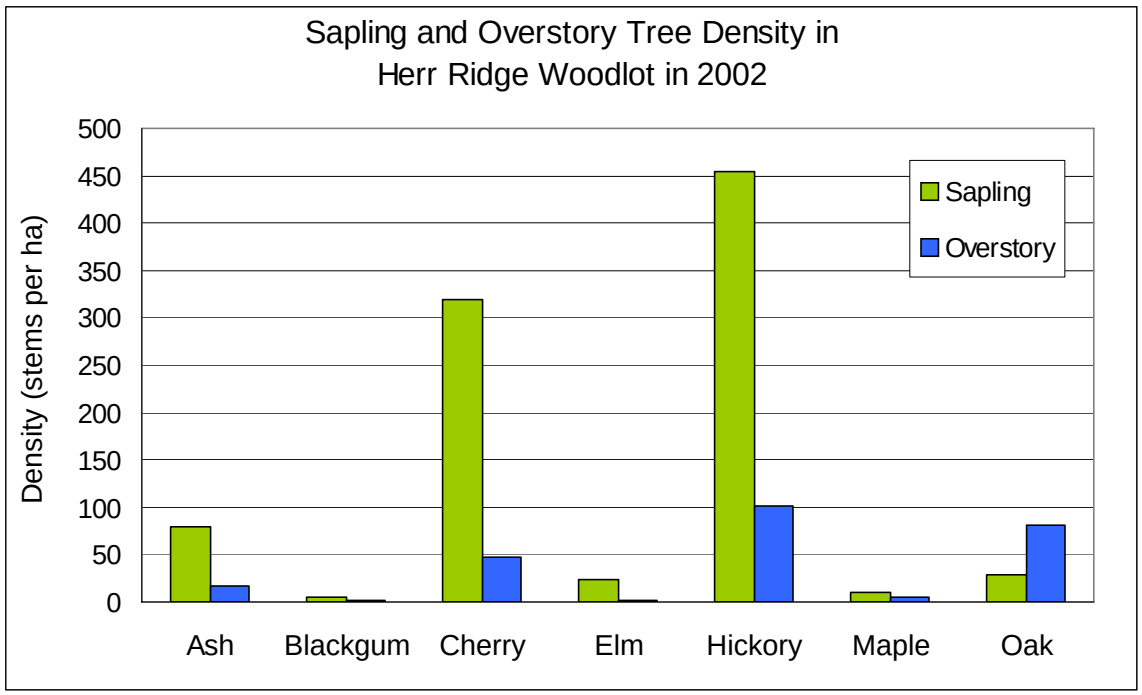


Figure 70. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) selected tree species in fifteen 20 x 20 m Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 2002.

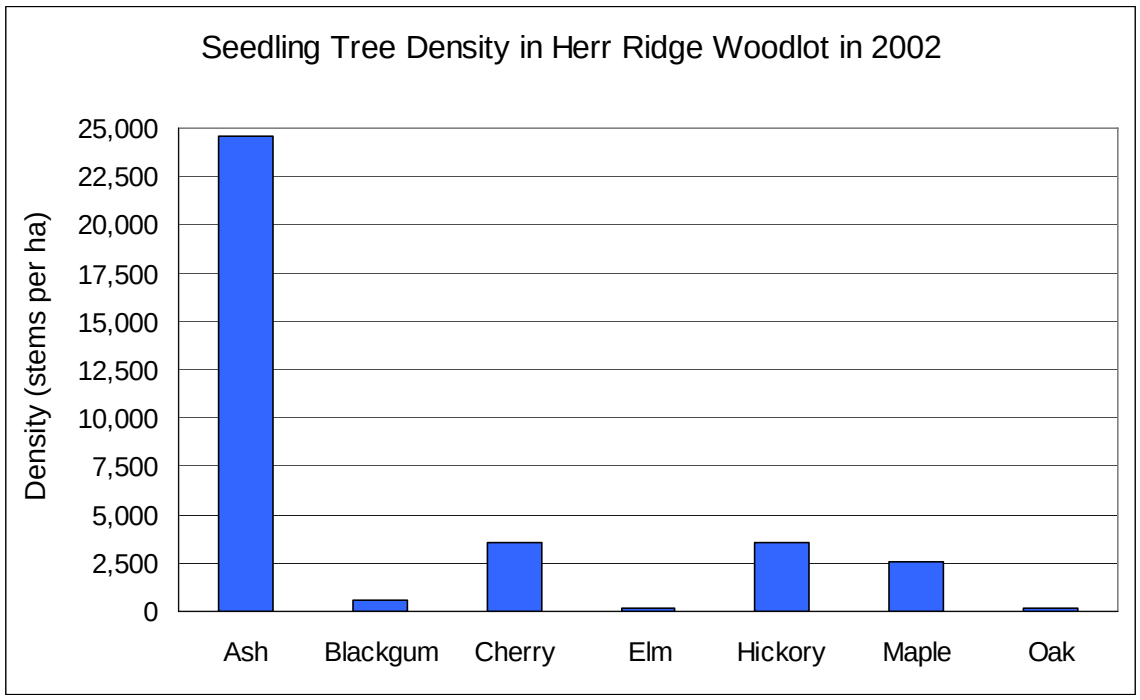


Figure 71. Density of seedling (≤150 cm in height) tree species in thirteen 2 x 2 m subplots within the Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 2002.

Table 45. Density of seedling[a] tree and shrub species in thirteen 2 x 2 m subplots within the Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)
Tree Species	
Ash	10,962
Cherry, sweet	962
Cherry, black	1,923
Hickory, mockernut	577
Hickory, pignut	1,153
Hickory, shagbark	577
Locust	192
Maple, red	769
Oak, white	577
Total	17,692
Shrub Species	
Barberry, Japanese	192
Blackhaw, smooth	8,269
Euonymus	769
Grape	385
Redbud, eastern	962
Ribes	577
Rose, multiflora	192
Rubus	34,615
Total	45,961

[a] Seedlings were stems ≤150 cm in height.
[b] Total area of 13 subplots was 0.0052 ha.

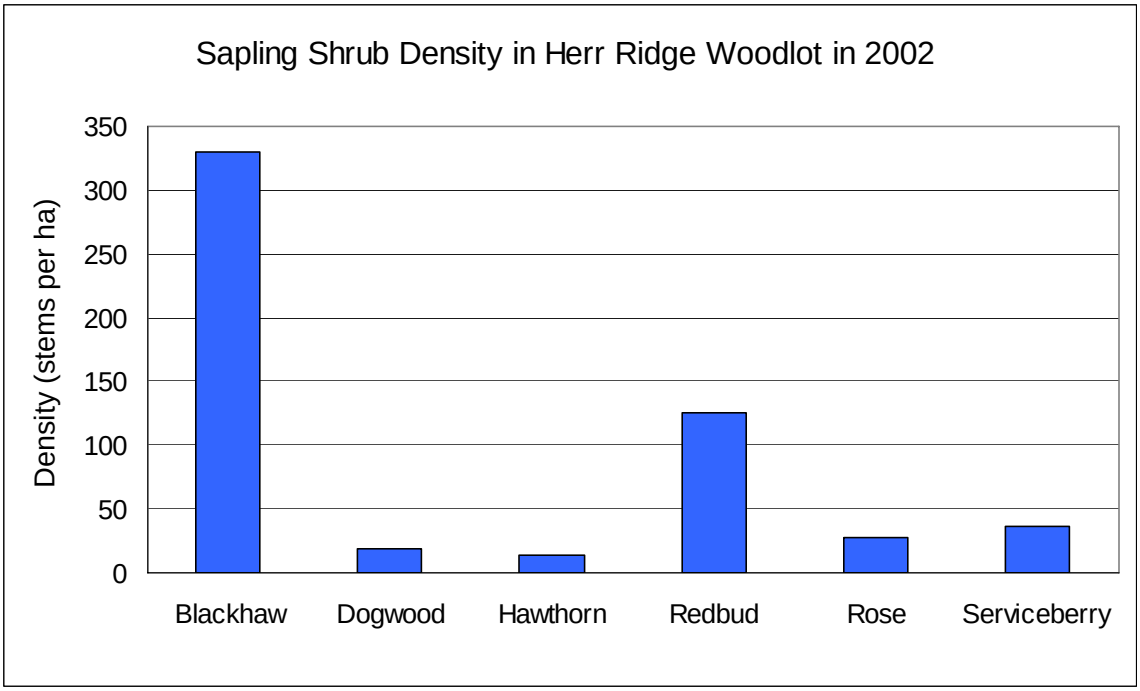


Figure 72. Density of sapling (>1.5 m in height and <12 cm dbh) shrub species in fifteen 20 x 20 m Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 2002.

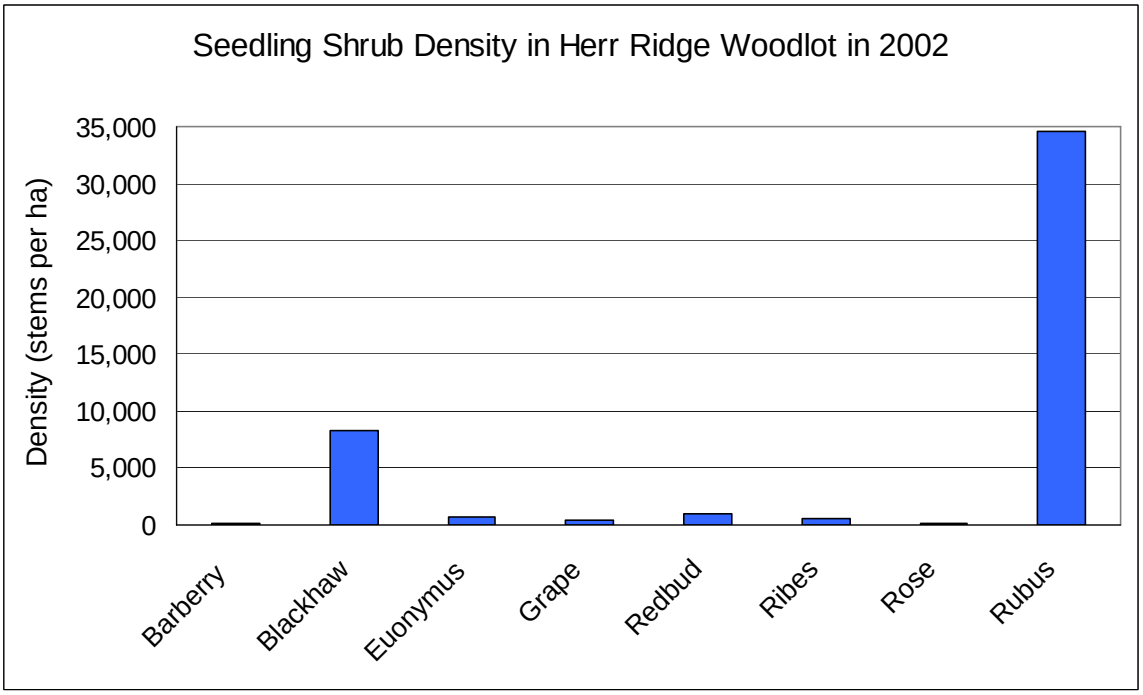


Figure 73. Density of seedling (≤150 cm in height) shrub species in thirteen 2 x 2 m subplots within the Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 2002.

Table 46. Average coverage for grass, forb, vine, and total species in fifteen 2 x 2 m subplots within the Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 2002.[a]

	Average Coverage (%)
Grass	0
Forb	17
Vine	3
Total	20

[a] Total area of 15 subplots was 0.006 ha.

Table 47. Comparison of the Importance Values (IV) of herbaceous and vine species with the ten greatest IVs in the unfenced 2 x 2 m subplots within the Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 1992 to 2002. The IVs were calculated from line transect data[a].

1992		1995		2002	
Species	IV	Species	IV	Species	IV
Enchanter's-nightshade	86.2	Enchanter's-nightshade	79.8	Enchanter's-nightshade	76.2
Japanese honeysuckle	84.2	Jewelweed	62.4	Virginia-creeper	71.7
Virginia-creeper	44.5	Virginia-creeper	48.1	Japanese honeysuckle	55.1
Wild licorice	20.4	Wild licorice	25.8	Wild licorice	16.1
Poison-ivy	18.4	Japanese honeysuckle	20.9	Sedge spp.	15.6
Sedge (C. rosea)	12.2	Sedge spp.	15.7	Mayapple	13.3
Sedge (C. laxiflora)	6.9	Mayapple	12.0	Smartweed spp.	5.4
Carrion-flower	6.3	Poison-ivy	8.7	Carrion-flower	4.1
Cinquefoil	5.1	Cinquefoil	7.0	Poison-ivy	2.3
Mayapple	3.4	Rough bedstraw	6.6	Hog-peanut	2.1

[a] Data were collected in two 0.981 m2 quadrants in the 2 x 2 m subplot.

Pitzer Woodlot (Combined Fenced and Unfenced Data)

The combined data results were based on data from 29 plots. None of the overstory plots and none of the sapling plots were fenced to exclude white-tailed deer. However, 14 of the plots had seedling subplots unfenced and 15 of the plots had seedling subplots fenced to exclude white-tailed deer.

Tree Species:

Overstory: In 2002, eighteen tree species were inventoried in the overstory (>1.5 m in height and ≥12 cm dbh) category. The total density was 297 stems/ha, with an average dbh of 25.1 cm, and a basal area of 25.81 m^2 per ha (Table 48). Overstory trees accounted for 32% of all stems >1.5 m in height (Figure 74). The tree species exhibiting the greatest density (percentage of the total) were white oak (17%), northern red oak (16%), red maple (15%), mockernut hickory (9%), blackgum (9%), pignut hickory (8%), and black cherry (7%) (Table 49). The remaining eleven species of trees accounted for 19% of the total overstory density. Overstory tree basal area was predominantly made up of white oak, which was 29.23 m2 per ha or 57% of the total basal area. Northern red maple, eastern red cedar, red maple, and mockernut hickory comprised 14, 5, 5, and 4%, respectively, of the basal area. The remaining thirteen species of trees combined made up 14% of the basal area. Oak, hickory, maple, cherry, and ash represented 34, 24, 15, 13, and 2%, respectively, of the overstory tree density (Figure 75). The overstory stocking level for the Pitzer woodlot was 90% (Roach and Gingrich 1962).

Large Sapling: Thirteen species were recorded in the large sapling (>1.5 m in height and 2-11.9 cm dbh) category. The density was 554 stems/ha, with an average dbh of 7 cm, and a basal area of 2.23 m^2 per ha (Table 48). Hickory species were the dominant component of the large sapling density with shagbark, pignut, and mockernut representing 20, 18, 12%, respectively, of the total density (Figure 75). Red maple, black cherry, and blackgum comprised 14, 10, and 9%, respectively, of the total density (Table 50). The remaining seven species of trees combined accounted for 17% of total large sapling density.

Small Sapling: Ten tree species were inventoried in the small sapling (>1.5 m in height and <2 cm dbh) category in 2002. The density was 63 stems/ha, with an average dbh of 1.4 cm, and a basal area of 0.0084 m^2 per ha (Table 48). Blackgum was the dominant species in this category, accounting for 49% of the total density (Table 51). Ash and black cherry were 18% and 13%, respectively, of the total density (Figure 75). The remaining seven species of trees combined accounted for 20% of the total small sapling density. There were no oak species recorded in this category in 2002.

Seedling: Ten species of trees were inventoried in the seedling (≤150 cm in height) category in 2002. The total density was 16,579 stems/ha (Table 52). Ash were the majority of seedling stems, representing 40% of the total density (Figure 76). The other four abundant trees in the seedling category were red maple (25%), blackgum (11%), American elm (9%), and sweet cherry (7%). Mockernut, pignut, and shagbark hickory combined totaled 6%, white oak 2%, and locust <1% of the total seedling density.

Shrub Species:

Overstory: Three shrub species were inventoried in the overstory category in 2002. Overstory shrubs were only 2% of the shrub species with stems >1.5 m in height (Figure 77). The overstory shrub density was six stems/ha, with an average dbh of 15.8 cm, and a basal area of 0.12 m^2 per ha (Table 48). Sassafras, flowering dogwood, and smooth blackhaw comprised 67, 17, and 17%, respectively, of the total overstory shrub basal area (Table 49).

Large Sapling: Nine species of shrubs were recorded in the large sapling category in 2002. The density was 163 stems/ha, with an average dbh of 4.3 cm, and a basal area of 0.41 m^2 per ha (Tables 48 and 50). Large sapling density was mostly comprised of smooth blackhaw (60%), flowering dogwood (12%), serviceberry (11%), witch hazel (6%), and sassafras (5%) (Figure 77). The remaining four species of shrubs combined accounted for 6% of the total density.

Small Sapling: Eight shrub species were inventoried in the small sapling category. The density was 174 stems/ha, with an average dbh of 1.1 cm, and a basal area of 0.0126 m^2 per ha (Tables 48 and 51). The small sapling density was comprised of multiflora rose (44%), smooth blackhaw (22%), *Rubus* (20%), witch hazel (5%), serviceberry (4%), Japanese barberry (2%), Tartarian honeysuckle (2%), and flowering dogwood (1%) (Figure 77).

Seedling: Seven shrub species were recorded in the seeding category in 2002. The density was 16,316 stems/ha (Table 52). Smooth blackhaw was the predominant species, accounting for 50% of the total seedling shrub density (Figure 78). *Rubus*, Japanese barberry, and multiflora rose were also abundant representing 30, 10, and 7%, respectively, of the total seedling density. Autumn olive, flowering dogwood, and sassafras combined accounted for 3% of the total seedling density.

Herbaceous and Vine Vegetation: Herbaceous data (vine included) showed an average total herbaceous coverage of 25%. Forb coverage was greatest at 20%, followed by vine and grass coverages (4% and 2%, respectively) (Table 53).

Table 48. Density, average diameter, and basal area of small sapling, large sapling, and overstory tree and shrub species in twenty-nine 20 x 20 m Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.[a]

	Small Sapling[b]	Large Sapling[b]	Overstory[b]
Tree Species			
Density (stems/ha)	63.0	554.0	297.0
Average DBH (cm)	1.4	7.0	25.1
Basal Area (m^2/ha)	0.0084	2.23	25.81
Shrub Species			
Density (stems/ha)	174.0	163.0	6.0
Average DBH (cm)	1.1	4.3	15.8
Basal Area (m^2/ha)	0.0126	0.41	0.12

[a] Total area of 29 plots was 1.16 ha.
[b] Small saplings were stems >1.5 m in height and <2 cm dbh; large saplings were stems >1.5 m in height and 2-11.9 cm dbh; overstory were stems >1.5 m in height and ≥12 cm dbh.

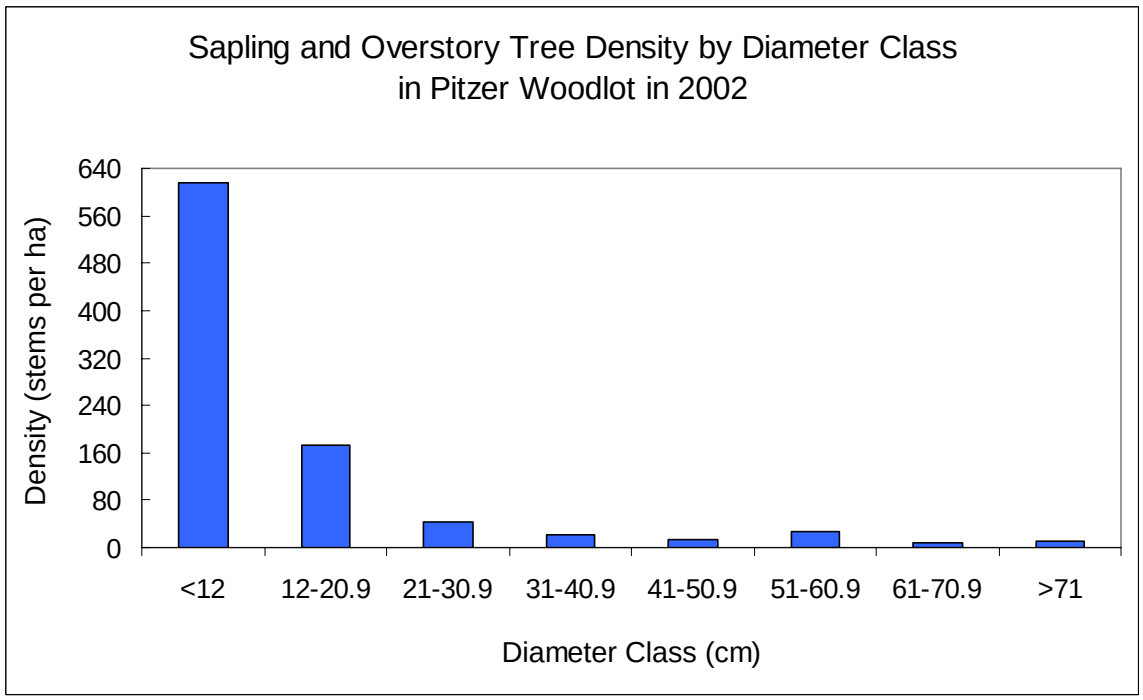


Figure 74. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) tree species by diameter class in twenty-nine 20 x 20 m Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

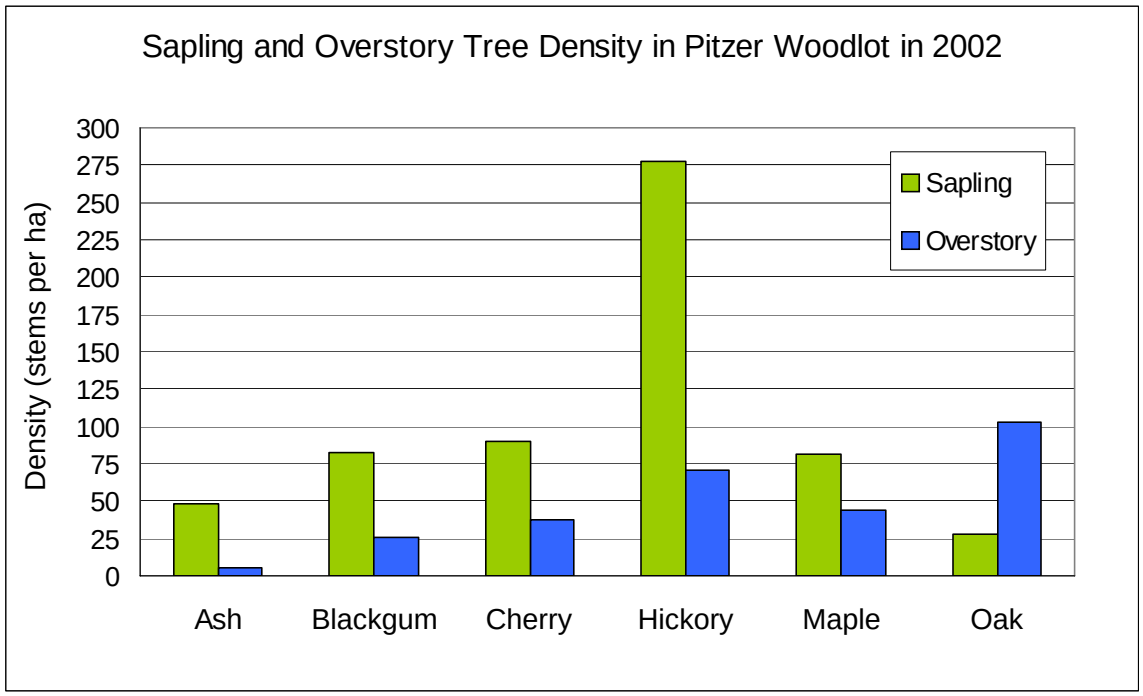


Figure 75. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) selected tree species in twenty-nine 20 x 20 m Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

Table 49. Density, average diameter, and basal area of overstory[a] tree and shrub species in twenty-nine 20 x 20 m Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	5	17.0	0.12
Blackgum	26	22.7	1.33
Cedar, eastern red	1	13.7	0.02
Cherry, sweet	16	16.0	0.32
Cherry, black	22	16.1	0.39
Elm, American	3	14.7	0.07
Hemlock, eastern	1	32.0	0.07
Hickory, mockernut	28	20.7	1.11
Hickory, pignut	24	22.6	1.00
Hickory, shagbark	19	18.5	0.57
Maple, red	43	18.0	1.18
Maple, sugar	1	12.7	0.01
Oak, black	4	44.8	0.89
Oak, northern red	47	26.6	3.70
Oak, white	52	56.2	14.61
Pine, Virginia	2	32.9	0.15
Sycamore, American	1	41.7	0.12
Walnut, black	4	24.4	0.24
Total	297	25.1	25.81
Shrub Species			
Blackhaw-smooth	1	15.2	0.02
Dogwood, flowering	1	15.2	0.02
Sassafras	4	17.1	0.09
Total	6	15.8	0.12

[a] Overstory were stems >1.5 m in height and ≥12 cm dbh.
[b] Total area of 29 plots was 1.16 ha.

Table 50. Density, average diameter, and basal area of large sapling[a] tree and shrub species in twenty-nine 20 x 20 m Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	37	5.5	0.10
Blackgum	52	6.4	0.21
Cedar, eastern red	3	7.9	0.02
Cherry, sweet	21	8.4	0.12
Cherry, black	57	6.5	0.24
Elm, American	6	6.8	0.03
Hickory, mockernut	65	6.5	0.25
Hickory, pignut	100	6.5	0.39
Hickory, shagbark	109	5.9	0.34
Maple, red	76	7.7	0.39
Maple, sugar	1	6.4	0.01
Oak, northern red	19	8.8	0.13
Oak, white	9	7.1	0.04
Total	554	7.0	2.23
Shrub Species			
Blackhaw, smooth	98	4.5	0.21
Boxelder	2	2.3	0.001
Dogwood, flowering	20	5.7	0.07
Hawthorn	1	3.0	0.001
Honeysuckle, Tartarian	2	2.0	0.001
Rose, multiflora	4	3.1	0.003
Sassafras	9	8.7	0.06
Serviceberry	17	6.2	0.06
Witch hazel	10	2.9	0.01
Total	163	4.3	0.41

[a] Large saplings were stems >1.5 m in height and 2-11.9 cm dbh.
[b] Total area of 29 plots was 1.16 ha.

Table 51. Density, average diameter, and basal area of small sapling[a] tree and shrub species in twenty-nine 20 x 20 m Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	11	1.4	0.0018
Blackgum	31	1.2	0.0036
Cherry, sweet	3	0.9	0.0003
Cherry, black	9	1.4	0.0012
Elm, American	1	1.7	0.0002
Hickory, mockernut	1	1.8	0.0002
Hickory, pignut	1	1.8	0.0002
Hickory, shagbark	2	1.7	0.0004
Maple, Norway	1	1.0	0.0001
Maple, red	3	1.4	0.0005
Total	63	1.4	0.0084
Shrub Species			
Barberry, Japanese	3	1.0	0.0002
Blackhaw, smooth	40	1.2	0.0043
Dogwood, flowering	2	1.5	0.0003
Honeysuckle, Tartarian	3	1.0	0.0003
Rose, multiflora	78	0.8	0.0053
Rubus	34	0.6	0.0007
Serviceberry	7	1.6	0.0006
Witch hazel	9	1.3	0.0008
Total	174	1.1	0.0126

[a] Small saplings were stems >1.5 m in height and <2 cm dbh.
[b] Total area of 29 plots was 1.16 ha.

Table 52. Density of seedling[a] tree and shrub species in nineteen 2 x 2 m subplots within the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)
Tree Species	
Ash	6,579
Blackgum	1,842
Cherry, sweet	1,184
Elm, American	1,447
Hickory, mockernut	263
Hickory, pignut	395
Hickory, shagbark	395
Locust	132
Maple, red	4,079
Oak, White	263
Total	16,579
Shrub Species	
Autumn olive	132
Barberry, Japanese	1,579
Blackhaw, smooth	8,158
Dogwood, flowering	132
Rose, multiflora	1,184
Rubus	4,868
Sassafras	263
Total	16,316

[a] Seedlings were stems ≤150 cm in height.
[b] Total area of 19 subplots was 0.0076 ha.

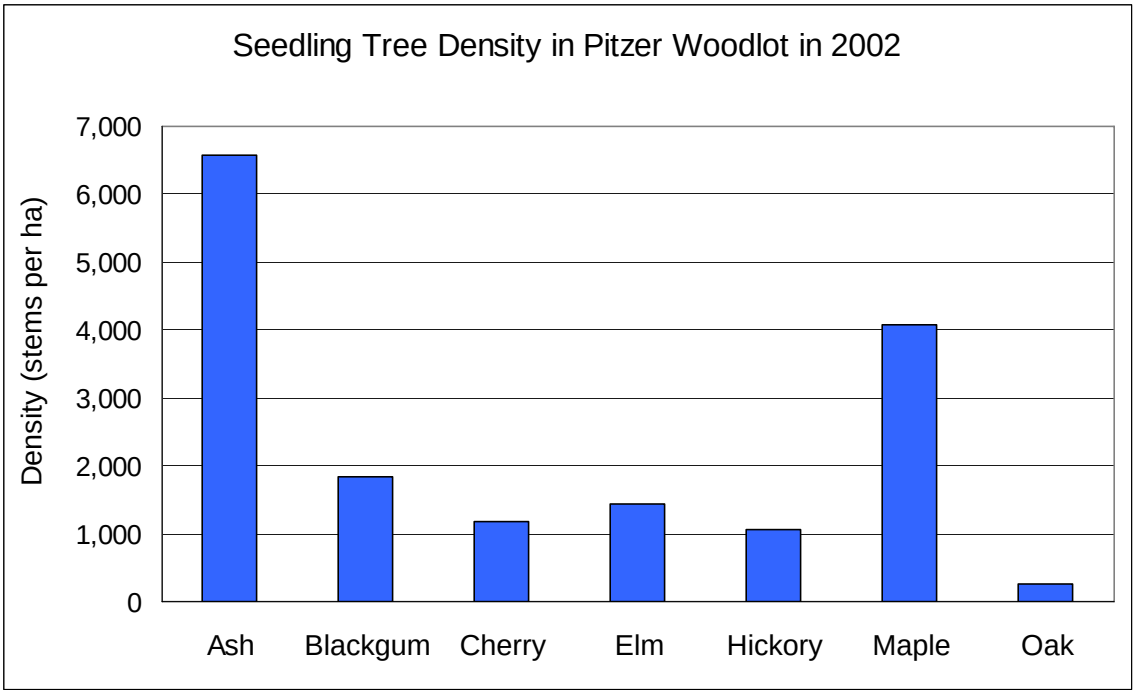


Figure 76. Density of seedling (≤150 cm in height) selected tree species in nineteen 2 x 2 m subplots within the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

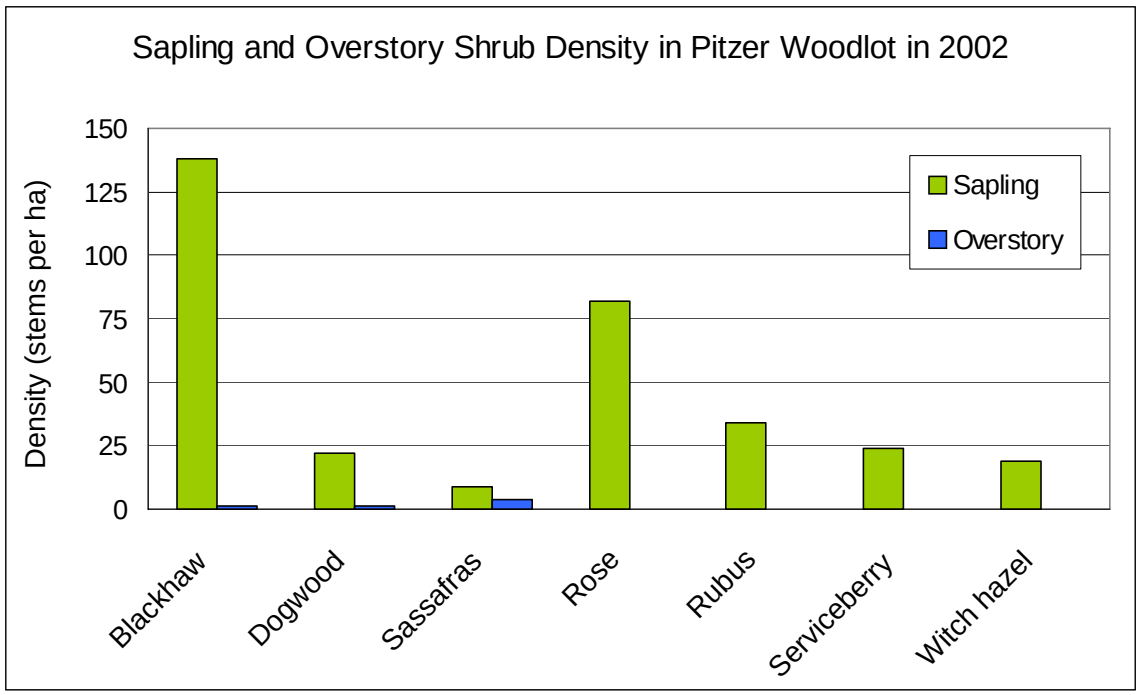


Figure 77. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) selected shrub species in twenty-nine 20 x 20 m Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

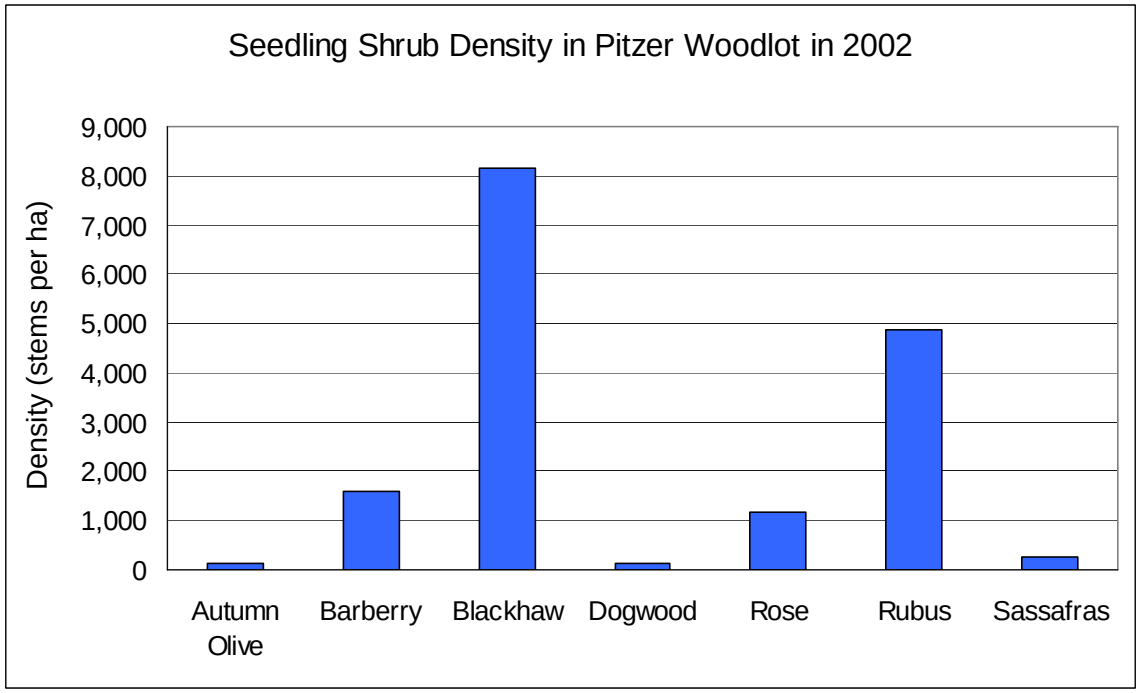


Figure 78. Density of seedling (≤150 cm in height) shrub species in nineteen 2 x 2 m subplots within the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

Table 53. Average coverage for grass, forb, vine, and total species in twenty-nine 2 x 2 m subplots within the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.[a]

	Average Coverage (%)
Grass	2
Forb	20
Vine	4
Total	25

[a] Total area of 29 subplots was 0.0116 ha.

Pitzer Woodlot (Fenced and Unfenced Seedling and Herbaceous Comparison)

Tree Species:
Seedling: In 2002, the density of seedling trees in the unfenced (16,667 stems/ha) and fenced (16,500 stems/ha) subplots were almost equal (Table 54). Eight species of trees were recorded in the fenced subplots versus ten species of trees in the unfenced subplots. Ash was the dominant species in the fenced subplots comprising 62% of the total seedling density (Figure 79). The prevalent species in the fenced subplots were American elm (12%), sweet cherry, and blackgum (9% each). Mockernut, pignut, and shagbark hickory collectively accounted for 6% and red maple 2% of the total seedling density in the fenced subplots. Red maple was the dominant tree species in the unfenced subplots accounting for 50% of the total density (Figure 79). In the unfenced plots, ash (15%), blackgum (13%), American elm, and sweet cherry (5% each) were prevalent (Table 54). Locust and white oak were recorded in unfenced subplots, but not in fenced subplots in 2002.

Analysis indicated that seedling tree density was significantly different between the two fence treatments and that there was a significant interaction between woodlot and fence treatment. Among the two woodlots, the seedling tree density in the fenced subplots was significantly different than in the unfenced subplots. There was no significant difference in seedling tree density between the Pitzer woodlot fenced and unfenced subplots.

Shrub Species:
Seedling: The density of seedling shrubs in the unfenced subplots (21,112 stems/ha) was much greater than in the fenced subplots (12,000 stems/ha) in 2002 (Table 54). Five species of shrubs were recorded in both the fenced and unfenced subplots. *Rubus* was the dominant shrub in the fenced subplots (8,500 stems/ha), accounting for 71% of the fenced seedling shrub density (Figure 80). In the fenced subplots, multiflora rose (19%) and smooth blackhaw (6%) were also prevalent. In the unfenced subplots, the seedling shrub density was comprised of smooth blackhaw (78%), Japanese barberry (14%), *Rubus* (4%), sassafras (3%), and autumn olive (1%) (Figure 80).

Analysis of the seedling shrub data indicated that woodlot and fence treatment were significant predictors of seedling shrub density. However, there was no significant difference in seedling shrub density between the Pitzer woodlot fenced and unfenced subplots.

Herbaceous and Vine Vegetation: In Pitzer, the average total herbaceous coverage in the fenced and unfenced subplots was comparable at 26 and 24%, respectively (Table 55). Forb coverages were equal in both fence treatments (20% each). Vine coverage was greater in the fenced subplots (5%) than in the unfenced subplots (2%). Grass coverage was slightly greater in the unfenced subplots (2%) than in the fenced subplots (1%).

Analysis of total average herbaceous coverage indicated that fence treatment was a significant predictor in 2002. Among the two woodlots, the percent of total herbaceous coverage in the fenced subplots was significantly different than in the unfenced subplots. Analysis of average forb coverage indicated that woodlot, fence treatment, and the interaction between woodlot and fence treatment were significant predictors. Among the two woodlots, the fenced subplots had significantly different average forb coverage than the unfenced subplots.

Pitzer Fenced: Virginia-creeper had the greatest IV in 2002 (Table 56). Japanese honeysuckle was second-ranked and Enchanter's-nightshade was third-ranked in 2002. The Shannon Index value was 1.09, and the Evenness Index value was 0.78 in 2002 (Table 31).

Pitzer Unfenced-Control: Enchanter's-nightshade was first rank in 2002 (Table 57). Virginia-creeper was second-ranked, and wild licorice was third in 2002. The Shannon Index value was 1.08, and the Evenness Index value was 0.76 in 2002 (Table 31).

Pitzer Unfenced: The top four IV's in 2002 were for enchanter's-nightshade, Japanese honeysuckle, wild licorice, and Virginia-creeper (Table 58). The Shannon Index value was 0.88 and the Evenness Index value was 0.69 in 2002 (Table 31).

Table 54. Density of seedling[a] tree and shrub species by fence treatment[b] in nineteen 2 x 2 m subplots within the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.[c]

	Fenced Treatment Density (stems/ha)	Unfenced Treatment Density (stems/ha)
Tree Species		
Ash	10,250	2,500
Blackgum	1,500	2,222
Cherry, sweet	1,500	833
Elm, American	2,000	833
Hickory, mockernut	250	278
Hickory, pignut	500	278
Hickory, shagbark	250	556
Locust	0	278
Maple, red	250	8,333
Oak, white	0	556
Total	16,500	16,667
Shrub Species		
Autumn Olive	0	278
Barberry, Japanese	250	3,056
Blackhaw, smooth	750	16,389
Dogwood, flowering	250	0
Rose, multiflora	2,250	0
Rubus	8,500	833
Sassafras	0	556
Total	12,000	21,112

[a] Seedlings were stems ≤150 cm in height.
[b] Nine plots contained a 3 x 3 m square and 1.8 m high fence, enclosing the 2 x 2 m subplot.
[c] Total area of 19 subplots was 0.0076 ha, unfenced treatment was 0.0036 ha and the fenced treatment was 0.004 ha.

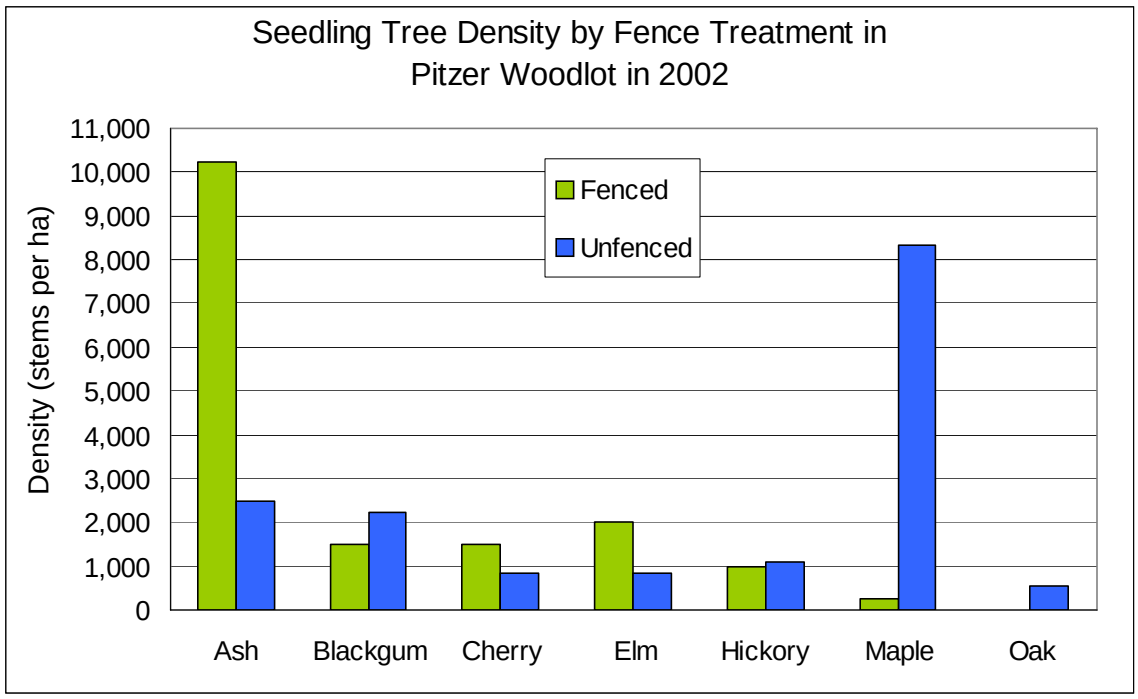


Figure 79. Density of seedling (≤150 cm in height) tree species in ten fenced and nine unfenced 2 x 2 m subplots within the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

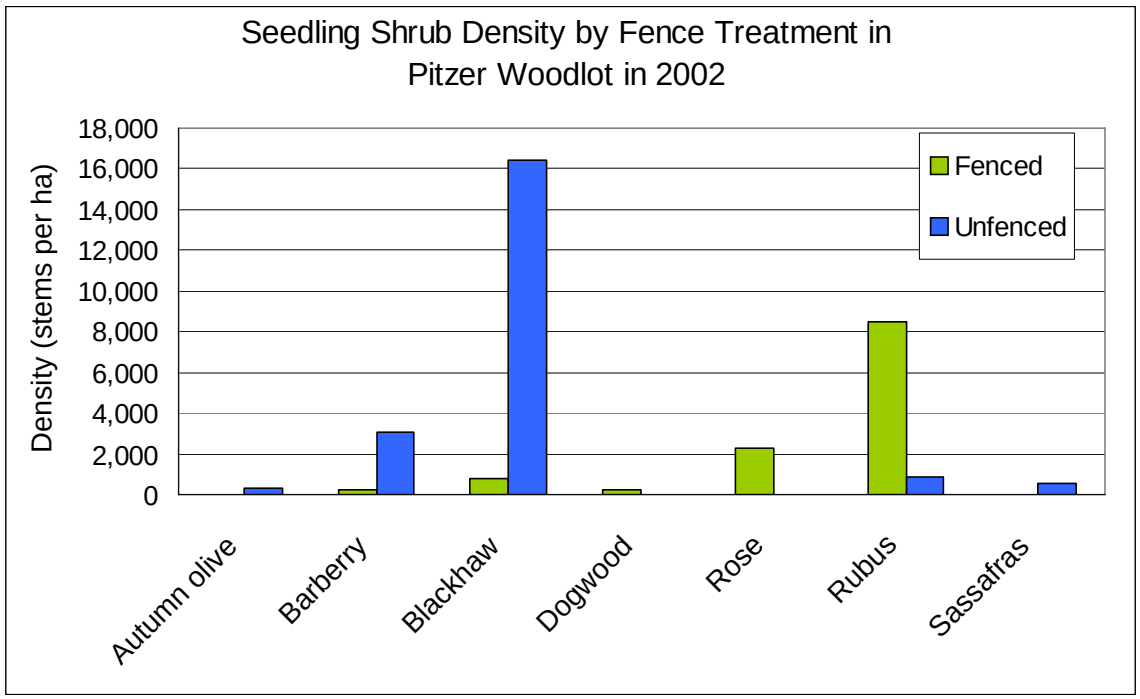


Figure 80. Density of seedling (≤150 cm in height) shrub species in ten fenced and nine unfenced 2 x 2 m subplots within the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.

Table 55. Average coverage for grass, forb, vine, and total species by fence treatment[a] in twenty-nine 2 x 2 m subplots within the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 2002.[b]

	Fenced Treatment Average Coverage (%)	Unfenced Treatment Average Coverage (%)
Grass	1	2
Forb	20	20
Vine	5	2
Total	26	24

[a] Fifteen plots contained a 3 x 3 m square and 1.8 m high fence, enclosing the 2 x 2 m subplot.
[b] Total area of 29 subplots was 0.0116 ha; fenced treatment plots were 0.006 ha and the unfenced plots were 0.0056 ha.

Table 56. Comparison of the Importance Values (IV) of herbaceous and vine species with the ten greatest IVs in the fenced 2 x 2 m subplots within the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 1995 to 2002. The IVs were calculated from line transect data[a].

1995		2002	
Species	IV	Species	IV
Enchanter's-nightshade	75.7	Virginia-creeper	53.6
Smartweed spp.	47.5	Japanese honeysuckle	48.5
Rough bedstraw	37.9	Enchanter's-nightshade	42.1
Wild licorice	18.1	Smartweed spp.	31.9
Jewelweed	16.6	Jewelweed	22.7
Jumpseed	13.5	Wild licorice	20.5
Japanese honeysuckle	12.5	Poison-ivy	16.9
Poison-ivy	12.1	Cinquefoil	10.5
Clearweed	10.2	Rough bedstraw	9.0
Virginia-creeper	9.0	Lion's foot	6.6

[a] Data were collected in two 0.981 m2 quadrants in the 2 x 2 m subplot.

Table 57. Comparison of the Importance Values (IV) of herbaceous and vine species with the ten greatest IVs in the unfenced-control 2 x 2 m subplots in Pitzer woodlot, Gettysburg National Military Park, 1995 to 2002. The IVs were calculated from line transect data[a].

1995		2002	
Species	IV	Species	IV
Grass spp.	72.1	Enchanter's-nightshade	115.1
Wild licorice	53.3	Virginia-creeper	67.6
Smartweed spp.	51.7	Wild licorice	29.3
Japanese honeysuckle	29.1	Jumpseed	15.2
Enchanter's-nightshade	27.7	Smartweed spp.	11.1
Three-seeded mercury	17.1	Solomon's-seal	9.6
Hog-peanut	11.7	Japanese honeysuckle	9.3
Sedge spp.	11.7	White-snakeroot	7.9
American pennyroyal	8.0	Naked-flowered tick-seed	7.7
Virginia-creeper	4.8	Jewelweed	7.0

[a] Data were collected in two 0.981 m2 quadrants in the 2 x 2 m subplot.

Table 58. Comparison of the Importance Values (IV) of herbaceous and vine species with the ten greatest IVs in the unfenced 2 x 2 m subplots within the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 1995 to 2002. The IVs were calculated from line transect data[a].

1995		2002	
Species	IV	Species	IV
Smartweed spp.	111.8	Enchanter's-nightshade	94.9
Stiltgrass	50.9	Japanese honeysuckle	40.4
Enchanter's-nightshade	33.3	Wild licorice	28.4
Jewelweed	29.1	Virginia-creeper	21.8
Hog-peanut	13.7	Jewelweed	18.5
Poison-ivy	9.9	Hog-peanut	13.0
Wild licorice	8.5	Cinquefoil	9.4
Clearweed	7.2	Sedge spp.	9.2
Naked-flowered tick-seed	5.9	Grass spp.	8.3
Jumpseed	5.8	Wood geranium	7.3

[a] Data were collected in two 0.981 m2 quadrants in the 2 x 2 m subplot.

Powers Hill Woodlot

Tree Species:
Overstory: In 2002, twenty-one species of trees were inventoried in the overstory (>1.5 m in height and ≥12 cm dbh) category. The overstory tree density was 274 stems/ha, with an average dbh of 26.9 cm, and a basal area of 23.69 m^2 per ha (Tables 59 and 60). Overstory trees accounted for 44% of the stems >1.5 m in height (Figure 81). The most abundant species of trees were white oak (16%), ash (14%), northern red oak (12%), yellow poplar (9%), black oak (9%), and mockernut hickory (7%) (Figure 82). The remaining fourteen species of trees combined accounted for 26% of the total overstory density. The tree species with the greatest basal area (percent of total) were white oak (24%), northern red oak (16%), black oak (15%), yellow poplar (15%), ash (5%), and shagbark hickory (5%). The remaining fifteen species of trees combined accounted for 21% of the total basal area (Table 60). The overstory density and basal area values would place the Powers Hill woodlot in the 82% stocking level (Roach and Gingrich 1962).

Large Sapling: Fifteen tree species were recorded in the large sapling (>1.5 m in height and 2-11.9 cm dbh) category in 2002. The large sapling tree density was 194 stems/ha, with an average dbh of 8.2 cm, and a basal area of 0.86 m^2 per ha (Tables 59 and 61). The density was mostly comprised of black cherry (27%), ash (16%), mockernut hickory (12%), shagbark hickory (10%), blackgum (10%), and red maple (7%) (Figure 82). The remaining nine species of trees accounted for 18% of the total large sapling density.

Small Sapling: In 2002, three species of trees were inventoried in the small sapling (>1.5 m in height and <2 cm dbh) category with a density of 152 stems/ha, with an average dbh of 1.3 cm, and a basal area of 0.0241 m^2 per ha (Table 62). Black cherry was the predominant species, with 148 stems/ha, or 97% of the total small sapling density (Figure 82). Mockernut and shagbark hickory each accounted for 1% of the total density.

Seedling: Thirteen species of trees were recorded in the seedling (≤150 cm in height) category in 2002. The total seedling tree density was 46,334 stems/ha (Table 63). The density of ash was 21,833 stems/ha or 47% of the total seedling tree density (Figure 83). Elm, cherry, hickory, blackgum, and red maple comprised 20, 17, 9, 3, and 3%, respectively, of the total seedling tree density. Red, white, and swamp white oak combined only accounted for 2% of the total density.

Shrub Species:
Overstory: Four shrub species were inventoried in the overstory category in 2002. The density was 19 stems/ha, with an average dbh of 14.0 cm, and a basal area of 0.24 m^2 per ha (Tables 59 and 60). The density was almost evenly distributed among the four shrub species. Eastern redbud was slightly more abundant, representing 37% of the total density. Flowering dogwood, serviceberry, and sassafras were 26, 26, and 11%, respectively, of the total overstory shrub density. Serviceberry, eastern redbud, flowering dogwood, and sassafras comprised 42, 29, 17, and 13%, respectively, of the overstory shrub basal area (Table 60).

Large Sapling: Nine shrub species were recorded in the large sapling category in 2002. The density was 496 stems/ha, with an average dbh of 5.6 cm, and a basal area of 0.67 m^2 per ha (Tables 59 and 61). The majority of the large sapling density was comprised of spicebush (59%), flowering dogwood (21%), and eastern redbud (10%) (Figure 84). The remaining six species of shrubs combined accounted for 11% of the total large sapling density.

Small Sapling: In 2002, twelve shrub species were inventoried in the small sapling category. The density was 2,552 stems/ha, with an average dbh of 1.0 cm, and basal area of 0.2478 m^2 per ha (Tables 59 and 62). Spicebush was the dominant species, accounted for 76% of the total density and 83% of the total basal area (Figure 84). Japanese barberry and eastern redbud comprised 7% and 6%, respectively, of the total density. The remaining nine species of shrubs combined accounted for 11% of the small sapling density.

Seedling: Fourteen shrub species were recorded in the seedling category in 2002. The seedling shrub density was 67,001 stems/ha (Table 63). Spicebush was the dominant species with a density of 26,167 stems/ha, or 39% of the total seedling shrub density (Figure 85). *Rubus*, Japanese barberry, eastern redbud, flowering dogwood, and smooth blackhaw comprised 20, 19, 8, 5, and 4%, respectively, of the total density. The remaining eight species of shrubs combined accounted for 6%of the total seedling shrub density.

Herbaceous and Vine Vegetation: Herbaceous data (vine included) showed an average total herbaceous coverage of 48%. Forb coverage was greatest (37%), followed by grass and vine coverages (7 and 4%, respectively) (Table 64).

Stiltgrass had the greatest IV in 2002 (Table 65). Japanese honeysuckle ranked second, and white-snakeroot (*Eupatorium rugosum*) ranked third in 2002. The Shannon Index value was 0.97, and the Evenness Index value was 0.70 in 2002 (Table 31).

Table 59. Density, average diameter, and basal area of small sapling, large sapling, and overstory tree and shrub species in fifteen 20 x 20 m Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 2002.[a]

	Small Sapling[b]	Large Sapling[b]	Overstory[b]
Tree Species			
Density (stems/ha)	152.0	194.0	274.0
Average DBH (cm)	1.3	8.2	26.9
Basal Area (m^2/ha)	0.0241	0.86	23.69
Shrub Species			
Density (stems/ha)	2,552.0	496.0	19.0
Average DBH (cm)	1.0	5.6	14.0
Basal Area (m^2/ha)	0.2478	0.67	0.24

[a] Total area of 15 plots was 0.6 ha.
[b] Small saplings were stems >1.5 m in height and <2 cm dbh; large saplings were stems >1.5 m in height and 2-11.9 cm dbh; overstory were stems >1.5 m in height and ≥12 cm dbh.

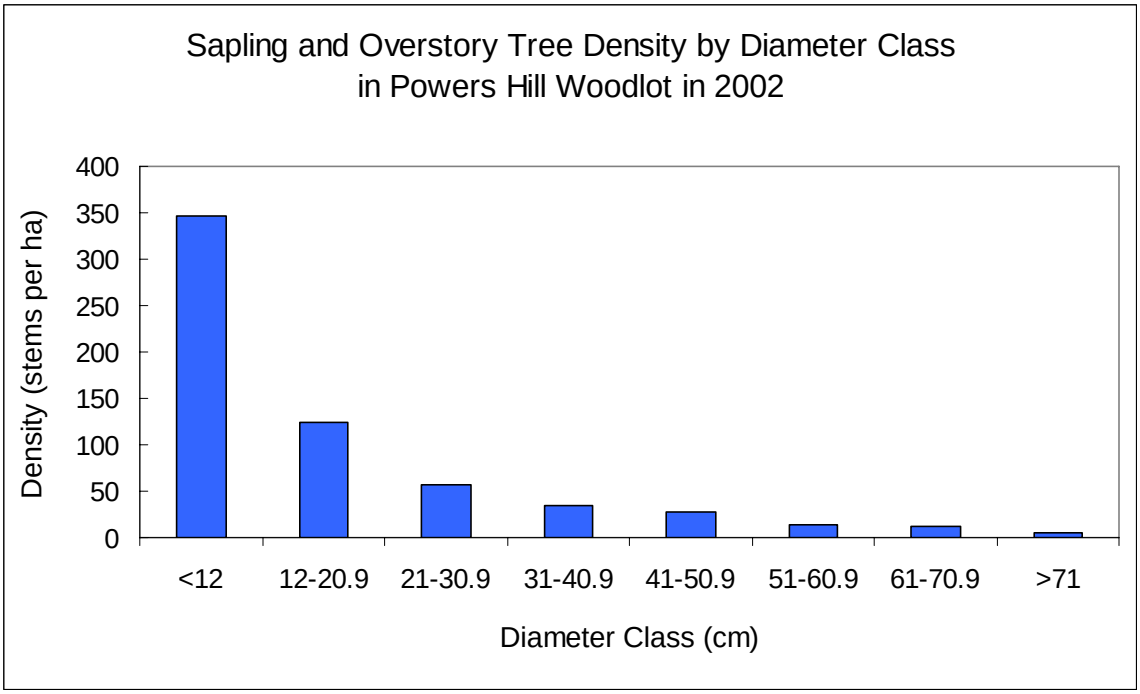


Figure 81. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) tree species by diameter class in thirteen 20 x 20 m Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 2002.

Table 60. Density, average diameter, and basal area of overstory[a] tree and shrub species in fifteen 20 x 20 m Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	37	19.8	1.21
Blackgum	12	20.9	0.36
Butternut	2	30.5	0.12
Cedar, eastern red	8	22.2	0.36
Cherry, sweet	5	16.2	0.10
Cherry, black	2	13.0	0.02
Elm, American	2	28.4	0.11
Elm, slippery	2	12.7	0.02
Hickory, mockernut	18	21.8	0.77
Hickory, pignut	13	29.0	1.04
Hickory, shagbark	25	22.4	1.10
Maple, Norway	2	18.8	0.05
Maple, red	8	16.7	0.19
Maple, sugar	3	23.5	0.15
Oak, black	22	43.7	3.60
Oak, chestnut	5	26.6	0.35
Oak, northern red	32	35.6	3.73
Oak, scarlet	3	63.4	1.06
Oak, white	43	35.1	5.60
Polar, yellow	25	38.1	3.44
Walnut, black	5	26.2	0.31
Total	274	26.9	23.69
Shrub Species			
Dogwood, flowering	5	12.7	0.04
Redbud, eastern	7	13.5	0.07
Sassafras	2	14.5	0.03
Serviceberry	5	15.4	0.10
Total	19	14.0	0.24

[a] Overstory were stems >1.5 m in height and ≥12 cm dbh.
[b] Total area of 15 plots was 0.6 ha.

Table 61. Density, average diameter, and basal area of large sapling[a] tree and shrub species in fifteen 20 x 20 m Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	32	8.8	0.22
Blackgum	20	7.9	0.11
Cherry, black	53	3.0	0.04
Elm, American	3	7.7	0.02
Elm, slippery	3	9.8	0.03
Hackberry	2	6.6	0.01
Hickory, bitternut	2	10.7	0.02
Hickory, mockernut	23	6.3	0.08
Hickory, pignut	10	7.9	0.06
Hickory, shagbark	20	7.6	0.10
Maple, red	13	7.2	0.06
Maple, sugar	3	7.6	0.02
Oak, northern red	2	10.7	0.02
Oak, white	3	11.2	0.03
Poplar, yellow	5	10.0	0.04
Total	194	8.2	0.86
Shrub Species			
Barberry, Japanese	12	2.0	0.004
Blackhaw, smooth	8	5.9	0.03
Dogwood, flowering	103	5.4	0.29
Grape	8	4.6	0.03
Redbud, eastern	48	4.2	0.08
Sassafras	2	10.9	0.02
Serviceberry	8	7.7	0.04
Spicebush	292	2.3	0.13
Witch hazel	15	6.1	0.05
Total	496	5.6	0.67

[a] Large saplings were stems >1.5 m in height and 2-11.9 cm dbh.
[b] Total area of 15 plots was 0.6 ha.

Table 62. Density, average diameter, and basal area of small sapling[a] tree and shrub species in fifteen 20 x 20 m Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Cherry, black	148	1.4	0.0237
Hickory, mockernut	2	1.3	0.0002
Hickory, shagbark	2	1.3	0.0002
Total	152	1.3	0.0241
Shrub Species			
Autumn olive	5	1.2	0.0006
Barberry, Japanese	190	0.9	0.0132
Blackhaw, smooth	5	1.5	0.0003
Dogwood, flowering	20	1.4	0.0032
Grape	2	1.5	0.0003
Greenbriar	80	0.5	0.0016
Honeysuckle, Tartarian	28	0.5	0.0006
Redbud, eastern	160	1.1	0.0169
Rose, multiflora	45	0.6	0.0012
Rubus	87	0.6	0.0032
Sassafras	2	0.5	0.0001
Spicebush	1,928	1.1	0.2066
Total	2,552	1.0	0.2478

[a] Small saplings were stems >1.5 m in height and <2 cm dbh.
[b] Total area of 15 plots was 0.6 ha.

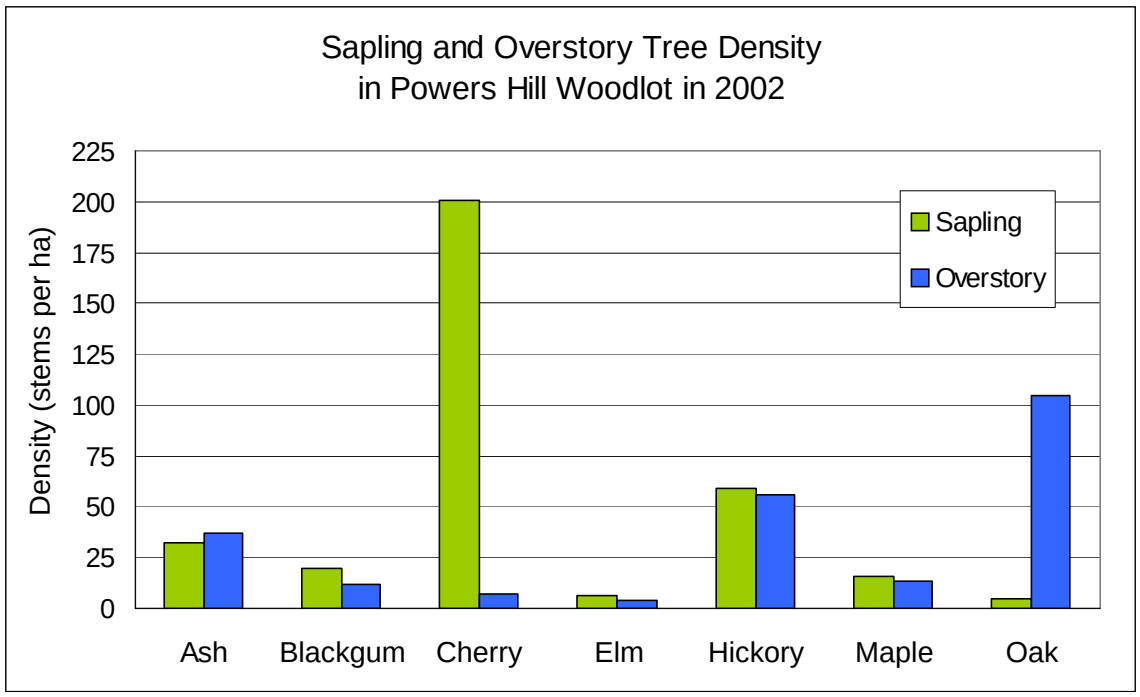


Figure 82. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) selected tree species in fifteen 20 x 20 m Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 2002

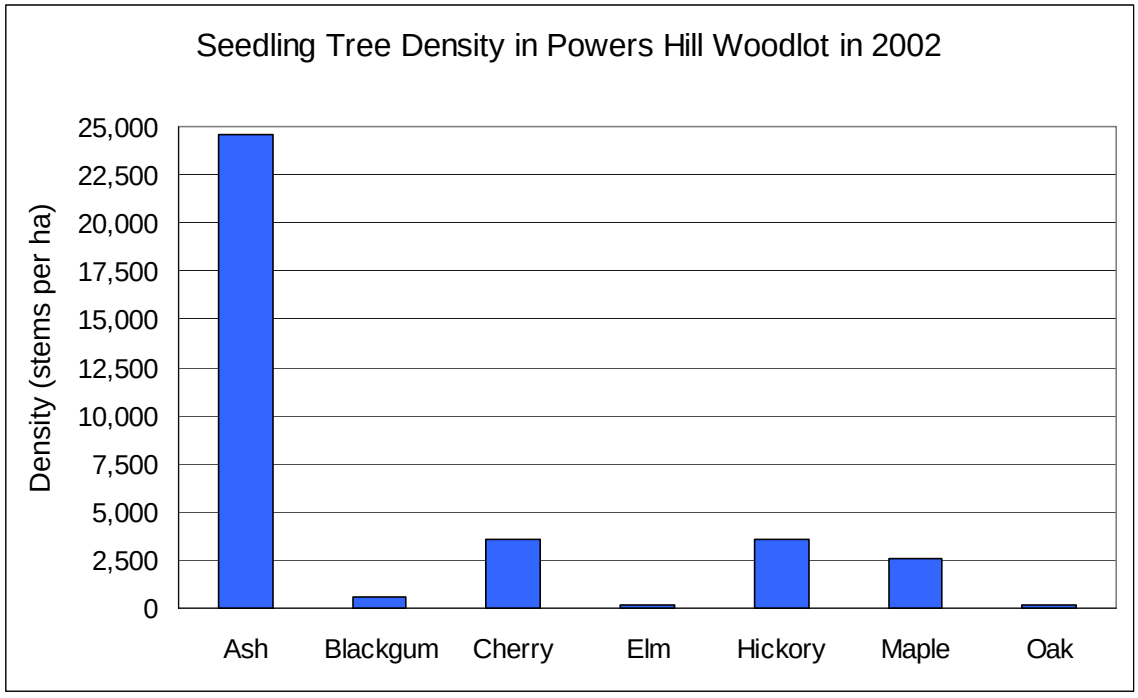


Figure 83. Density of seedling (≤150 cm in height) tree species in fifteen 2 x 2 m subplots within the Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 2002.

Table 63. Density of seedling[a] tree and shrub species in fifteen 2 x 2 m subplots within the Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)
Tree Species	
Ash	21,833
Blackgum	1,500
Cherry, black	6,500
Cherry, sweet	1,167
Elm, American	4,000
Elm, slippery	5,333
Hickory, mockernut	2,500
Hickory, pignut	333
Hickory, shagbark	1,167
Maple, red	1,167
Oak, red	167
Oak, swamp white	167
Oak, white	500
Total	46,334
Shrub Species	
Autumn Olive	167
Barberry, Japanese	12,500
Blackhaw, smooth	2,500
Dogwood, flowering	3,333
Euonymus	333
Hazelnut	167
Honeysuckle, Tartarian	1,167
Redbud, eastern	5,167
Rose, multiflora	1,000
Rubus	13,500
Sassafras	500
Serviceberry	333
Spicebush	26,167
Witch hazel	167
Total	67,001

[a] Seedlings were stems ≤150 cm in height.
[b] Total area of 15 subplots was 0.006 ha.

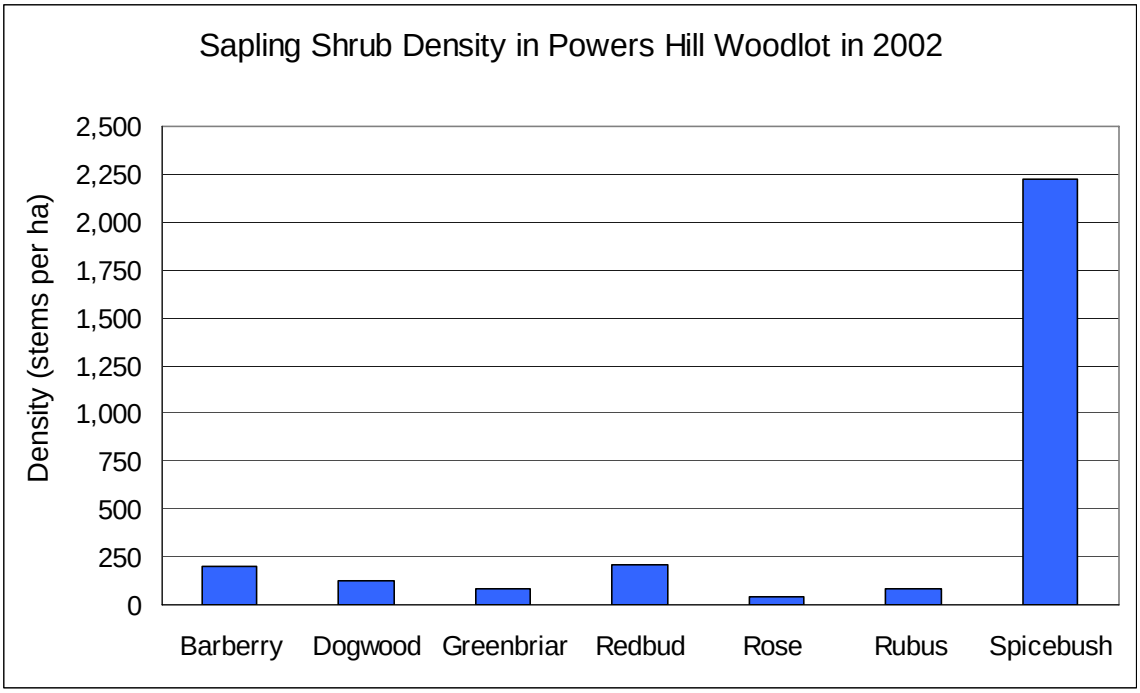


Figure 84. Density of sapling (>1.5 m in height and <12 cm dbh) selected shrub species in fifteen 20 x 20 m Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 2002.

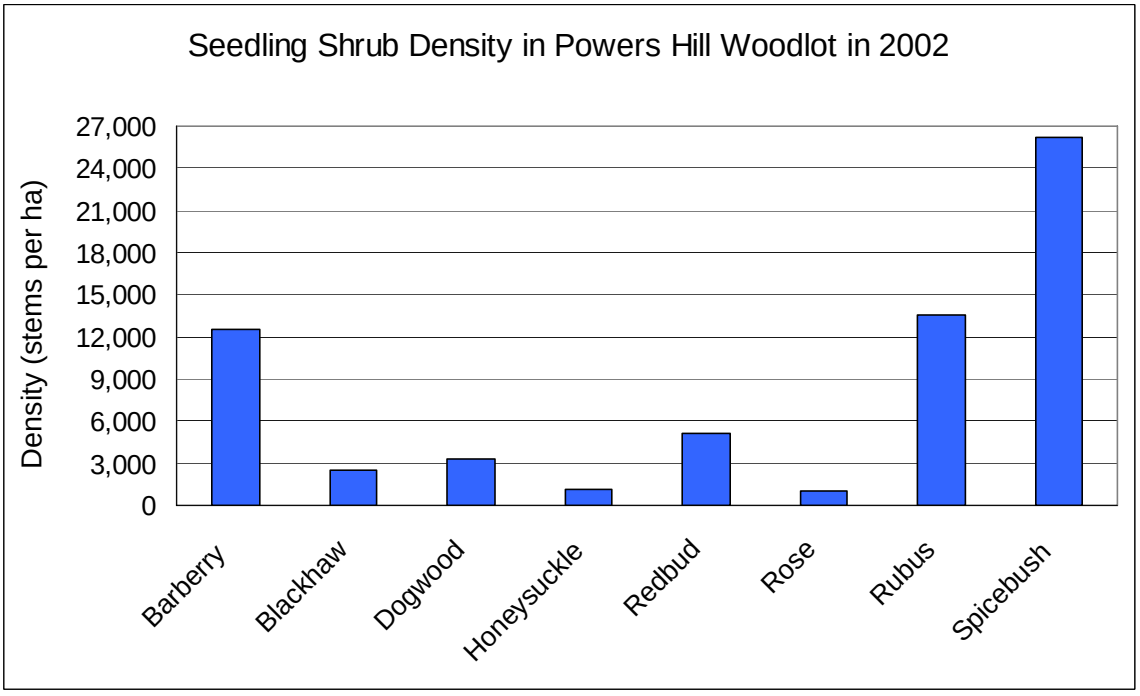


Figure 85. Density of seedling (≤150 cm in height) shrub species in fifteen 2 x 2 m subplots within the Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 2002.

Table 64. Average coverage for grass, forb, vine, and total species in fifteen 2 x 2 m subplots within the Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 2002.[a]

	Average Coverage (%)
Grass	7
Forb	37
Vine	4
Total	48

[a] Total area of 15 subplots was 0.006 ha.

Table 65. Comparison of the Importance Values (IV) of herbaceous and vine species with the ten greatest IVs in the unfenced 2 x 2 m subplots within the Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 1992 to 2002. The IVs were calculated from line transect data[a].

1992		1995		2002	
Species	IV	Species	IV	Species	IV
Japanese honeysuckle	98.7	Enchanter's-nightshade	35.0	Stiltgrass	75.6
Wild licorice	42.9	Japanese honeysuckle	30.4	Japanese honeysuckle	65.3
Bedstraw spp.	25.8	Rough bedstraw	29.8	White-snakeroot	23.8
Jewelweed	20.6	Wild licorice	29.2	Grass spp.	22.3
Club-rush	19.2	Sedge spp.	26.7	Virginia-creeper	21.1
Enchanter's-nightshade	18.4	White-snakeroot	22.9	Wild licorice	20.7
Lady's-thumb	16.1	Grass spp.	21.2	Jack-in-the-pulpit	12.6
Sedge (C. laxiflora)	13.3	Jack-in-the-pulpit	15.8	Common blue violet	10.7
White-snakeroot	11.1	Stiltgrass	12.3	Sedge spp.	8.5
Rue-anemone	7.9	Cinquefoil	9.2	Enchanter's-nightshade	7.6

[a] Data were collected in two 0.981 m2 quadrants in the 2 x 2 m subplot.

Spangler Woodlot

Tree Species:
Overstory: In 2002, fourteen tree species were inventoried in the overstory (>1.5 m in height and ≥12 cm dbh) category with a density of 321 stems/ha, an average dbh of 24.1 cm, and a basal area of 24.55 m^2 per ha (Tables 66 and 67). Overstory trees accounted for 40% of stems >1.5 m in height (Figure 86). The tree species with the greatest densities were white oak (22%), northern red oak (16%), black cherry (14%), sweet cherry (13%), mockernut hickory (9%), and ash (6%) (Figure 87). The other eight species of trees accounted for 21% of the total density (Table 67). The tree species with the greatest basal area were oak (72%), hickory (14%), and cherry (6%). The remaining six species of trees accounted for 7% of the total basal area. The overstory stocking level in the Spangler woodlot was 87% (Roach and Gingrich 1962).

Large Sapling: Twelve tree species were inventoried in the large sapling (>1.5 m in height and 2-11.9 cm dbh) category in 2002. The large sapling tree density was 468 stems/ha, with an average dbh of 7.1 cm, and a basal area of 2.17 m^2 per ha (Tables 66 and 68). The density was mostly distributed between mockernut hickory (22%), shagbark hickory (19%), black cherry (16%), sweet cherry (14%), pignut hickory (12%), and American elm (5%) (Figure 87). The remaining six species of trees accounted for 12% of the total density.

Small Sapling: Three tree species were recorded in the small sapling (>1.5 m in height and <2 cm dbh) category in 2002. The small sapling tree density was 13 stems/ha, with an average dbh of 1.2 cm, and a basal area of 0.0016 m^2 per ha (Tables 66 and 69). Black cherry, shagbark hickory, and white oak represented 57, 29, and 14%, respectively, of the total small sapling density (Figure 87). There were no small sapling-size ash recorded in 2002.

Seedling: Eleven species of trees were inventoried in the seedling (≤150 cm in height) category in 2002. The seedling tree density was 34,616 stems/ha (Table 70). Ash comprised the majority of the seedling density with 23,654 stems/ha or 68% of the total density (Figure 88). Cherry, hickory, and red maple represented 10, 10, and 7%, respectively, of the seedling tree density. The remaining five species of trees accounted for 5% of the total density.

Shrub Species:
Overstory: Two shrub species were inventoried in the overstory category in 2002. Only three percent of shrubs >1.5 m in height were overstory-size. The overstory shrub density was 10 stems/ha, with an average dbh of 17.8 cm, and a basal area of 0.29 m^2 per ha (Table 66). Sassafras and serviceberry comprised 60 and 40%, respectively, of the total overstory shrub density (Table 67).

Large Sapling: In 2002, four species of shrubs were recorded in the large sapling category with a density of 137 stems/ha, with an average dbh of 7.1 cm, and a basal area of 0.46 m^2 per ha (Tables 66 and 68). Smooth blackhaw was the most abundant species representing 72% of the total large sapling shrub density (Figure 89). Serviceberry, sassafras, and flowering dogwood comprised 15, 11, and 1%, respectively, of the total density.

Small Sapling: In 2002, five shrub species were inventoried in the small sapling category. The density was 144 stems/ha, with an average dbh of 0.8 cm, and a basal area of 0.0092 m^2 per ha (Tables 66 and 69). The density was comprised of multiflora rose (36%), smooth blackhaw (35%), *Rubus* (20%), serviceberry (8%), and Tartarian honeysuckle (1%) (Figure 89).

Seedling: Seven shrub species were recorded in the seedling category in 2002 with a total density of 23,845 stems/ha (Table 70). Smooth blackhaw was the predominant species with 10,577 stems/ha, or 44% of the total seedling shrub density (Figure 90). *Rubus* was also abundant, accounting for 37%. Wisteria and Japanese barberry contributed 9% and 5%, respectively, to the total seedling shrub density. The remaining three species of shrubs combined were 5% of the total density.

Herbaceous and Vine Vegetation: Herbaceous data (vine included) showed an average total herbaceous coverage of 22%. Forb coverage was greatest (17%), followed by vine and grass coverages (2% each) (Table 71).

Table 66. Density, average diameter, and basal area of small sapling, large sapling, and overstory tree and shrub species in thirteen 20 x 20 m Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 2002.[a]

	Small Sapling[b]	Large Sapling[b]	Overstory[b]
Tree Species			
Density (stems/ha)	13.0	468.0	321.0
Average DBH (cm)	1.2	7.1	24.1
Basal Area (m^2/ha)	0.0016	2.17	24.55
Shrub Species			
Density (stems/ha)	144.0	137.0	10.0
Average DBH (cm)	0.8	7.1	17.8
Basal Area (m^2/ha)	0.0092	0.46	0.29

[a] Total area of 13 plots was 0.52 ha.

[b] Small saplings were stems >1.5 m in height and <2 cm dbh; large saplings were stems >1.5 m in height and 2-11.9 cm dbh; overstory were stems >1.5 m in height and ≥12 cm dbh.

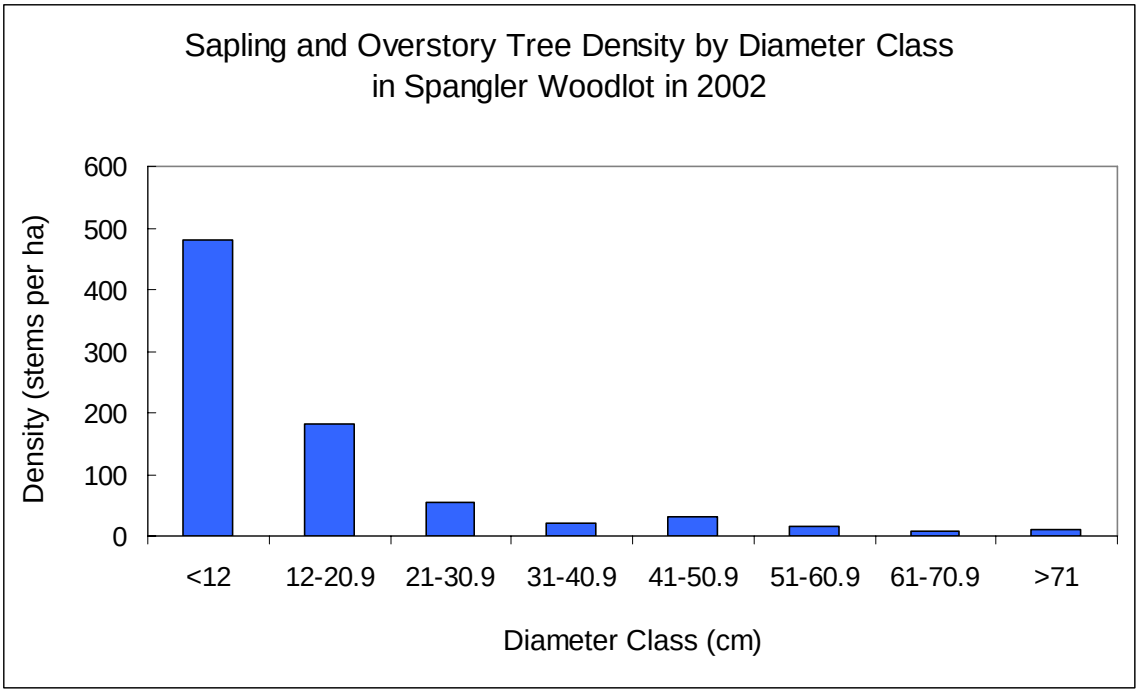


Figure 86. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) tree species by diameter class in thirteen 20 x 20 m Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 2002.

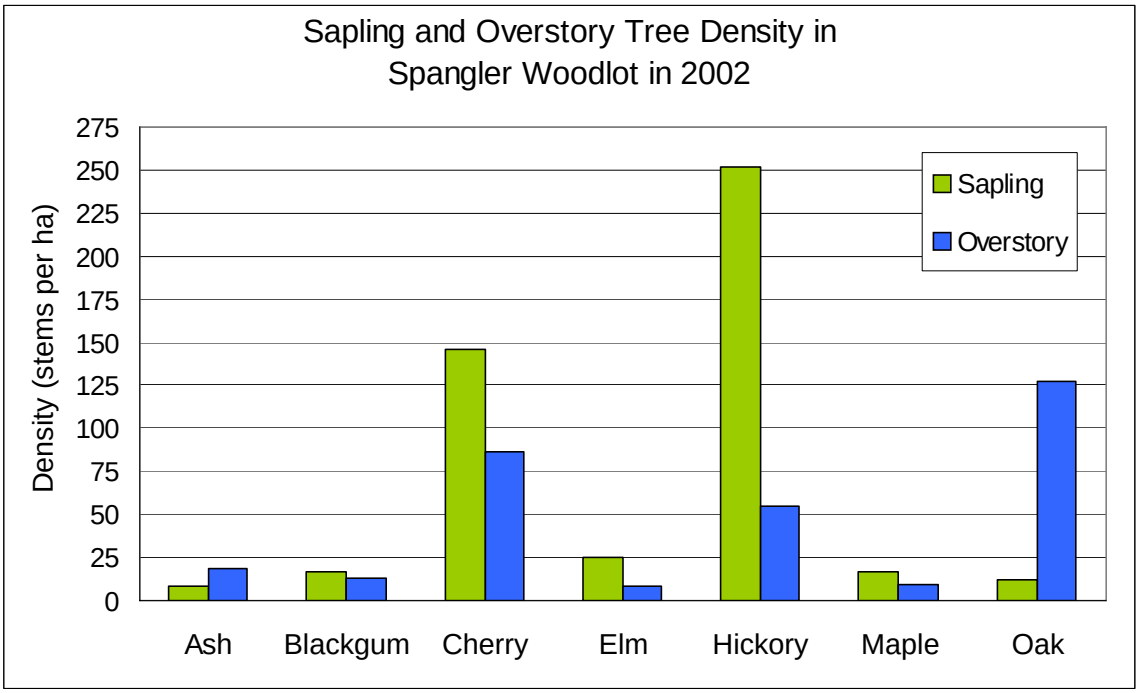


Figure 87. Density of sapling (>1.5 m in height and <12 cm dbh) and overstory (>1.5 m in height and ≥12 cm dbh) selected tree species in thirteen 20 x 20 m Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 2002.

Table 67. Density, average diameter, and basal area of overstory[a] tree and shrub species in thirteen 20 x 20 m Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	19	18.8	0.58
Blackgum	13	21.8	0.55
Cherry, sweet	42	15.3	0.80
Cherry, black	44	15.2	0.82
Elm, American	6	14.6	0.10
Elm, slippery	2	14.2	0.03
Hemlock, eastern	2	19.1	0.05
Hickory, mockernut	29	23.2	1.56
Hickory, pignut	13	22.7	0.59
Hickory, shagbark	13	34.6	1.33
Maple, red	9	20.3	0.36
Oak, black	8	40.0	1.26
Oak, northern red	69	27.2	4.31
Oak, white	50	50.9	12.21
Total	321	24.1	24.55
Shrub Species			
Sassafras	6	21.1	0.23
Serviceberry	4	14.5	0.07
Total	10	17.8	0.29

[a] Overstory were stems >1.5 m in height and ≥12 cm dbh.
[b] Total area of 13 plots was 0.52 ha.

Table 68. Density, average diameter, and basal area of large sapling[a] tree and shrub species in thirteen 20 x 20 m Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Ash	8	8.2	0.04
Blackgum	17	7.7	0.09
Cedar, eastern red	2	2.2	0.001
Cherry, sweet	65	8.5	0.39
Cherry, black	73	8.2	0.40
Elm, American	25	6.7	0.10
Hackberry	2	8.1	0.01
Hickory, mockernut	104	6.3	0.39
Hickory, pignut	54	6.4	0.21
Hickory, shagbark	90	7.0	0.40
Maple, red	17	7.8	0.09
Oak, northern red	10	7.9	0.05
Total	468	7.1	2.17
Shrub Species			
Blackhaw, smooth	98	5.1	0.25
Dogwood, flowering	2	6.6	0.01
Sassafras	15	9.9	0.12
Serviceberry	21	6.7	0.08
Total	137	7.1	0.46

[a] Large saplings were stems >1.5 m in height and 2-11.9 cm dbh.
[b] Total area of 13 plots was 0.52 ha.

Table 69. Density, average diameter, and basal area of small sapling[a] tree and shrub species in thirteen 20 x 20 m Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)	Average DBH (cm)	Basal Area (m^2/ha)
Tree Species			
Cherry, black	8	1.2	0.0010
Hickory, shagbark	4	1.0	0.0003
Oak, white	2	1.4	0.0003
Total	13	1.2	0.0016
Shrub Species			
Blackhaw, smooth	50	1.2	0.0056
Honeysuckle, Tartarian	2	0.7	0.0001
Rose, multiflora	52	0.6	0.0016
Rubus	29	0.7	0.0010
Serviceberry	12	1.0	0.0009
Total	144	0.8	0.0092

[a] Small saplings were stems >1.5 m in height and <2 cm dbh.
[b] Total area of 13 plots was 0.52 ha.

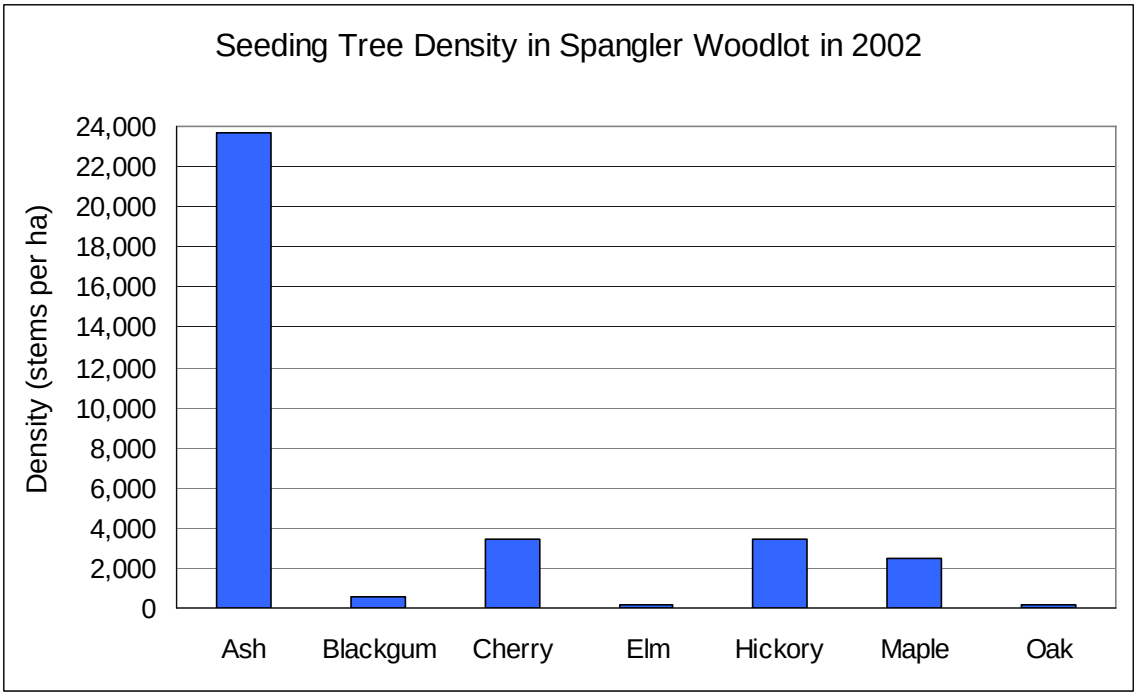


Figure 88. Density of seedling (≤150 cm in height) tree species in thirteen 2 x 2 m subplots within the Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 2002.

Table 70. Density of seedling[a] tree and shrub species in thirteen 2 x 2 m subplots within the Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 2002.[b]

	Density (stems/ha)
Tree Species	
Ash	23,654
Blackgum	577
Cedar, eastern red	385
Cherry, sweet	385
Cherry, black	3,077
Elm, slippery	192
Hackberry	192
Hickory, mockernut	577
Hickory, pignut	2,885
Maple, red	2,500
Oak, northern red	192
Total	34,616
Shrub Species	
Barberry, Japanese	1,154
Blackhaw, smooth	10,577
Rose, multiflora	769
Rubus	8,846
Sassafras	192
Serviceberry	192
Wisteria	2,115
Total	23,845

[a] Seedlings were stems ≤150 cm in height.
[b] Total area of 13 subplots was 0.0052 ha.

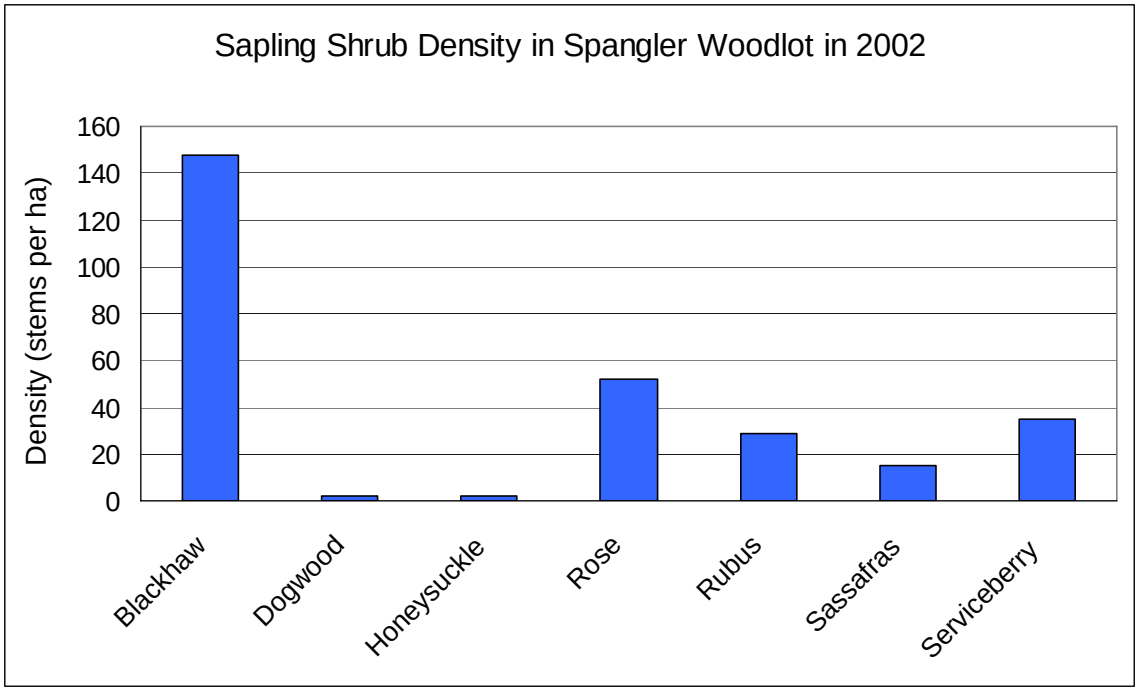


Figure 89. Density of sapling (>1.5 m in height and <12 cm dbh) shrub species in thirteen 20 x 20 m Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 2002.

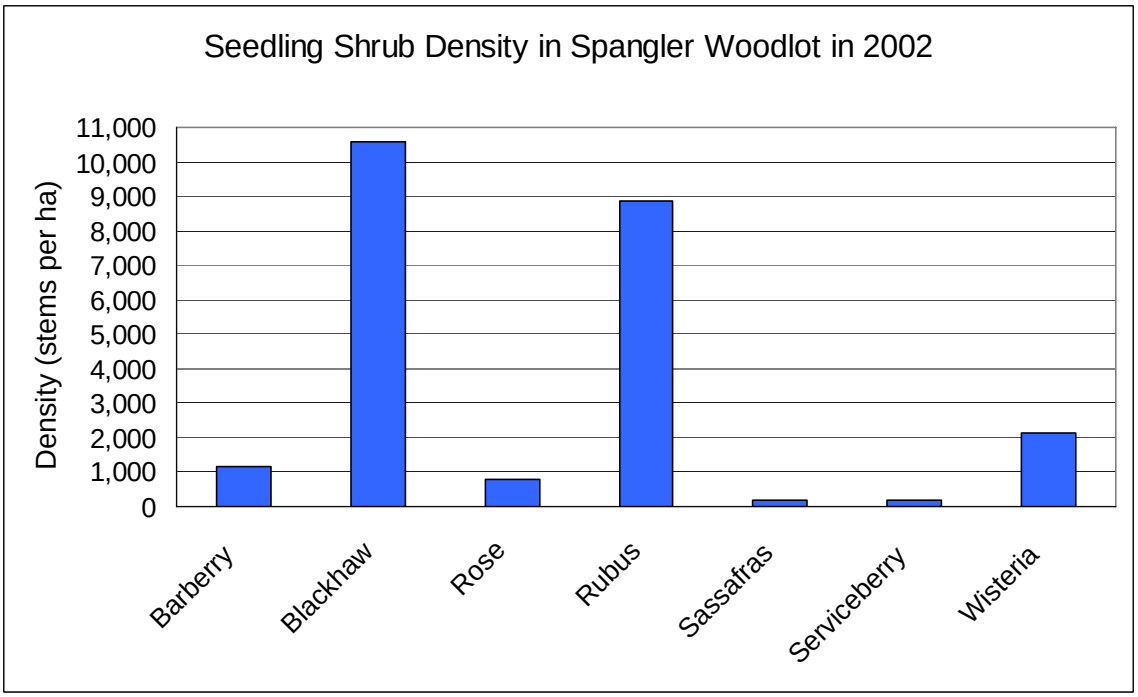


Figure 90. Density of seedling (≤1.5 m in height) shrub species in thirteen 2 x 2 m subplots within the Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 2002.

Table 71. Average coverage for grass, forb, vine, and total species in thirteen 2 x 2 m subplots within the Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 2002.[a]

	Average Coverage (%)
Grass	2
Forb	17
Vine	2
Total	22

[a] Total area of 13 subplots was 0.0052 ha.

Discussion

Values of tree and shrub species diversity (number of species) and density for 1990/92 and 1996 were taken from Bowersox et al. 2002.

Biesecker Woodlot (Combined Fenced and Unfenced Data)

Tree Species:
Overstory: Between 1990/92 and 1996, the density of overstory trees remained stable at 310 and 305 stems/ha. Overstory tree species diversity decreased from 17 to 14 species during those inventories (Figure 91). From 1996 to 2002, there was a slight increase in overstory tree density from 305 to 328 stems/ha. The number of trees species recorded in the overstory also increased from 14 to 20 species from 1996 to 2002 (Figure 91). The dominant overstory species were oak, hickory, and cherry from 1990 to 2002. Tree species basal area steadily increased from 23 to 26.5 m^2/ha in the overstory between 1990/92 and 2002.

Large Sapling: The density of large sapling trees decreased from 986 to 747 to 552 stems/ha in 1990/92, 1996, and 2002, respectively. Tree species diversity went from 17 to 11 to 14 species, respectively (Figure 91). From 1990/92 to 2002, hickory was the most abundant species over time with densities that slowly declined from 558 stems/ha in 1990/92 to 374 stems/ha in 2002. Cherry and oak were the next most prevalent species during the three inventories.

Small Sapling: There was a decrease in small sapling tree density from 61 to 11 stems/ha from 1990/92 to 1996, but then a slight increase to 15 stems/ha in 2002. The diversity of tree species was seven, four, and six species in 1990/92, 1996, and 2002, respectively (Figure 91). In 1990/92, black cherry (36 stems/ha) was the dominant species, with white oak second most abundant (14 stems/ha). In 1996, the cherry and oak were the most abundant trees with densities (four stems/ha, each) that were equivalent. In 2002, the small sapling density was comprised of hickory (8 stems/ha), cherry (five stems/ha), and ash (two stems/ha). There were no oaks inventoried in 2002.

Seedling: Tree species density decreased between the 1990/92 to 1996 inventories from 25,250 to 14,722 stems/ha, but increased to 18,889 stems/ha in 2002 (Figure 92). Between 1990/92 and 1996, the seedling tree diversity decreased from nine to eight species, but increased to thirteen species in 2002 (Figure 91). In 1990, oak (10,167 stems/ha) and cherry (10,000 stems/ha) were the dominant species. In 1996, the densities of oak and cherry species (5,556 and 6,667 stems/ha, respectively) had decreased but they were still the most abundant species. The trend of oak and cherry dominance continued through the 2002 inventory, but the densities increased. In 2002, cherry was the dominant species with 8,889 stems/ha, or 47% of the total seedling tree density, and oak density was 5,695 stems/ha.

Goal Stocking Levels: In the 1990/92, 1996, and 2002 inventories, the density of overstory trees (310, 305, and 328 stems/ha, respectively) was at or exceeded the 60% stocking level goal (306 stems/ha) for the woodlot. In 1996 and 2002, the densities of large sapling trees (747 and 552 stems/ha, respectively) were not adequate to meet the 60% stocking level goal (935 stems/ha) for the woodlot, although the density initially recorded in 1990/92 (986 stems/ha) was great enough. In all three inventories, the density of small sapling trees was severely below the 60% stocking level goal (2,806 stems/ha). The densities recorded in 1990/92 (62 stems/ha), 1996 (11 stems/ha), and 2002 (15 stems/ha) were less than 2.2%, 0.4%, and 0.5%, respectively, of the goal density needed to adequately stock the forest. Conversely, the seedling tree densities in 1990/92 and 2002 (25,250 and 18,889

stems/ha, respectively) exceeded the seedling 60% stocking level goal (16,834 stems/ha). The density recorded in 1996 (14,722 stems/ha) was just slightly below the desired stocking level, but the 2002 results indicated an increasing trend may be starting.

Shrub Species:
Overstory: Overstory shrubs were inventoried in 1996 and 2002, but not in 1990. The density decreased from 3 to 0 stems/ha between 1996 and 2002. Eastern redbud was the only species inventoried in the overstory shrub size category in 1996. In 2002, there were no overstory shrubs recorded in the plots (Figure 91).

Large Sapling: Sapling shrubs were inventoried in 1996 and 2002, but not in 1990. From 1996 to 2002, the density of large sapling shrubs decreased from 80 to 57 stems/ha. However, the density of large sapling shrubs was still greater than their overstory densities. Between 1996 and 2002, the species composition of large sapling shrubs only changed from four to three species (Figure 91). Smooth blackhaw, flowering dogwood, and serviceberry were recorded in both inventories, eastern redbud was absent in 2002, and flowering dogwood densities declined substantially.

Small Sapling: From 1996 to 2002, the density of small sapling shrubs increased from 11 to 136 stems/ha. The diversity of shrubs increased from three to four species (Figure 91). The three species present in 1996 (percent of the total density) were smooth blackhaw (64%), flowering dogwood (27%), and serviceberry (18%). In 2002, the small sapling category was comprised of multiflora rose (59%), *Rubus* (29%), Japanese barberry (6%), and smooth blackhaw (7%).

Seedling: Between the 1990/92, 1996, and 2002 inventories, the density of seedling shrubs changed from 7,833 to 6,944 to 28,000 stems/ha, respectively (Figure 92), with a steady increase in species diversity from four to six species (Figure 91). In 1990/92, the greatest components of the seedling shrub category (percent of total density) were *Rubus* (51%) and smooth blackhaw (46%). In 1996, the dominant species were flowering dogwood (39%), Japanese barberry (39%), and multiflora rose (15%). In 2002, *Rubus* (59%), smooth blackhaw (18%), and Japanese barberry (14%) comprised the greatest portion of the seedling shrub density.

Herbaceous and Vine Vegetation: Compared to the 1996 herbaceous data, in 2002 there was an overall decrease in average total coverage from 24 to 19%, and decreases in vine (6 to 4%) and grass (7 to 1%) coverage. Forb coverage increased slightly from 11 to 15%.

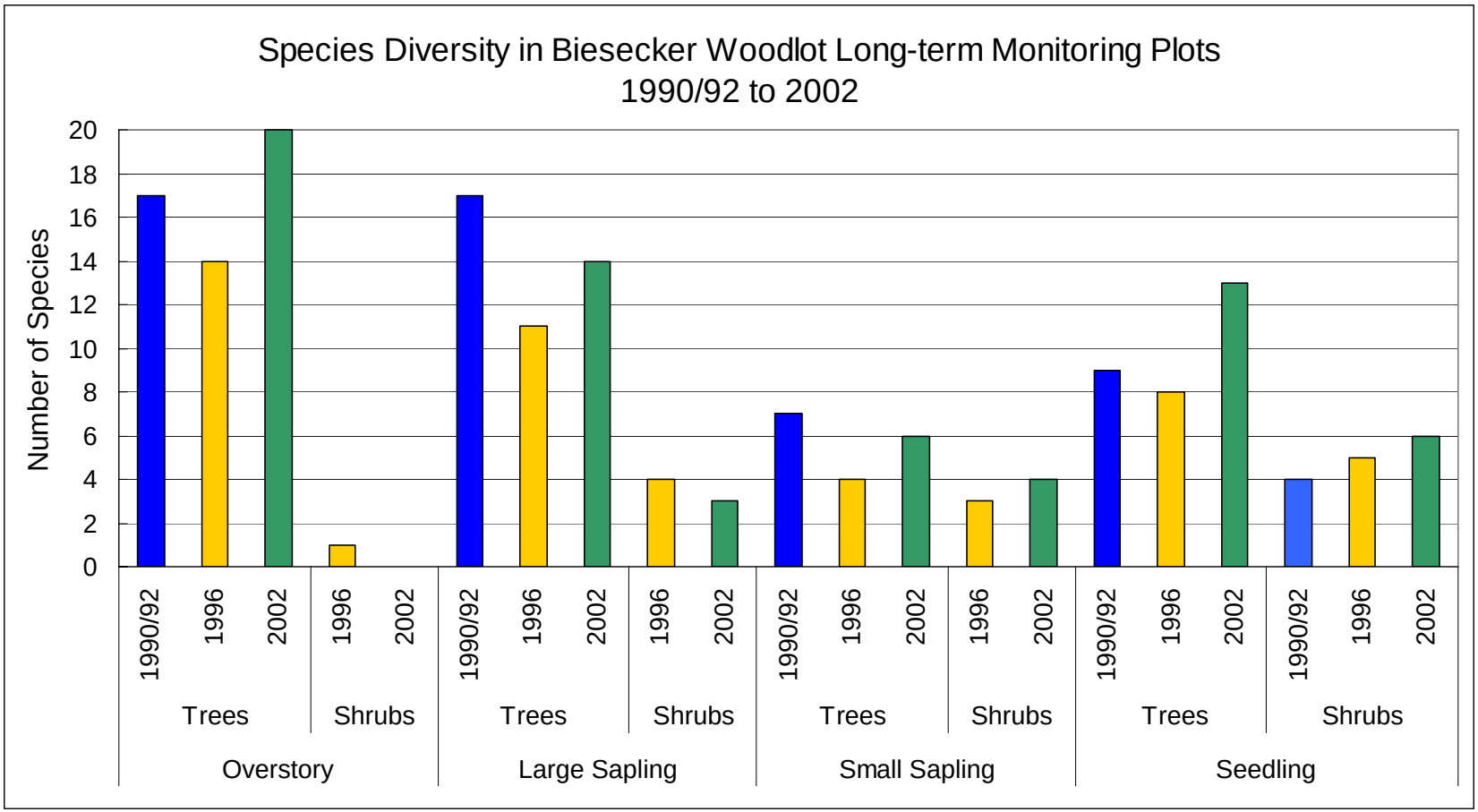


Figure 91. Number of overstory (>1.5 m in height and ≥12 cm dbh), large sapling (>1.5 m in height and 2-11.9 cm dbh), small sapling (>1.5 m in height and <2 cm dbh), and seedling (≤150 cm in height) tree and shrub species in the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 1990/92 to 2002.

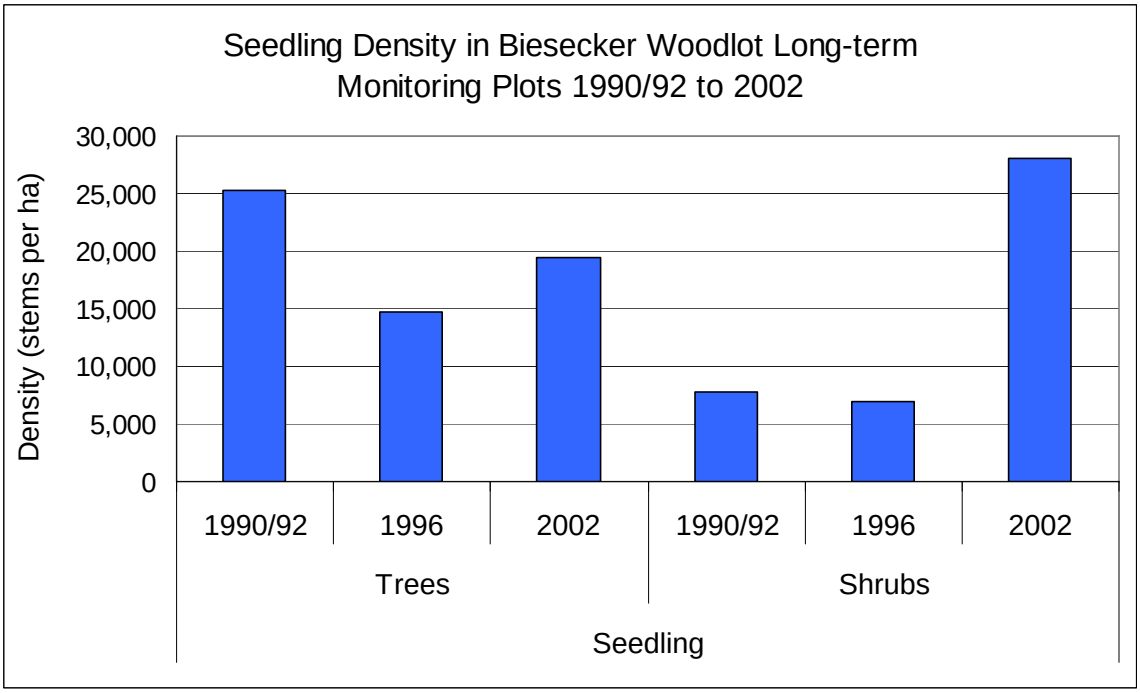


Figure 92. Density of seedling (≤150 cm in height) tree and shrub species in 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker woodlot, Gettysburg National Military Park, 1990/92 to 2002.

Biesecker Woodlot – Fenced and Unfenced Plot Comparisons

Tree Species:
Seedling: Since 1990/92, seedling tree densities were consistently greater in the fenced subplots than in the unfenced subplots. Seedling tree densities in the fenced subplots decreased from 43,501 stems/ha in 1990/92 to 20,833 stems/ha in 1996, then increased slightly to 24,791 stems/ha in 2002. The unfenced subplots exhibited a similar trend over time. The unfenced seedling tree density went from 7,000 stems/ha in 1990/92 to 2,500 stems/ha in 1996, and then increased to 7,084 stems/ha in 2002.

In 1996 and 2002, seedling tree diversity was much greater in the fenced subplots (8 and 13 species, respectively) than in the unfenced subplots (3 and 4 species, respectively). The seedling tree category was comprised predominantly of cherry in both the fenced and unfenced subplots (9,167 and 1,667 stems/ha, respectively) in 1996 and in 2002 (10,209 and 6,250 stems/ha, respectively). In 1996, there was a greater density of oaks in the fenced subplots (8,125 stems/ha) than in the unfenced subplots (417 stems/ha). This trend repeated in 2002, when oak seedling density was 8,542 stems/ha in the fenced subplots, but zero in the unfenced subplots.

Goal Stocking Levels: In 1996, the seedling tree density in the fenced subplots (20,833 stems/ha) was greater than the 60% stocking level goal (16,834 stems/ha), but the density in the unfenced subplots was severely low (2,500 stems/ha). This trend was still evident in 2002, when the density of seedling trees in the fenced subplots (24,791 stems/ha) exceeded the 60% stocking level goal (16,834 stems/ha) for the woodlot. However, the density in the unfenced subplots (7,084 stems/ha) was half of the density needed to achieve the forest management goals. In 1996 and 2002, cherry species were the dominant tree species in the unfenced subplots with densities of 1,667 and 6,250 stems/ha, respectively, or 66 and 88% of the total unfenced seedling tree density, respectively. Black cherry is not preferred and avoided by white-tailed deer and increases in density with increasing number of deer (Horsley et al. 2003).

Shrub Species:
Seedling: In 1996, the density of seedling shrubs was almost equal between the fenced (16,458 stems/ha) and the unfenced subplots (17,917 stems/ha). However, in 2002 there were twice as many shrub stems (33,124 stems/ha) in the fenced subplots than in the unfenced subplots (15,417 stems/ha). Between 1996 and 2002, shrub diversity increased slightly from four to five species in the fenced subplots and decreased five to three species in the unfenced subplots. In 1996, flowering dogwood was the most abundant shrub in the fenced subplots (8,542 stems/ha) and Japanese barberry was dominant in the unfenced subplots (13,750 stems/ha). In 2002, *Rubus* was the dominant species in the fenced subplots (20,625 stems/ha), but Japanese barberry (7,500 stems/ha) had a slightly greater density than *Rubus* (7,083 stems/ha) in the unfenced subplots.

The Deer Management Program was implemented in 1995, but the density of deer remained above the goal of 25 deer/forested square mile (Storm 2004). More time may be needed to see a recovery from the intense deer browse. In theory, if the Deer Management Program was successful in reducing the deer foraging pressure, then the seedling density values should be similar or at least approaching equivalency between the fenced and unfenced plots. However, this was not supported by the data recorded in Biesecker woodlot in 2002 (Table 28). The density of seedling trees in the fenced plot was three times greater than in the unfenced plot in 2002. The number of deer shot in the Biesecker woodlot compartment in 2000/01 and 2001/02 was greater than in any other compartment, however there remains a problem of deer traveling among compartments and between private and public Park lands on an annual basis (Storm 2004).

Deer foraging was not the sole factor in low seedling tree densities. Shrub species (native and non-native), closed canopy conditions, and small mammal predation may all be contributing to an overall negative impact on the presence of seedling trees. Non-native Japanese barberry densities were substantially greater in the unfenced plots than in the fenced plots (7,500 and 2,083 stems/ha, respectively) in 2002. These shrubs may pose a different problem in the management of the woodlot, because non-native invasive species will be much more deleterious to the forest health over time than the presence of the native shrub, *Rubus*. *Rubus* densities may fluctuate with time, but non-native shrubs like barberry and multiflora rose will only increase over time, unless controlled. Competition with *Rubus* and other shrub species (especially non-native species) could have a negative effect on seedling tree presence and growth.

Herbaceous and Vine Vegetation: From 1996 to 2002, grass (4 to 1%, respectively), vine (10 to 4%, respectively), and total herbaceous (27 to 25%, respectively) coverages decreased but forb coverage (13 to 20%, respectively) increased in the fenced subplots. In the unfenced subplots, grass (10 to 2%, respectively) and total herbaceous (22 to 14%, respectively) coverages decreased, but forb (9%) and vine (3%) coverages remained the same.

Fenced: Japanese honeysuckle (*Lonicera japonica*) had the greatest Importance Value (IV) in the spring 1992, 1995, and 2002 surveys. The IV increased from the initial 76.5 in 1992 to 86.4 in 1995 and to 128.0 in 2002 (Table 72). Spring-beauty (*Claytonia virginica*) had the second greatest IV rank in 1992 and 1995 with almost identical values; however its IV halved in 2002 and became fourth-ranked. Virginia-creeper (*Parthenocissus quinquefolia*) increased from 13.7 to 14.6 to 42.7 over the three sampling periods. Enchanter's-nightshade (*Circaea lutetiana*) didn't rank in the top ten IVs in 1992. It was fifth-ranked in 1995 and third in 2002. Sedges (*Carex* spp.) dropped from fourth rank in 1992 to tenth in 1995 and was not in the top ten in 2002. Seven of the top ten-ranked species in 1992 were still in the top ten in 2002. The Shannon Index values were 1.02, 0.96, and 0.80 in 1992, 1995, and 2002, respectively (Table 31). The Evenness Index values were 0.76, 0.74, and 0.65 during the same years, respectively.

Unfenced-Control: Spring-beauty had the greatest IV in 1992 and 1995, but dropped to third in rank in 2002 at about one-third the value of the two previous surveys (Table 32). Japanese honeysuckle, which ranked second in 1992 and 1995, had the greatest IV in 2002 at twice the numerical value of 1995. Grass spp. (*Poaceae*) were ranked second in 2002, third in 1992, and eighth in 1995. Enchanter's-nightshade increased from fifth rank in 1992 and 1995, to fourth rank in 2002 with nearly the same value as before. Only five species present in the top ten in 1992 were among the top ten in 2002. The Shannon Index values were 0.82, 0.86, and 0.78 in 1992, 1995 and 2002, respectively, and the Evenness Index values were 0.62, 0.68, and 0.65 during the same years, respectively (Table 31).

Unfenced: Within the unfenced Biesecker subplots, there was much greater change in the IV rankings between inventories from year to year. The unfenced subplots were some distance from the fenced subplots. Whereas Japanese honeysuckle dominated in the fenced and unfenced-control subplots, there was no dominant species in the unfenced subplots. Grass spp. increased to first rank IV in 2002. Japanese honeysuckle ranked second with approximately one third the IV of that in the fenced and unfenced-control subplots (Table 33). Spring-beauty, which had the greatest value in 1995, dropped to fourth rank in 2002 with about one quarter of the 1995 value. Enchanter's-nightshade also dropped from third to sixth rank, whereas it had moved up in the fenced subplots. A sedge species that was ranked first in 1992 (comprised part of the unspecified sedge category in 1995) did not appear in the top ten in 2002. Six species present in the top ten in 1992 were still in the top ten in 2002. The

Shannon Index values were 0.93, 0.78, and 1.06 in 1992, 1995, and 2002, respectively (Table 31). The Evenness Index values were 0.79, 0.63, and 0.80 in the same years, respectively.

Comparison of Biesecker Fence Treatment Plots in 2002: Japanese honeysuckle dominated in both the fenced and unfenced-control subplots in the 2002 inventory with IV's of 128.0 and 136.7, respectively. It dropped to second rank at roughly half of the IV in the unfenced subplots (Table 72). Four of the top five ranked species in the fenced subplots were also found in the top five of the unfenced control subplots, but only three were found in the top five species of the unfenced subplots. Grass spp. ranked fifth in the fenced subplots and first in the unfenced subplots.

Japanese honeysuckle continued to dominate the fenced subplots at Biesecker and nearly doubled its Importance Value (IV) since 1992 (Table 30). Its IV increased slightly in the unfenced-control subplots (Table 32), mainly due to its greater dominance value than spring-beauty, which has a much smaller leaf area. In the unfenced subplots, it ranked in the top ten species during all three sampling periods, but did not dominate nearly as much (Table 33). Because it is evergreen, Japanese honeysuckle has a growth advantage over most of the other herbaceous and vine species as it can start growing immediately once the air and soil warms up in the spring, whereas others have to start from seeds or underground organs. Since it is evergreen, it can photosynthesize throughout the winter when temperatures are favorable. Its evergreen nature also contributes to its greater recorded presence in that it is always visible. Others may have not yet developed or have mostly dried up at the inventory time and they may be missed because of timing of the survey.

Spring-beauty consistently ranked high in Biesecker, but did not appear in the top ten IVs in any of the other woodlots. Biesecker was always the first woodlot inventoried, so there were still intact leaves at that time. Some leaves were visible in the other woodlots, but they were nearly all deteriorated because spring-beauty is one of the earliest flowering plants in the area.

Interestingly, Virginia-creeper progressively increased in importance in the fenced subplots to a second ranking, but it did not appear within the top ten species in the unfenced subplots. It increased from less than a top ten ranking to eighth in the unfenced-control subplots, but at a very low numerical IV. The increase in importance in the fenced subplots may reflect the absence of white-tailed deer browse.

There did not seem to be any other trend or pattern of variation within the species between the fenced and unfenced subplots. There was variation from survey to survey, but it appeared to be just random variation due to climatic effects on germination and development or in shifts in the transect location. Slight differences in orientation of the line transect could easily alter the relative interception with the species present in the area. There were a number of species with IV in the top ten in both the 1992 and 2002 inventories. There were seven species in the fenced, five species in the unfenced-control, and six species in unfenced subplots, indicating a fair degree of constancy in coverage (Tables 30, 32, and 33).

The Shannon Index of Diversity and Evenness Index decreased from 1992 to 2002 in the fenced subplots, principally due to the dominance of Japanese honeysuckle (Table 31). There were no major trends in the unfenced-control or unfenced subplots. The number of species present declined in both the fenced and unfenced-control subplots, but increased in the unfenced subplots (Table 73). The number of species decreased 47% in the fenced subplots since 1992. This was likely due to a number of species being smothered by the accumulated leaf litter inside the fenced area. Leaf litter averaged 89% of the cover within the two fenced quadrants where the line transects were completed. There is nothing to indicate that the lesser decrease in the unfenced-control subplots and the slight increase in

species in the unfenced subplots is due to any other factor than natural variation over time. When woody shrubs were included in the transect data, the IV of blackberry-dewberry (*Rubus*) species ranked third overall in Biesecker.

Table 72. A comparison of the Importance Values (IV) of the herbaceous and vine species with the ten greatest IVs in the fenced and unfenced 2 x 2 m subplots within the Long-term Monitoring Plots and unfenced-control 2 x 2 m subplots in Biesecker woodlot, Gettysburg National Military Park, 2002. The values were calculated from line transect data[a] collected in May 2002.

Fenced		Unfenced-Control[b]		Unfenced		Combined Unfenced	
Species	IV	Species	IV	Species	IV	Species	IV
Japanese honeysuckle	128.0	Japanese honeysuckle	136.7	Grass spp.	59.0	Japanese honeysuckle	93.5
Virginia-creeper	42.7	Grass spp.	39.3	Japanese honeysuckle	39.8	Grass spp.	48.4
Enchanter's-nightshade	33.6	Spring-beauty	29.8	Sheep sorrel	25.8	Spring-beauty	27.3
Spring-beauty	22.7	Enchanter's-nightshade	23.3	Spring-beauty	24.7	Enchanter's-nightshade	23.3
Grass spp.	20.2	Garlic-mustard	16.0	Cut-leaved toothwort	23.6	Cut-leaved toothwort	13.7
Garlic-mustard	16.0	Wild licorice	15.6	Enchanter's-nightshade	23.4	Sheep sorrel	11.5
Jewelweed	13.1	Jewelweed	9.9	Cinquefoil	18.0	Wild licorice	10.5
Wild licorice	4.1	Virginia-creeper	9.0	Common blue violet	17.5	Cinquefoil	9.6
Cinquefoil	3.9	Goldenrod spp.	4.8	Violet wood-sorrel	12.4	Garlic-mustard	8.7
Cleavers	3.9	Cut-leaved toothwort	4.8	Field pussytoes	12.2	Jewelweed	8.2

[a] Data were collected in two 0.981 m2 quadrants in the 2 x 2 m subplot.

[b] An unfenced area adjacent to the fenced subplot were used as the unfenced-control subplot, in addition to the fixed unfenced subplot.

Table 73. A comparison between the number of herbaceous and vine species encountered in the line transects in the fenced and unfenced 2 x 2 m subplots within the Long-term Monitoring Plots and unfenced-control 2 x 2 m subplots in Biesecker, Bushman Hill, Herr Ridge, Pitzer, and Powers Hill woodlots, Gettysburg National Military Park, and the Coefficients of Similarity between the sampling periods. Calculated values were based on data inventoried in May-August 1992, and May-June, 2002, except for Pitzer woodlot, which was first inventoried from May-June, 1995.

	Number of Species		Species	Coefficient
	1992	2002	in Common	of Similarity
Biesecker				
Fenced	32	17	12	0.49
Unfenced-controls	21	16	12	0.65
Unfenced	15	21	12	0.67
Bushman Hill	32	29	18	0.59
Herr Ridge	22	15	10	0.54
Pitzer				
Fenced*	25	25	14	0.58
Unfenced-controls*	14	26	9	0.45
Unfenced*	12	19	12	0.67
Powers Hill	18	25	15	0.70

* Data collected May-June, 1995, instead of in 1992.

Bushman Hill Woodlot

Tree Species:
Overstory: Overstory trees were inventoried in 1990/92 and 2002, but not in 1996. From 1990/92 to 2002, the density of overstory trees decreased from 317 to 264 stems/ha. Sixteen species were recorded during both inventories (Figure 93). Oaks were the dominant component of this size category over time. Overstory tree basal area values were similar in 1992 and 2002, with 27 and 26.9 m^2 per ha.

Large Sapling: Sapling trees were inventoried in 1990/92 and 2002, but not in 1996. Between 1990/92 and 2002, the density of large sapling trees decreased from 292 to 171 stems/ha. The species diversity remained the same at 15 species in 1990/92 and 2002 (Figure 93). Over time, hickory was the dominant species with 183 stems/ha in 1990/92 and 70 stems/ha in 2002.

Small Sapling: Between 1990/92 and 2002, there was an increase in small sapling tree density from eight to 41 stems/ha. The number of trees doubled from three to six species (Figure 93). Black cherry was dominant in 1990/92 with three stems/ha, but elm were dominant in 2002 with 18 stems/ha.

Seedling: Seedling tree inventories were completed in 1990/92, 1996, and 2002. From 1990/92 to 1996, the density of seedling trees decreased from 43,832 to 26,500 stems/ha, then increased to 41,166 stems/ha in 2002 (Figure 94). The number of tree species was eleven, eight, and fifteen species in 1990/92, 1996, and 2002, respectively (Figure 93). Ash had the greatest density (17,167 stems/ha) in 1990/92, but black cherry replaced it as the dominant seedling tree species (6,667 stems/ha) in 1996. In 2002, ash was again the predominant species with 18,000 stems/ha.

Goal Stocking Levels: In 1990/92 and 2002, the density of overstory trees was 317 and 262 stems/ha, fluctuating below the 60% stocking level goal of 306 stems/ha. The large sapling tree densities in 1990/92 (292 stems/ha) and 2002 (171 stems/ha) were 31% and 18% of the 60% stocking level goal (935 stems/ha) for the woodlot. The 60% stocking goal for small sapling trees is 2,806 stems/ha. However, the small sapling densities recorded in 1990/92 (eight stems/ha) and 2002 (41 stems/ha) were a minor fraction (0.3% and 1.5%) of the goal stocking level. Seedling tree densities in 1990/92 (43,832 stems/ha) and 2002 (41,166 stems/ha) were more than double the stocking level goal (16,834 stems/ha).

This indicates a serious problem with the presence of tree species in the woodlot. Seedling tree densities were sufficient, however the seedlings were not maturing into sapling-sized stems. Even though the white-tailed deer herd has been reduced in this area of the park, the trees are not responding to the modest release from browse pressure. Other factors that are probably having deleterious impacts on the trees in the woodlot include canopy conditions and competition with shrub species. In 2002, the density of large sapling (428 stems/ha), small sapling (1,814 stems/ha), and seedling (74,167 stems/ha) shrubs surpassed all the tree density values in the perspective size categories.

Shrub Species:
Overstory: Overstory shrubs were inventoried in 2002, but not in 1990/92 or 1996. In 2002, the overstory shrub density was 14 stems/ha for five species (Figure 93). The shrubs growing in the overstory were sassafras, flowering dogwood, smooth blackhaw, eastern redbud, and serviceberry, with densities that ranged from two to five stems/ha each.

Large Sapling: Sapling shrubs were inventoried in 2002, but not in 1990/92 or 1996. In 2002, the density of large sapling shrubs was 428 stems/ha. Eleven shrubs were recorded in the plots (Figure

93). Eastern redbud was the dominant species, comprising 40% of the total large sapling shrub density. Smooth blackhaw, witch hazel, flowering dogwood, and spicebush were also prevalent.

Small Sapling: Small sapling shrubs were only inventoried in 2002 and had a density of 1,814 stems/ha. Of the nine species recorded (Figure 93), the two equally dominant shrubs were eastern redbud and multiflora rose (422 and 420 stems/ha, each).

Seedling: Seedling inventories were completed in 1990/92, 1996, and 2002. The density of seedling shrubs decreased from 37,167 stems/ha in 1990/92 to 20,833 stems/ha in 1996, then increased substantially to 74,167 stems/ha in 2002 (Figure 94). The shrub diversity went from nine species in 1990/92 to seven species in 1996, then increased to fourteen species in 2002 (Figure 93). Eastern redbud and *Rubus* were dominant in 1992, accounting for 35 and 26% of the total seedling density. In 1996, redbud density comprised 40% and serviceberry 30% of the total density. In 2002, *Rubus* was the most prevalent species comprising 25%, and eastern redbud 14% of the total density. Most of the eastern redbud seedlings from 1992 were probably the source of the sapling-sized stems that dominated the understory in 2002.

Herbaceous and Vine Vegetation: Herbaceous coverage varied from 1996 to 2002. Compared to the 1996 data, in 2002 there was an overall increase in total average coverage from 40 to 45%, an increase in forb coverage from 18 to 34%, and decreases in vine (13 to 10%) and grass (9 to 1%) coverages.

In 2002, the species with the greatest IV was Virginia-creeper, an increase from seventh rank in 1992 and sixth rank in 1995 (Table 40). Japanese honeysuckle was second-ranked in 2002, as it was in 1992. It had dropped to third rank in 1995. Naked-flowered tick-seed (*Desmodium nudiflorum*) moved up from fourth rank in 1995 to third in 2002, but at about the same numerical IV. Enchanter's-nightshade dropped in numerical value, but increased from fifth rank in 1995 to fourth in 2002. It was third-ranked in 1992. Six of the top ten-ranked species in 1992 were still in the top ten in 2002. The Shannon Index values were 1.12, 1.07, and 1.14 in 1992, 1995, and 2002, respectively (Table 31). The Evenness Index values were 0.74, 0.70, and 0.77 in the same years, respectively.

No one species dominated in Bushman Hill woodlot as Japanese honeysuckle did in Biesecker as is reflected in the greater Shannon Diversity Index (Table 31). While the number of species declined from 1992, they declined by only three and the number of species represented both years was the highest for all five woodlots (Table 73). There was less change in the herbaceous and vine species in Bushman Hill over the ten-year period than in the other woodlots. There is no apparent reason for the greater constancy of species in this woodlot as compared to the others. The terrain is much more varied than at Biesecker and there is a greater amount of undergrowth at Bushman Hill which may give better protection to the ground level species from herbivory and drought conditions. The large increase in Virginia-creeper is the most significant change in this woodlot since 1992. There was a slight increase in its IV from 1992 to 1995, but from 1995 to 2002 the IV increased four-fold (Table 40). Its large leaf area gives it an advantage over Japanese honeysuckle to generate extra growth and causes it to be better represented in the line transects. The larger leaves overshadow the honeysuckle vines, which tend to lie on the ground surface. Stiltgrass, which was not represented in the top ten in 1992, increased to fifth rank in 2002. This may reflect its progressive invasion of the area. The Shannon Diversity and Evenness Indices were constant over the time, which fits with the minimal change in number of species present (Tables 31 and 73). If the woody shrubs were included in the data, the IVs of blackberry-dewberry species and multiflora rose would have ranked third and fourth respectively. They dominated at some of the plots.

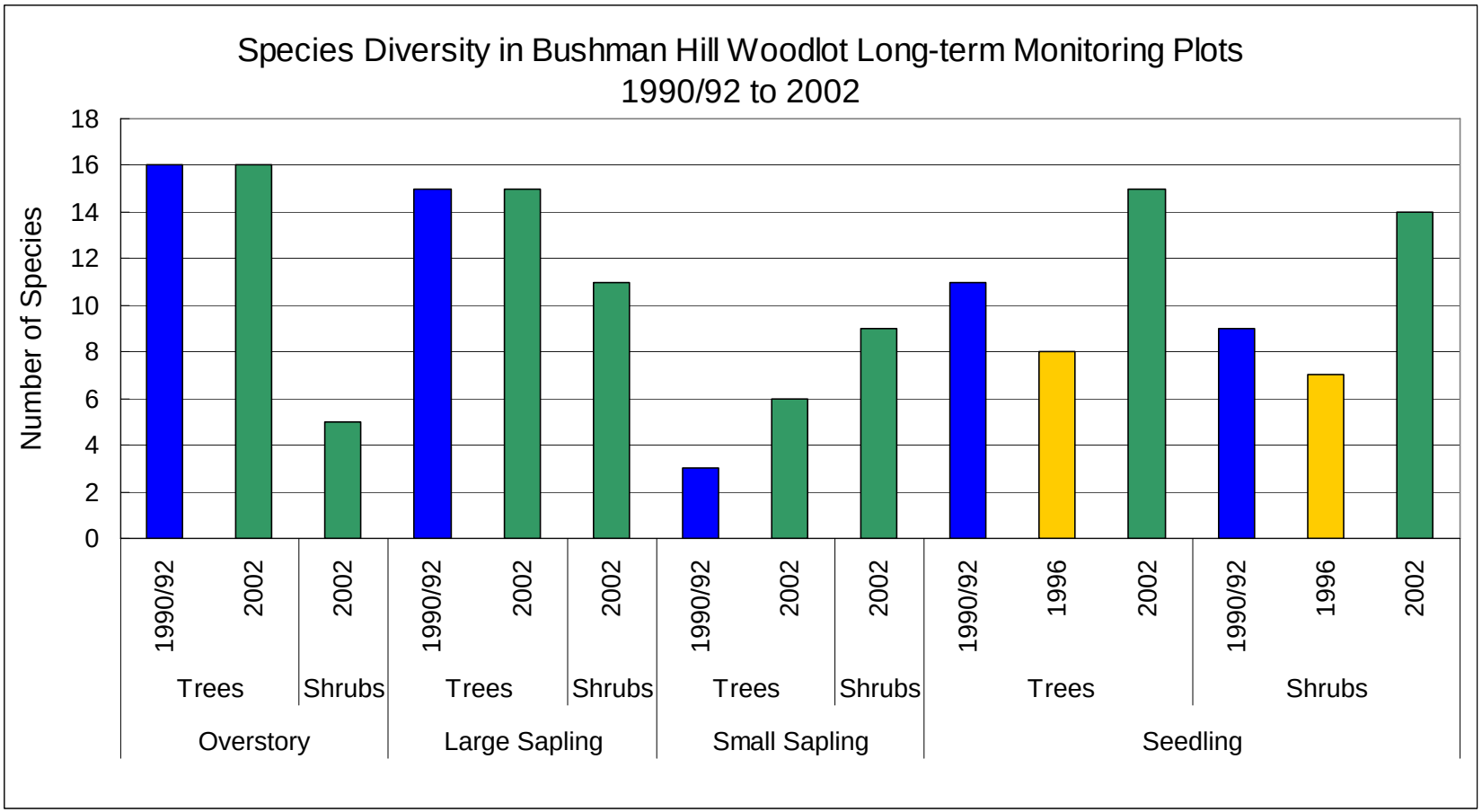


Figure 93. Number of overstory (>1.5 m in height and ≥12 cm dbh), large sapling (>1.5 m in height and 2-11.9 cm dbh), small sapling (>1.5 m and <2 cm dbh), and seedling (≤150 cm in height) tree and shrub species in the Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 1990/92 to 2002.

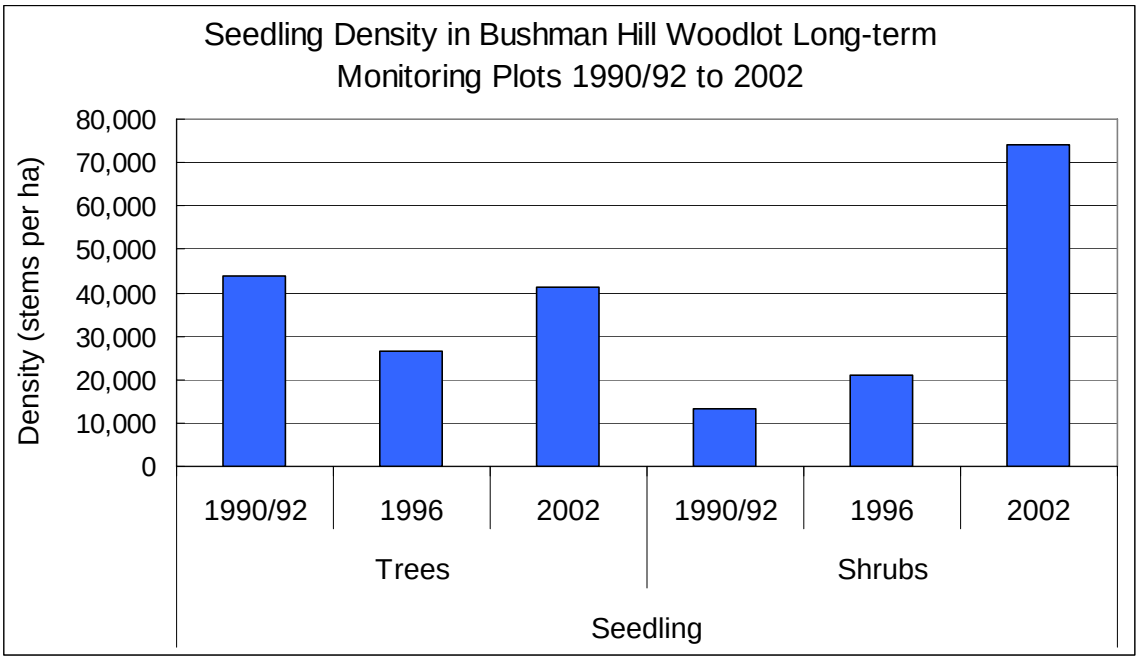


Figure 94. Density of seedling (≤150 cm in height) tree and shrub species in 2 x 2 m subplots within the Long-term Monitoring Plots in Bushman Hill woodlot, Gettysburg National Military Park, 1990/92 to 2002.

Herr Ridge Woodlot

Tree Species:
Overstory: Overstory tree density fluctuated slightly from 240 to 222 to 258 stems/ha in the 1990/92, 1996, and 2002 inventories, respectively. The basal area and species diversity followed a similar pattern over time. Ten species were recorded in the plots in 1990/92, nine in 1996, and fourteen in 2002 (Figure 95). Oaks were the dominant overstory tree species between 1990/92 and 1996, put were replaced by hickory in 2002.

Large Sapling: Large sapling tree density decreased from 1,025 in 1990/92 to 837 stems/ha in 1996 to 796 stems/ha in 2002. The diversity of tree species was 15, 11, and 15 species over the three inventories (Figure 95). Hickory remained the dominant large sapling tree from 1990/92 through 2002. Cherry was the second most prevalent species in 1996 and 2002. In 1990/92, 1996, and 2002, the density of large sapling oaks was 16, 37, and 11 stems/ha, respectively.

Small Sapling: There was a steady decline in small sapling tree density from 392 stems/ha in 1990/92 to 315 stems/ha in 1996 to only 127 stems/ha in 2002. The diversity of trees in the small sapling category went from seven in 1990/92 to nine species in 1996 and 2002 (Figure 95). Black cherry consistently accounted for the greatest percentage of the total small sapling density from 1990/92 to 2002.

Seedling: The density of seedling trees steadily decreased from 22,833 to 18,654 to 17,692 stems/ha in the 1990/92, 1996, and 2002 inventories, respectively (Figure 96). Seedling tree diversity also declined over time from eleven species in 1990/92 to nine species in 2002 (Figure 95). Ash was the most abundant tree in 1992 (10,167 stems/ha) followed by black cherry (8,167 stems/ha). This alternated in 1996 when cherry were the dominant seedling trees (8,077 stems/ha) and ash were second most prevalent (7,115 stems/ha). In 2002, ash densities increased to 10,962 stems/ha, accounting for 61% of the total seedling tree density.

Goal Stocking Levels: In Herr Ridge, the density of overstory trees was consistently below the 60% stocking level goal for the woodlot (306 stems/ha). In 1990/92, 1996, and 2002, the overstory tree densities were 240, 222, and 258 stems/ha, respectively. The large sapling tree density went from being adequate in 1990/92 (1,025 stems/ha) to below the 60% stocking level goal of 935 stems/ha in 1996 (837 stems/ha) and 2002 (796 stems/ha). The density of small sapling trees was consistently below the stocking level goal of 2,806 stems/ha. From 1990/92 to 2002, the density of small sapling trees declined from 392 to 127 stems/ha (13.9% and 4.5% of the goal density). The density of seedling trees steadily decreased from 22,833 to 18,654 to 17,692 stems/ha in the 1990/92, 1996, and 2002 inventories, respectively, however, all were greater than the stocking level goal density of 16,834 stems/ha.

These results indicate a problem in maintaining the forest structure. Seedling tree recruitment was adequate in the woodlot, but the small and large sapling tree densities were exceedingly deficient. The white-tailed deer population has not been reduced in this area of the park due to the proximity of residential housing, and during the 2002 inventory a herd of 6-10 deer was evident throughout the summer. Non-native shrub densities were very low in this woodlot, compared to other woodlots inventoried. Competition with non-native shrub species was not the problem with seedling tree and sapling recruitment. *Rubus* seedling densities were very high in 1990/92 and 2002 (34,500 and 34,615 stems/ha) and could have a negative effect on seedling tree presence and growth.

Shrub Species:
Overstory: Overstory shrubs were inventoried in 2002, but not in 1990/92 or 1996. There were no overstory-size shrubs recorded in 2002.

Large Sapling: Large sapling shrubs were inventoried in 1996 and 2002, but not in 1990/92. The density of large sapling shrubs increased from 317 to 393 stems/ha from 1996 to 2002. Shrub diversity doubled from four species in 1996 to eight species in 2002, with the inclusion of hawthorn (*Crataegus* spp.), privet, and witch hazel (Figure 95). In 1996 and 2002, smooth blackhaw was the dominant species (142 and 213 stems/ha), representing 45% and 54% of the total large sapling shrub density. Eastern redbud was the second most prevalent species over time with a density of 110 stems/ha in 1996 and 113 stems/ha in 2002.

Small Sapling: Small sapling shrubs were inventoried in 1996 and 2002, but not in 1990/92. From 1996 to 2002, there was a slight change in the small sapling shrub density from 183 to 179 stems/ha. The species diversity increased over time from five to nine species (Figure 95), due to the inclusion of multiflora rose, Tartarian honeysuckle, witch hazel, and privet. Smooth blackhaw comprised the majority of the small sapling density with 152 stems/ha in 1996 and 117 stems/ha in 2002. Rose was not recorded in the 1996 inventory, but had a density of 27 stems/ha in 2002.

Seedling: In the initial inventory in 1990/92, the density of seeding shrubs was 45,667 stems/ha. Then it decreased substantially to 15,962 stems/ha in 1996. Between 1996 and 2002, the seedling shrub density tripled to 45,961 stems/ha (Figure 96). Seedling shrub diversity exhibited the same pattern as the density over time with eight, five, and eight species in 1990/92, 1996, and 2002 (Figure 95). The shrub composition varied little over time. *Rubus* were consistently the dominant seedling shrub, with densities of 34,500 stems/ha in 1990/92, 7,308 stems/ha in 1996, and 34,615 stems/ha in 2002. Smooth blackhaw was the second most abundant shrub in 1990/92 and 2002 with densities of 6,000 and 8,269 stems/ha. In 1996, flowering dogwood and rose were equally prevalent with 3,462 and 3,269 stems/ha. Flowering dogwood was not inventoried in the seedling category in 2002. Three species that were recorded in 1992 (azalea, arrow wood, and maple-leaved viburnum) were not inventoried in 1996 or 2002. In 2002, additional species were recorded that had not been present before (Japanese barberry and *Euonymus*).

Herbaceous and Vine Vegetation: There was an overall increase in the herbaceous coverage from 1996 to 2002. Compared to the 1996 data, in 2002 there was a decrease in the average total coverage (27 to 20%), a slight increase in the forb coverage (14 to 17%), and decreases in vine and grass coverage (13 to 3%) and (<1 to 0%).

Enchanter's-nightshade had the greatest IV during all three inventories at nearly the same numerical value (Table 47). Virginia-creeper was second-ranked in 2002, up from third rank in both 1992 and 1995. Japanese honeysuckle was third-ranked in 2002. It was fifth-ranked in 1995 and second-ranked in 1992. Wild licorice (*Galium circaezans*) was fourth-ranked in all three inventories. Eight species that were in the top ten in 1992 were still in the top ten in 2002. The Shannon Index values were 0.91, 0.93, and 0.81 in 1992, 1995, and 2002, respectively (Table 31). The Evenness Index values were 0.77, 0.73, and 0.69 in the same years, respectively.

Enchanter's-nightshade had the greatest IV in all spring inventories (Table 47); it dropped to second rank in the summer of 1995, possibly because it was drying up during the late summer. Mayapple's (*Podophyllum peltatum*) IV increased about four-fold during the same time. Its growth habit is to spread out from a central point in an increasing circle by an underground rhizome, which accounts for

its increase in presence. There were other changes from year to year, but in no real pattern or trend. Both the Shannon Diversity and Evenness Indices dropped slightly from 1992 to 2002, and the number of species present decreased by a third (Tables 31 and 73). When the woody shrubs are included in the data, the IV of blackberry-dewberry species ranked first and Japanese barberry ranked ninth.

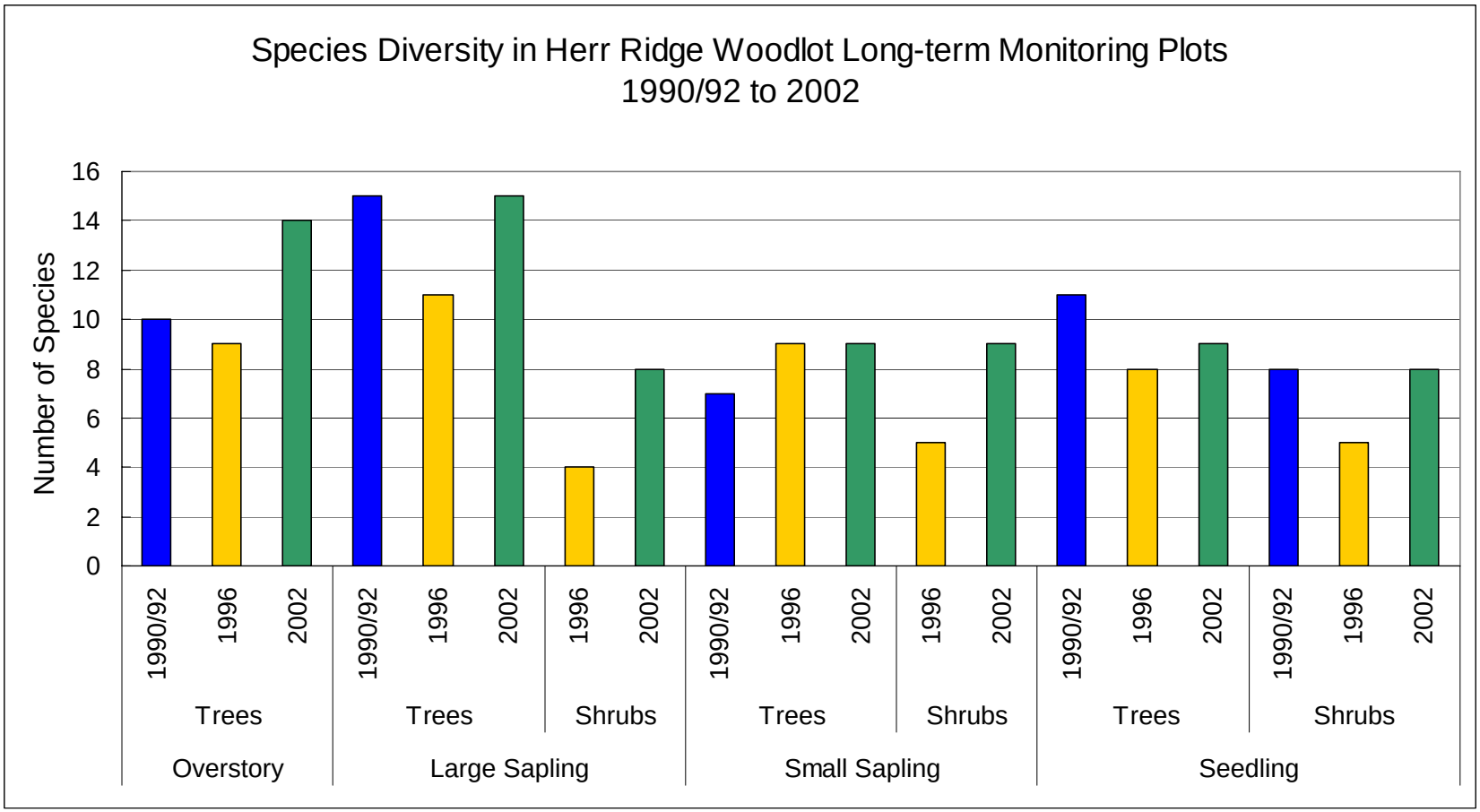


Figure 95. Number of overstory (>1.5 m in height and ≥12 cm dbh), large sapling (>1.5 m in height and 2-11.9 cm dbh), small sapling (>1.5 m in height and <2 cm dbh), and seedling (≤150 cm in height) tree and shrub species in the Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 1990/92 to 2002.

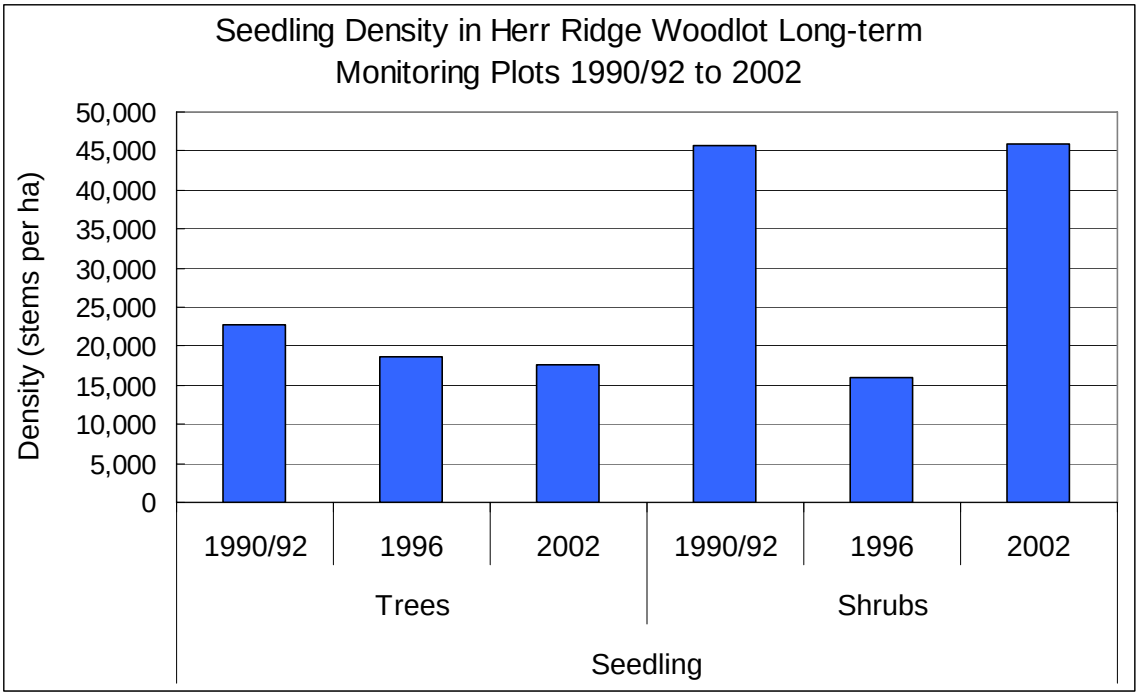


Figure 96. Density of seedling (≤150 cm in height) tree and shrub species in 2 x 2 m subplots within the Long-term Monitoring Plots in Herr Ridge woodlot, Gettysburg National Military Park, 1990/92 to 2002.

Pitzer Woodlot (Combined Fenced and Unfenced Data)

Tree Species:
Overstory: The density of overstory trees remained stable at 304 stems/ha in 1990/92, 291 stems/ha in 1996, and 297 stems/ha in 2002. Overstory tree basal area values in 1990, 1996, and 2002 were relatively the same with 23, 25, and 25.8 m^2 per ha, respectively. The number of overstory tree species changed slightly from 18 to 15 to 18 species, respectively (Figure 97). Oaks remained the dominant species, comprising the greatest portion of the total density and basal area over the ten- year period. Hickory, red maple, and blackgum densities remained the same over time. The only noticeable change was the growth of cherry. By 2002, cherry accounted for 13% of the overstory tree density.

Large Sapling: The density of large sapling trees declined steadily from 1,143 to 744 to 554 stems/ha in 1990/92, 1996, and 2002, respectively. The species composition did not change between the inventories. Hickory remained the dominant species, accounting for 50% of the total large sapling density in 2002. Ash, cherry, and maple were prevalent from 1990/92 to 2002.

Small Sapling: The small sapling tree density decreased from 169 to 23 stems/ha between 1990/92 and 1996, then increased slightly to 63 stems/ha in 2002. The diversity of tree species was nine, five, and ten species in 1990/92, 1996, and 2002 (Figure 97). Ash was the dominant species from 1990/92 to 1996, but in 2002 blackgum became well established and comprised 49% of the total small sapling tree density. Black cherry and hickory species were more prevalent in 1990/92 and 1996, whereas ash and black cherry were more prevalent in 2002. There were no oak species inventoried in the small sapling size category in 2002.

Seedling: Seedling tree density decreased between 1990/92 and 1996 from 11,501 to 6,711 stems/ha, then increased substantially to 16,579 stems/ha in 2002 (Figure 98). Tree species diversity was ten, six, and ten species in 1990/92, 1996, and 2002, respectively (Figure 97). The density of specific species varied greatly between inventories. In 1990/92, ash was the dominant species, comprising 45% of the total seedling tree density. Red maple, oak, and cherry were also well represented, accounting for 17, 15, and 13% of the total density, respectively. In 1996, hickory species accounted for 65% and red maple 22% of the total seedling tree density. In 2002, ash was the dominant species comprising 40% of the seedling tree density, and red maple remained a substantial component of the density at 25% of the total.

Goal Stocking Levels: The densities of overstory trees in 1990/92, 1996, and 2002 (304, 291, and 297 stems/ha, respectively) were all below the 60% stocking level goal (306 stems/ha). The density of large sapling trees started out above the 60% stocking level goal (935 stems/ha) in 1990/92 (1025 stems/ha), but then declined below the goal in 1996 and 2002 (744 and 554 stems/ha). The density of small sapling trees was severely deficient from 1990/92 through 2002. The small sapling goal stocking level is 2,806 stems/ha, however the densities recorded in 1990/92 (169 stems/ha), 1996 (23 stems/ha), and 2002 (63 stems/ha) were fractions (6, 0.8, and 2.2%, respectively) of the goal density. The density of seedling trees in Pitzer in 1990/92 (11,501 stems/ha), 1996 (6,711 stems/ha), and 2002 (16,579 stems/ha) were all below the stocking level goal of 16,834 stems/ha. Seedling tree densities did increase from 1996 to 2002, and may have been a positive response to the reduction in the white-tailed deer population after the implementation of the Deer Management Program. However, the data indicate a problem in sapling-sized tree species presence and growth at levels adequate to maintain the historic mixed-oak forest structure.

Shrub Species:
Overstory: Overstory shrubs were inventoried in 1996 and 2002, but not in 1990. In 1996 and 2002, overstory shrub density was eight and six stems/ha. Sassafras, flowering dogwood, serviceberry, and smooth blackhaw were inventoried as overstory stems between 1996 and 2002. Sassafras was the dominant species in both inventories, comprising 50 and 67%, respectively, of the total overstory shrub density.

Large Sapling: Sapling shrubs were inventoried in 1996 and 2002, but not in 1990/92. The large sapling shrub density decreased from 214 stems/ha in 1996 to 163 stems/ha in 2002. The number of shrub species doubled from four to nine species (Figure 97). Smooth blackhaw was the dominant species in 1996 and 2002, comprising 51 and 60% of the total density. Flowering dogwood was also very common and represented 32% of the density in 1996, but decreased to 12% in 2002. Serviceberry and sassafras maintained their growth over the six years. Witch hazel was first recorded in 2002.

Small Sapling: In contrast to the trend for small sapling trees, small sapling shrub density increased from 45 to 174 stems/ha from 1996 to 2002. The diversity of shrub species almost tripled from three to eight species (Figure 97). Smooth blackhaw accounted for 96% of the total small sapling shrub density in 1996. Multiflora rose was the dominant small sapling shrub in 2002, with a density of 78 stems/ha or 45% of the total density. New species recorded for the first time in 2002 included Japanese barberry, Tartarian honeysuckle, multiflora rose, *Rubus*, and witch hazel.

Seedling: Seedling shrub density progressively increased from 5,917 to 7,237 to 16,316 stems/ha in 1990/92, 1996, and 2002, respectively (Figure 98), with a steady rise in diversity from three to four to seven species, respectively (Figure 97). In 1990/92, smooth blackhaw and flowering dogwood were the dominant shrubs with densities of 3,167 and 1,750 stems/ha (54 and 30% of the total seedling density). In 1996, flowering dogwood was dominant with 5,263 stems/ha (73% of the total density). Dramatic changes occurred between 1996 and 2002. In 2002, smooth blackhaw seedling growth rebounded to a density of 8,158 stems/ha, comprising 50% of the total seedling shrub density. *Rubus* was now the second most prevalent species with 4,868 stems/ha or 30% of the density. In 2002, Japanese barberry and multiflora rose (non-native species) had densities greater than flowering dogwood and sassafras.

Herbaceous and Vine Vegetation: Compared to the 1996 data, in 2002 there was an increase in total herbaceous coverage from 19 to 25%, vine coverage remained the same at 4%, forb coverage increased from 15 to 20%, and grass coverage increased very slightly from 1 to 2%.

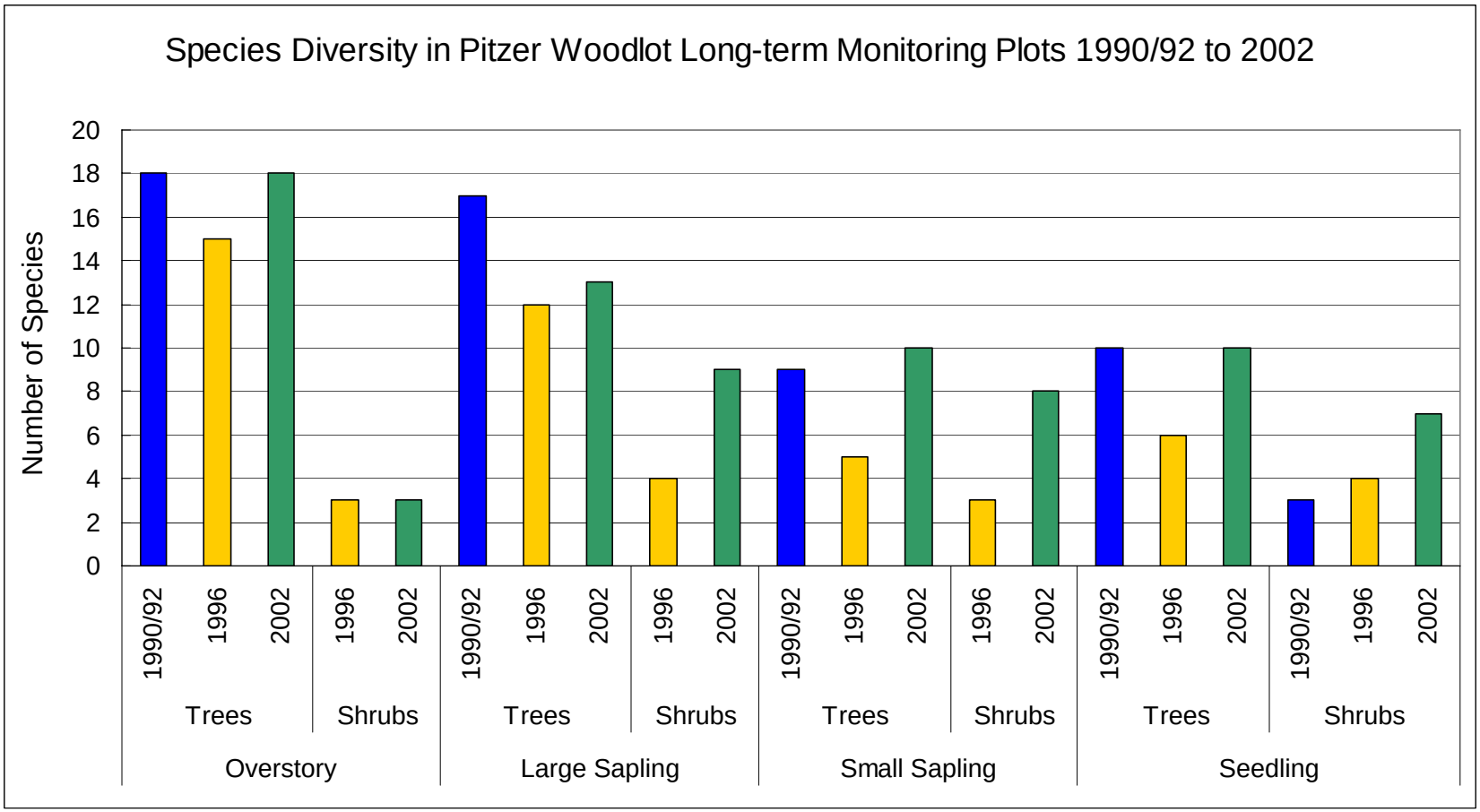


Figure 97. Number of overstory (>1.5 m in height and ≥12 cm dbh), large sapling (>1.5 m in height and 2-11.9 cm dbh), small sapling (>1.5 m in height and <2 cm dbh), and seedling (≤150 cm in height) tree and shrub species in the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 1990/92 to 2002.

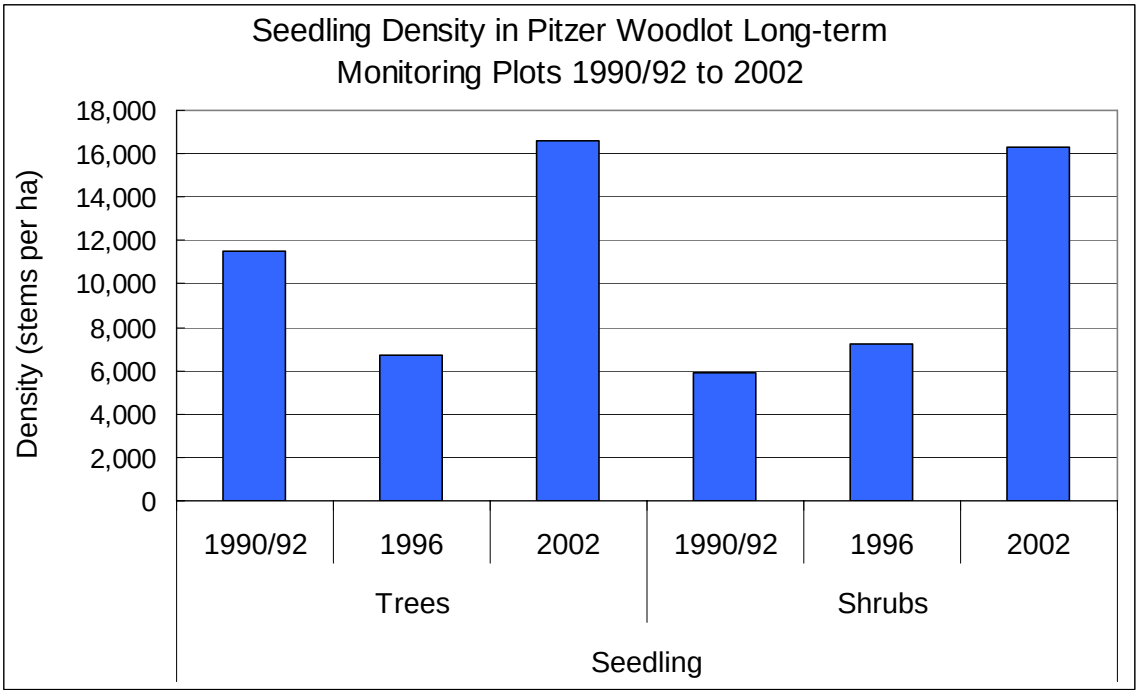


Figure 98. Density of seedling (≤150 cm in height) tree and shrub species in 2 x 2 m subplots within the Long-term Monitoring Plots in Pitzer woodlot, Gettysburg National Military Park, 1990/92 to 2002.

Pitzer Woodlot – Fenced and Unfenced Plot Comparisons

Tree Species:
Seedling: There was a trend of decreasing seedling tree density in both the fenced and unfenced subplots from 1990/92 to 1996, and then a substantial increased in 2002. Seedling tree density in the fenced subplots decreased from 9,999 stems/ha in 1990/92 to 5,833 stems/ha in 1996, then increased to 16,500 stems/ha in 2002. Similarly, the density in the unfenced subplots decreased from 13,001 stems/ha in 1990/92 to 7,500 stems/ha in 1996, then increased to 16,667 stems/ha in 2002. In 2002, the seedling tree density in the fenced subplots (16,500 stems/ha) was not statistically different than in the unfenced subplots (16,667 stems/ha). Tree species diversity in the fenced subplots decreased from seven species in 1990/92 to three species in 1996, then rebounded to eight species in 2002. Similarly, the tree species diversity in the unfenced subplots went from seven to four to ten species between the three inventories. In 1996, red maple was predominant (3,056 stems/ha) in the fenced subplots and hickory were predominant (6,250 stems/ha) in the unfenced subplots. However, this changed in 2002 when the density of ash increased to 10,250 stems/ha in the fenced subplots and red maple density reached 8,333 stems/ha in the unfenced subplots. In Pitzer, oaks were not regenerating well in the fenced or unfenced subplots. There were no oak seedlings in the fenced subplots in 2002, and the density of white oak seedlings in the unfenced subplots was 556 stems/ha. Species recorded in 1990/92 or 1996, but not in 2002 included hackberry (*Celtis occidentalis*), oak (fenced subplots), and hackberry only (unfenced subplots). Species first recorded in 2002 that were not in 1990/92 or 1996 included red maple (fenced subplots) and blackgum and elm (unfenced subplots).

Shrub Species:
Seedling: The density of seedling shrubs was consistently greater in the unfenced plots than in the fenced plots over time. In 1996, the density in the unfenced plots (11,389 stems/ha) was substantially greater than in the fenced plots (3,500 stems/ha). In 2002, seedling shrub density reached 21,112 stems/ha in unfenced plots, compared to only 12,000 stems/ha in fenced plots. Shrub species diversity increased over time, but the increase was mostly due to the introduction of non-native species like autumn olive, Japanese barberry, and multiflora rose. In 1996, flowering dogwood was the dominant seedling shrub with 9,167 in unfenced plots and 1,750 stems/ha in the fenced plots. In 2002, smooth blackhaw was the dominant species in the unfenced plots with a density of 16,389 stems/ha and *Rubus* were dominant in fenced plots with 8,500 stems/ha.

There was an increase in non-native species (rose and barberry) in the forest understory in 2002. Japanese barberry densities were substantially greater in the unfenced subplots than in the fenced subplots (3,056 and 250 stems/ha) in 2002. The same is true for the autumn olive population. The presence of these non-native shrubs in the understory poses a threat to the development of the tree community. The management of the woodlots must include non-native plant species control due to the deleterious threat on the presence and growth of tree species and eventually on the forest structure over time. *Rubus* densities may fluctuate with time, but non-native shrubs like barberry and autumn olive will only increase over time unless managed.

Herbaceous and Vine Vegetation: From 1996 to 2002, the total herbaceous coverage decreased within the fence treatment subplots from 28 to 26%, but increased slightly in the unfenced subplots from 10 to 24%. Grass coverage did not change between treatments or years. The only notable change in vegetation was that forb coverage increased from 7 to 20% in the unfenced subplots.

Line Transect Herbaceous Data:
Fenced subplots: No transects of the herbaceous and vine species were done in 1992 or in the spring of 1995. The comparisons of the Pitzer herbaceous species were between the summer 1995 and the spring 2002 surveys. Virginia-creeper had the greatest IV in 2002 (Table 56). In 1995, Virginia-creeper was tenth. Japanese honeysuckle was second-ranked in 2002, up from seventh in 1995. Enchanter's-nightshade decreased to third rank in 2002 from first rank in 1995. Smartweed was second-ranked in 1995 but dropped to fourth rank in 2002. Jewelweed (*Impatiens capensis*) was ranked fifth in 1995 and 2002. Eight of the species in the top ten in 1995 were still in the top ten in 2002. The Shannon Index values were 1.11 and 1.09 in 1995 and 2002, respectively (Table 31). The Evenness Index values were 0.80 and 0.78 in the same years, respectively.

Unfenced-Control subplots: Enchanter's-nightshade increased dramatically from fifth rank in 1995 to first rank in 2002, when its IV was nearly double that of the second-ranked species, Virginia-creeper (Table 57). Virginia-creeper was second-ranked in 2002, but had been tenth-ranked in 1995. Wild licorice dropped from second rank in 1995 to third in 2002. Japanese honeysuckle dropped from fourth rank to seventh in 2002. Five species that were in the top ten in 1995 were still in the top ten in 2002. The Shannon Index values were 0.87 and 1.08 in 1992 and 2002, respectively, and the Evenness Index values were 0.76 both years (Table 31).

Unfenced subplots: The top four IV's in 2002 were for enchanter's-nightshade, Japanese honeysuckle, wild licorice, and Virginia-creeper (Table 58). Smartweed, which had the greatest IV in 1995, was not in the top ten in 2002. In 1995, enchanter's-nightshade was third-ranked, wild licorice was seventh-ranked, and Virginia-creeper was not in the top ten. Stiltgrass (*Microstegium vimineum*), which was second-ranked in 1995, was not in the top ten in 2002. Japanese honeysuckle, which was second-ranked in 2002, was not in the top ten in 1995. Six species that were in the top ten in 1995 were still in the top ten in 2002. The Shannon Index values were 0.83 and 0.88 in 1995 and 2002, respectively (Table 31). The Evenness Index values were 0.68 and 0.69 in the same years, respectively.

Comparison of Fence Plot Treatments in 2002: Enchanter's-nightshade had the greatest IV in both the unfenced and unfenced-control subplots, with IV values three to four times greater than in the fenced subplots (Tables 56, 57, and 58). Japanese honeysuckle ranked second in both the fenced and unfenced subplots, but dropped to seventh rank in the unfenced-control subplots. There was good correlation between the top ranks in the unfenced and unfenced-control subplots except for Japanese honeysuckle.

Virginia-creeper increased significantly between 1995 and 2002 (Tables 56,57, and 58). The increases ranged from four to thirteen-fold among the three sets of subplots between the summer of 1995 and the spring of 2002. The largest increase in IV was in the unfenced-control subplots (Table 74); the smallest was in the fenced subplots (Table 70). The smaller increase in the fenced subplots was likely due to the smothering effect of leaves trapped within the fence, although the leaf litter averaged only 66% of the cover within the quadrants where the line transects were completed. Less shading due to the more open spacing of the mature trees and much less undergrowth at Pitzer would allow for Virginia-creeper's greater increase than at Bushman Hill. Enchanter's-nightshade dominated both the unfenced and unfenced-control subplots, having an IV twice that of the second-ranked species (Tables 57 and 58). It increased by a factor of three and four, respectively, in the two sets of plots, while it decreased by nearly 50% in the fenced subplots between 1995 and 2002. Its decrease in the fenced subplots may also be due to a smothering effect (Table 56). Japanese honeysuckle, however, increased four-fold in the fenced subplots during the same time (Table 56). It may tolerate being covered better than other species. It decreased by a factor of three in the unfenced-control subplots over the interval

between inventories (Table 57), but increased from no presence to second rank IV in the unfenced subplots in 2002 (Table 56). Other changes in relative presence occurred within the different sets of subplots between 1995 and 2002, but no discernible pattern was seen.

The number of species in the unfenced-control subplots nearly doubled between 1995 and 2002 and those in the unfenced subplots increased by a little over 50%, while those in the fenced subplots did not change. However, the number of species in common between 1995 and 2002 was the lowest in the unfenced-control subplots (Table 73). The Shannon Diversity Index reflected the degree of change in number of species within the different subplots between the summer of 1995 and the spring of 2002. However, the Evenness Index was essentially constant in all three sets of subplots, so the relative number of individuals of each species present didn't change much with the addition of new species (Table 31). The new species apparently filled new niches rather than displacing some of the original species present.

Multiflora rose and blackberry-dewberry ranked fifth and eighth in IV when shrubs were included in the data. Significant numbers of these shrubs were present and they dominated in some plots, greatly decreasing the herbaceous and vine cover.

Powers Hill Woodlot

Tree Species:
Overstory: Overstory tree species were inventoried in 1990/92 and 2002, but not in 1996. In 1990/92 and 2002, overstory tree densities were 320 to 274 stems/ha, and the number of species increased from eighteen to twenty one (Figure 99). The density of oak species decreased slightly from 125 stems/ha in 1990/92 to 105 stems/ha in 2002, but they remained the dominant species over time. The density of hickory and yellow poplar hardly changed, and ash densities increased slightly between 1990/92 and 2002. Overstory tree basal area was essentially the same at 24 and 23.7 m^2 per ha between 1990/92 and 2002.

Large Sapling: Sapling trees were inventoried in 1990/92 and 2002, but not in 1996. From 1990/92 to 2002, the density of large sapling trees decreased from 275 to 194 stems/ha, but the number of tree species increased from twelve to fifteen species (Figure 99). In 1992, ash was the dominant large sapling tree with 93 stems/ha. Some of the large sapling ash inventoried in 1990/92 probably matured into overstory-size trees in 2002, accounting for the increase in overstory ash. In 2002, hickory and cherry were co-dominant with densities of 55 and 53 stems/ha, respectively.

Small Sapling: The density of small sapling trees increased from 25 to 152 stems/ha in 1990/92 and 2002, and the number of tree species decreased from five to three (Figure 99). In 2002, black cherry comprised almost the entire category, accounting for 97% of the total small sapling tree density. There were no small sapling ash or oak recorded in the 2002 inventory.

Seedling: Seedling tree densities decreased from 32,502 stems/ha in 1990/92 to 23,500 stems/ha in 1996, then doubled to 46,334 stems/ha in 2002 (Figure 100). The diversity of tree species recorded in the woodlot was thirteen, eight, and thirteen species in 1990/92, 1996, and 2002, respectively (Figure 99). Ash remained the dominant species with densities of 13,167 stems/ha in 1990/92, 8,667 stems/ha in 1996, and 21,833 stems/ha in 2002. Cherry was second most prevalent with 10,667 stems/ha in 1990/92 and 6,167 stems/ha 1996. Elm densities increased to 9,333 stems/ha in 2002. Oak seedling densities steadily decreased from 1,833 to 1,334 to 834 stems/ha in 1990/92, 1996, and 2002, respectively.

Goal Stocking Levels: In 1990/92, the density of overstory trees was 320 stems/ha, exceeding the 60% stocking level goal of 306 stems/ha, but then it decreased to 274 stems/ha in 2002. The density of large sapling trees was 275 and 194 stems/ha in 1990/92 and 2002. respectively, much lower than the 60% stocking level of 935 stems/ha. Although the density of small sapling trees increased from 25 stems/ha in 1990/92 to 152 stems/ha in 2002, the densities were still minor fractions of the 60% stocking density of 2,806 stems/ha. Black cherry made up 97% of the small sapling density in 2002. White-tailed deer avoid black cherry, selectively affording the species protection from browse, and resulting in higher black cherry densities (Horsley et al. 2003). Seedling tree densities in the woodlot were 32,502 stems/ha in 1990/92, 23,500 stems/ha in 1996, and 46,334 stems/ha in 2002. All of these densities exceeded the stocking level goal of 16,834 stems/ha. There was a trend over time of ash being the dominant seedling tree species and cherry the second most abundant species in each inventory.

Shrub Species:
Overstory: Overstory shrubs were inventoried in 2002, but not in 1990/92 and 1996. In 2002, the overstory shrub density was 19 stems/ha. The four species of shrubs growing in the overstory were eastern redbud, flowering dogwood, serviceberry, and sassafras (Figure 99).

Large Sapling: Large sapling shrubs were inventoried in 2002, but not in 1990/92 and 1996. In 2002, the density was 496 stems/ha for nine species (Figure 99). Spicebush had the greatest large sapling density (292 stems/ha), comprising 59% of the total density.

Small Sapling: Small sapling shrubs were inventoried in 2002, but not in 1990/92 and 1996. In 2002, the small sapling shrub density was 2,552 stems/ha for twelve species. Spicebush was the dominant species (1,928 stems/ha), accounting for 76% of the total small sapling density.

Seedling: The seedling shrub density doubled from 30,667 stems/ha in 1990/92 to 63,167 in 1996, and tapered off to 67,001 stems/ha in 2002 (Figure 100). There was an increase in shrub species diversity from six to seven to fourteen species in the 1990/92, 1996, and 2002 inventories, respectively (Figure 99). In 1990/92, spicebush was the dominant species with a density of 13,667 stems/ha. Japanese barberry (5,833 stems/ha) and flowering dogwood (4,167 stems/ha) also being prevalent that inventory year. In 1996, the density of Japanese barberry increased substantially to 34,500 stems/ha, accounting for 55% of the total density. Spicebush densities (18,667 stems/ha) were also high in 1996. In 2002, the density of spicebush increased to 26,167 stems/ha, making it the dominant seedling shrub accounting for 39% of the total density. *Rubus* and Japanese barberry (13,500 and 12,500 stems/ha, respectively) were also prevalent in 2002. Most of the spicebush seedlings recorded in 1990/92 were probably the source of the sapling-size spicebush that dominated the understory in 2002.

Herbaceous and Vine Vegetation: Compared to the 1996 data, in 2002 there were increases in total herbaceous coverage from 42 to 48%, and in forb coverage from 19 to 37%. Grass and vine coverages decreased from 12 to 7% and 11 to 4%, respectively.

Stiltgrass had the greatest IV in 2002 (Table 65). It ranked ninth in 1995 and was not in the top ten in 1992. Japanese honeysuckle ranked first in 1992, and second in 1995 and 2002, but its numerical IV increased substantially from 1992 to 2002. White-snakeroot (*Eupatorium rugosum*) incrementally increased from ninth rank in 1992 to sixth rank in 1995 and to third rank in 2002. Grass spp., which did not rank in the top ten in 1992, increased to seventh rank in 1995 and to fourth rank in 2002. Virginia-creeper, which was fifth-ranked in 2002, was not in the top ten in either 1992 or 1995. Only four species that ranked in the top ten in 1992, ranked in the top ten in 2002. The Shannon Index values were 0.97, 1.25, and 0.97 in 1992, 1995, and 2002, respectively (Table 31). The Evenness Index values were 0.77, 0.77, and 0.70 in the same years, respectively.

While Japanese honeysuckle dropped from first rank IV in 1992 to second rank in 1995, in 2002 it still maintained a significant presence in Powers Hill (Table 65). The other four species having the greatest IVs either disappeared from the top ten species ranking or dropped several ranks. Enchanter's-nightshade increased from fifth rank in 1992 to first rank in 1995 and then dropped to tenth rank in 2002. One possible reason was the recent drought conditions, which may have had a greater effect on its growth than on many of the other species, since it has a thin cuticle and very watery type of tissue. Stiltgrass increased from zero presence in 1992, to ninth rank in 1995, to first rank in 2002, reflecting its invasion into the area. White-snakeroot also increased in rank during the three inventories, although the actual IV was nearly the same from 1995 to 2002. White-snakeroot is taller than most of the other species present and has relatively large leaves, which may contribute to its increase. Other changes were apparently random.

The Shannon Diversity Index increased from 0.97 in 1992 to 1.25 in 1995, but then dropped back to 0.97 in 2002 (Table 31). The Evenness Index was the same in 1995 as in 1992, indicating that while there were more species, there was a more even distribution in numbers of individuals per species. But,

the Evenness Index decreased between 1995 and 2002 along with the Diversity Index indicating that not only were there fewer species, the number of individuals per species decreased. The Coefficient of Similarity between species present in 1992 and 2002 was the greatest for the Powers Hill woodlot (Table 73).

Japanese barberry had the greatest IV at Powers Hill when the woody shrubs were included in the data. Its IV was one and a half times that of stiltgrass, which was the herbaceous species with the greatest IV. One plot was nearly 100% Japanese barberry and it was present in large numbers at several plots. Blackberry-dewberry species would have ranked eighth if included in the data.

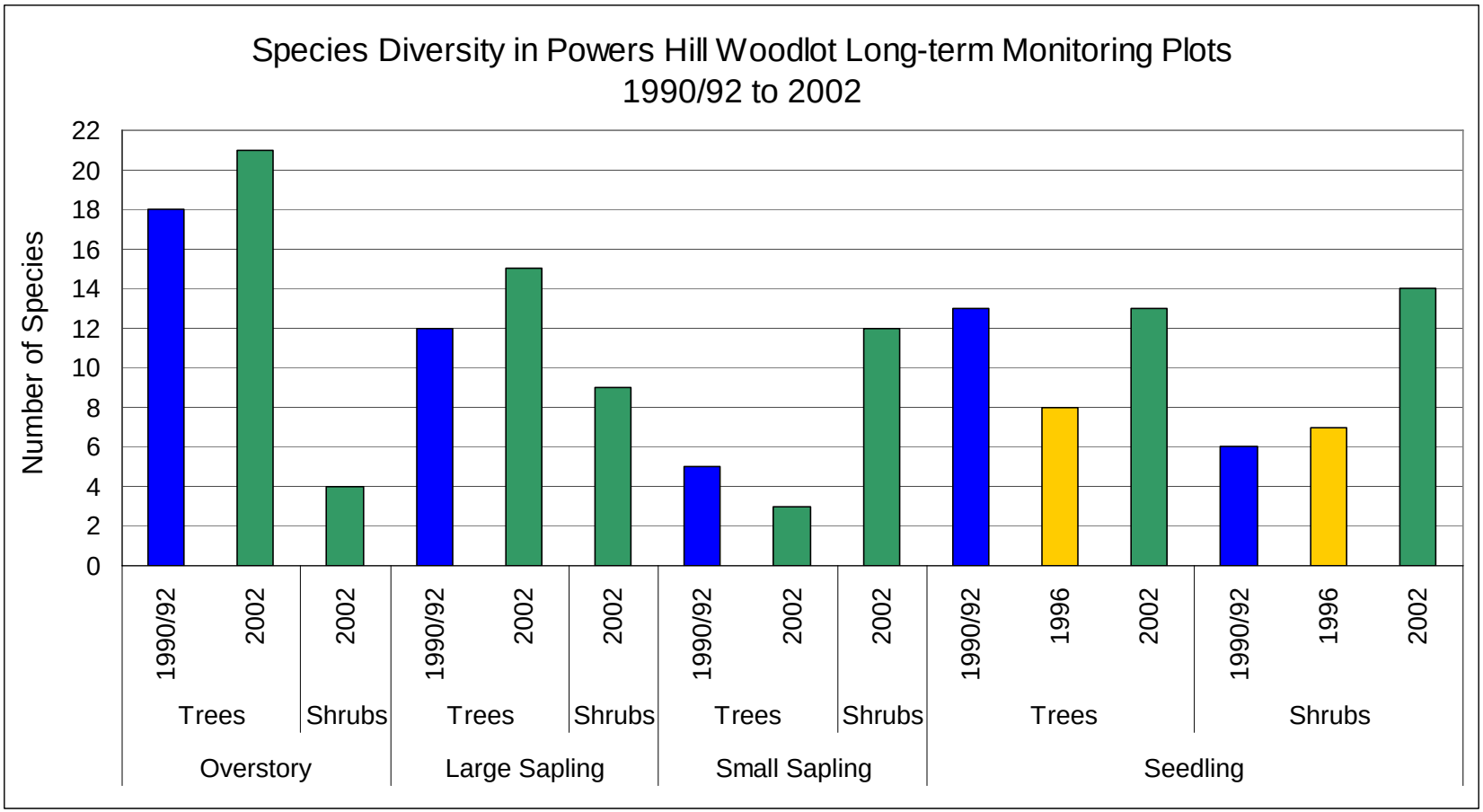


Figure 99. Number of overstory (>1.5 m in height and ≥12 cm dbh), large sapling (>1.5 m in height and 2-11.9 cm dbh), small sapling (>1.5 m in height and <2 cm dbh), and seedling (≤150 cm in height) tree and shrub species in the Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 1990/92 to 2002.

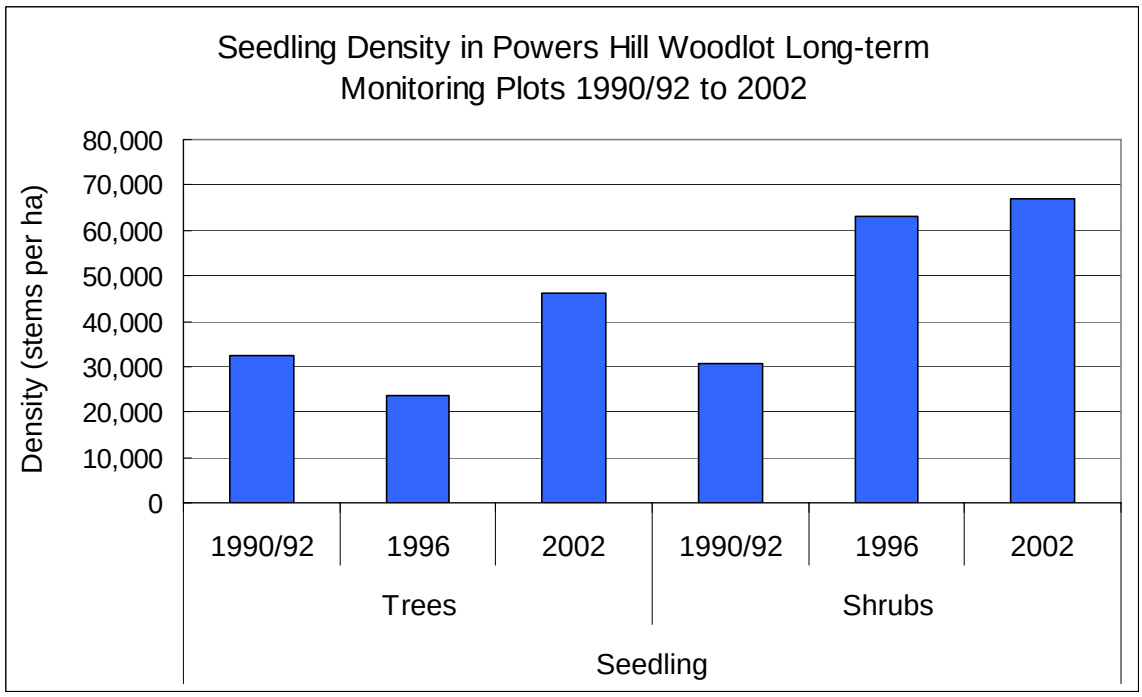


Figure 100. Density of seedling (≤150 cm in height) tree and shrub species in 2 x 2 m subplots within the Long-term Monitoring Plots in Powers Hill woodlot, Gettysburg National Military Park, 1990/92 to 2002.

Spangler Woodlot

Tree Species:
Overstory: The density of overstory trees decreased from 365 to 302 stems/ha between 1990/92 and 1996, then increased to 321 stems/ha in 2002. Basal area changed from 26 to 23 to 25.5 m^2 per ha, respectively. The diversity of tree species was twelve, eleven, and fourteen species in 1990/92, 1996, and 2002, respectively (Figure 101). Oak remained the dominant species of tree from 1990/92 through 2002. Hickory densities gradually increased, but cherry and ash densities decreased from 1990/92 to 2002.

Large Sapling: In the 1990/92, 1996, and 2002 inventories, the density of large sapling trees decreased from 868 to 532 to 468 stems/ha, respectively. The diversity of tree species changed from 13 to 11 to 12 species, respectively (Figure 101). In 1990/92, cherry were the dominant large sapling trees with a density of 272 stems/ha. During that inventory, hickory and ash (243 and 235 stems/ha, respectively) also comprised great portions of the large sapling density. In 1996, hickory and cherry were equally co-dominant in the woodlot with densities of 183 stems/ha each (34% each of the total large sapling density). However, in 2002 the density of hickory increased to 248 stems/ha (53% of the total density) making it the dominant tree, while cherry density decreased to 138 stems/ha.

Small Sapling: The density of small sapling trees decreased from 42 in 1990/92 to 13 stems/ha in both the 1996 and 2002 inventories. The number of tree species shifted from three to one to three species, respectively (Figure 101). In 1990/92, ash was the dominant species accounting for 88% of the total small sapling density. In 1996, ash was the only species recorded, however in 2002, there were no ash recorded. Instead, black cherry (8 stems/ha) was the dominant species comprising 57% of the total small sapling tree density. Hickory and white oak had densities of four and two stems/ha, respectively, in 2002.

Seedling: Seedling tree density increased substantially from 6,333 stems/ha in 1990/92 to 9,333 stems/ha in 1996 to 34,616 stems/ha in 2002 (Figure 102). Seedling tree diversity was stable at eight species in 1990/92 and 1996, then increased slightly to eleven species in 2002 (Figure 101). There was no trend in species dominance over time. In 1991, hackberry (2,833 stems/ha) comprised 45% of the total seedling density. In 1996, hickory became the dominant seedling tree with a density of 4,833 stems/ha or 52% of the total seedling tree density. In 2002, the density of ash seedlings surged to 23,654 stems/ha, accounting for 68% of the total seedling tree density.

Goal Stocking Levels: The density of overstory trees decreased from 365 in 1990/92 to 302 stems/ha in 1996, then increased to 321 stems/ha in 2002, essentially exceeding the 60% stocking level goal of 306 stems/ha. In the 1990/92, 1996, and 2002 inventories, the density of large sapling trees decreased from 868 to 532 to 468 stems/ha, respectively, consistently below the large sapling stocking level goal of 935 stems/ha. The 60% stocking level goal density for small sapling trees was 2,806 stems/ha. However, the densities recorded in the three inventories were 42, 13, and 13 stems/ha, respectively. The density of small sapling trees was only 0.5% of the goal stocking level in 1996 and 2002. The 60% stocking level goal for seedling trees was 16,834 stems/ha. Seedling tree densities in 1990/92 and 1996 (6,333 and 9,333 stems/ha) were well below the goal density, however in 2002 there was a surge in seedling tree density to 34,616 stems/ha. This was a positive indicator that the trees were capable of producing seedlings in adequate densities to regenerate the woodlots, however not enough seedlings were surviving and growing into sapling-sized trees.

Shrub Species:
Overstory: Shrub species were inventoried in 1996 and 2002, but not in 1990/92. From 1996 to 2002, the overstory shrub density increased from 5 to 10 stems/ha, and basal area increased from 0.08 to 0.29 m^2 per ha. Sassafras and serviceberry were the only two species of shrubs recorded in the overstory during both inventories. In 1996 and 2002, sassafras densities were three and six stems/ha, and serviceberry densities were two and four stems/ha.

Large Sapling: Large sapling shrubs were inventoried in 1996 and 2002, but not in 1990/92. From 1996 to 2002, the large sapling shrub densities decreased from 173 to 137 stems/ha. The number of shrub species decreased from five to four species (Figure 101). In 1996, flowering dogwood (83 stems/ha) was the dominant species accounting for 50% of the total density, but it severely declined to only two stems/ha in 2002. The density of smooth blackhaw increased from 40 to 98 stems/ha between 1996 and 2002, making it the dominant shrub accounting for 72% of the total large sapling shrub density.

Small Sapling: From 1996 to 2002, the small sapling shrub density increased from 13 to 144 stems/ha, and the diversity increased from three to five species (Figure 101). In 1996, smooth blackhaw (7 stems/ha) and flowering dogwood (5 stems/ha) accounted for 54 and 38%, respectively, of the small sapling shrub density. In 2002, multiflora rose and Tartarian honeysuckle (non-native species) were recorded in the woodlot. The densities of multiflora rose (52 stems/ha) and smooth blackhaw (50 stems/ha) accounted for 36 and 35% of the total small sapling density, respectively. *Rubus* were recorded for the first time in the plots in 2002 with a density of 29 stems/ha.

Seedling: The density of seedling shrubs decreased from 3,666 to 1,667 stems/ha between 1990/92 and 1996, but then dramatically increased to 23,845 stems/ha in 2002 (Figure 102). The diversity of seedling shrubs was four, two, and seven species in 1990/92, 1996, and 2002, respectively (Figure 101). Flowering dogwood was the dominant species in 1990/92 (1,667 stems/ha) and 1996 (1,167 stems/ha). There was a dramatic change in the seedling composition between 1996 and 2002. Smooth blackhaw was first recorded in the plots during the 2002 inventory and had a density of 10,577 stems/ha (44% of the total seedling shrub density). The density of *Rubus* increased from zero stems/ha in 1996 to 8,846 stems/ha in 2002 (37% of the seedling shrub density). This was the only woodlot in which wisteria (2,115 stems/ha) was recorded. Japanese barberry and multiflora rose, non-native species, were first recorded in the woodlot in 2002.

Herbaceous and Vine Vegetation: From 1996 to 2002, the average total herbaceous coverage increased from 11 to 22%. Forb coverage increased from 8 to 17%, grass coverage remained the same at 2%, and vine coverage increased slightly from 1 to 2%.

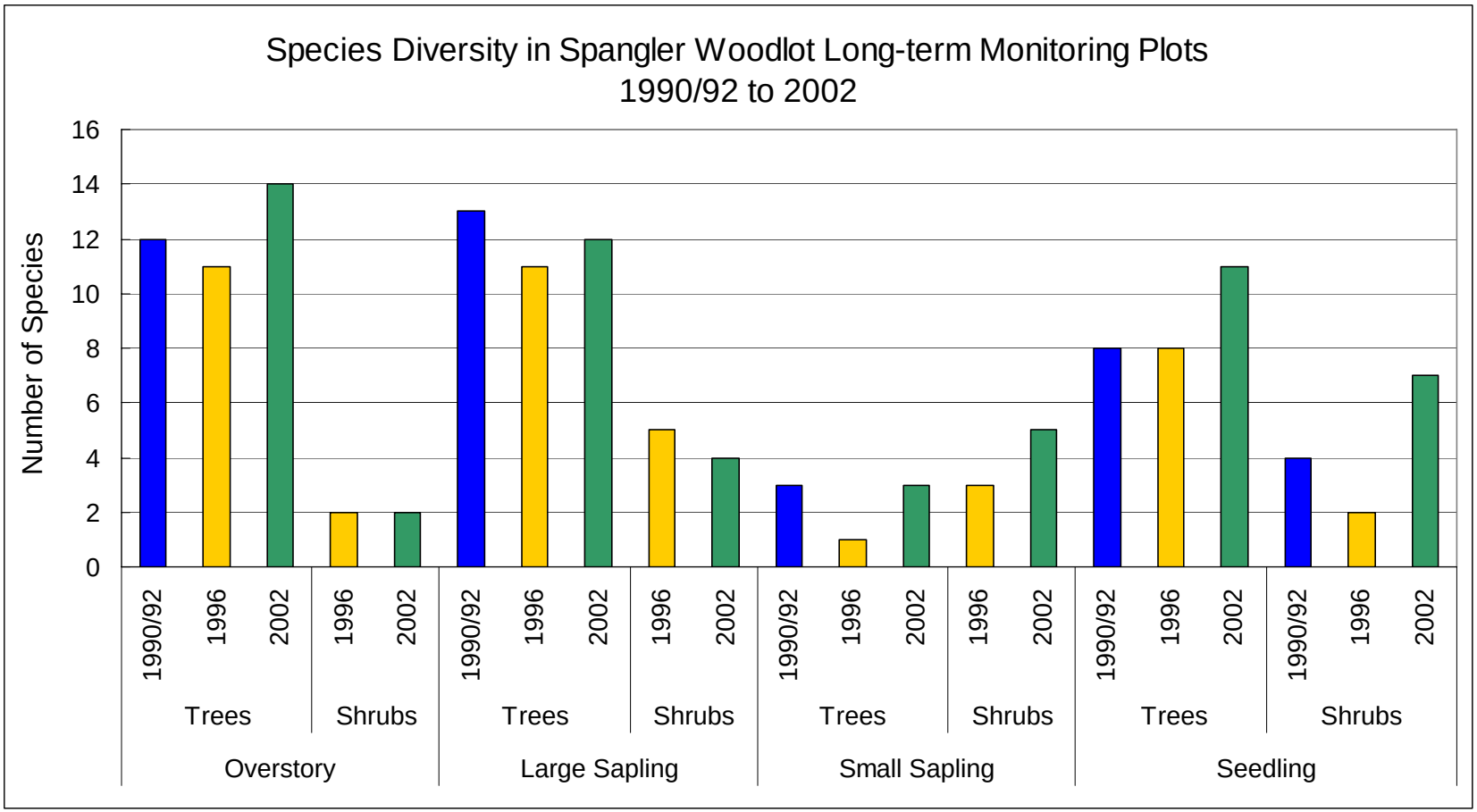


Figure 101. Number of overstory (>1.5 m in height and ≥12 cm dbh), large sapling (>1.5 m in height and 2-11.9 cm dbh), small sapling (>1.5 m in height and <2 cm dbh), and seedling (≤150 cm in height) tree and shrub species in the Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 1990/92 to 2002.

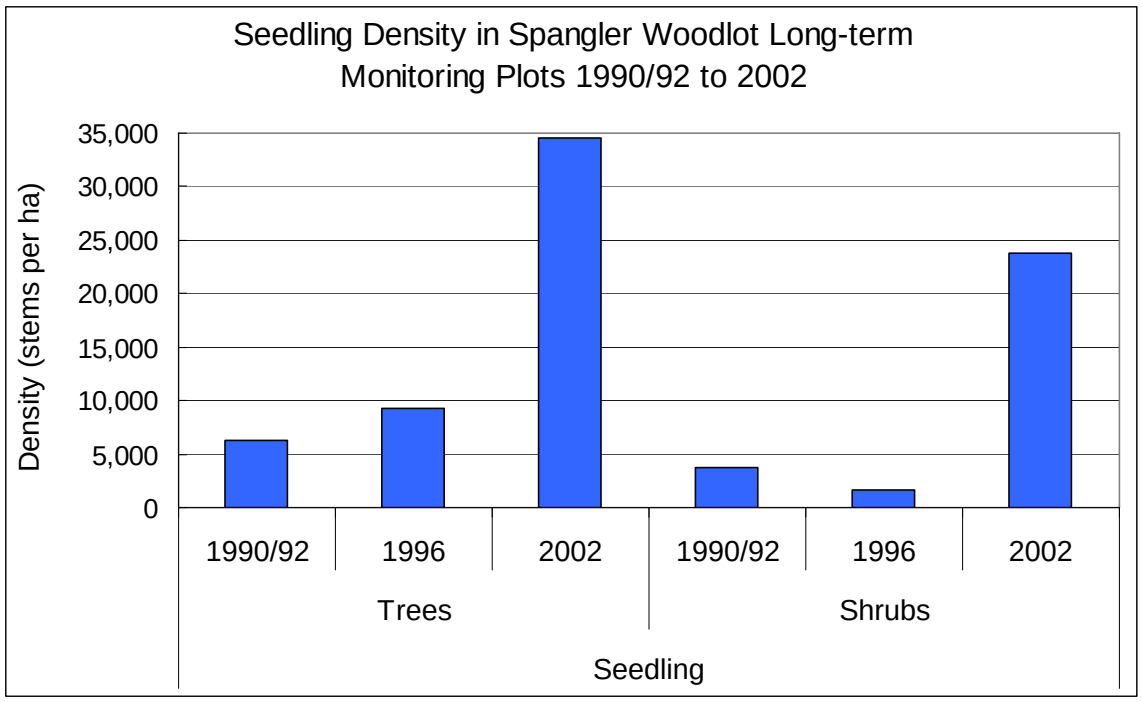


Figure 102. Density of seedling (≤150 cm in height) tree and shrub species in 2 x 2 m subplots within the Long-term Monitoring Plots in Spangler woodlot, Gettysburg National Military Park, 1990/92 to 2002.

Overall Woodlots

Not all data were collected from the six woodlots in the same manner during each of the three inventories. The 2002 inventory was the only inventory in which seedling, sapling, and overstory data were collected for both tree and shrub species in all six woodlots. Nevertheless, the following are our best overall woodlot assessments of changes in the park woodlots from 1990/92 to 2002. Overstory and sapling-sized tree and shrub species in Biesecker and Pitzer woodlots were inventoried in plots that had both fenced and unfenced seedling subplots, but are reported here as combined data since the subplot was a small portion of the plot and the fence treatment had no significant effect on sapling and overstory density. The seedling data presented here is from the unfenced subplots in the six woodlots.

Tree Species:
Overstory: Among the woodlots inventoried, the average density of overstory trees decreased slightly from 309 to 280 to 290 stems/ha in 1990/92, 1996, and 2002, respectively. The overstory tree basal area varied slightly from 24 to 22.8 to 25.2 m^2 per ha, and the average number of tree species recorded was 15, 12, and 17 species in 1990/92, 1996, and 2002, respectively (Figure 103). From 1990/92 to 2002, oaks were the dominant species of tree in five of the six woodlots. In Spangler, cherry was the dominant species in the 1990/92 and 1996 inventories, however oaks were dominant in 2002.

Large Sapling: The average density of large sapling trees decreased from 765 to 715 to 456 stems/ha in the 1990/92, 1996, and 2002 inventories, respectively. The average number of tree species was 15, 11, and 14 species in 1990/92, 1996, and 2002, respectively (Figure 103). Hickory were the dominant large sapling species in five of the six woodlots from 1990/92 through 2002. In Powers Hill, ash and black cherry were the dominant species in 1990/92 and 2002.

Small Sapling: The average density of small sapling trees steadily decreased from 116 stems/ha in 1990/92 to 91 stems/ha in 1996, to only 69 stems/ha in 2002. The average number of tree species recorded was six in 1990/92, five in 1996, and six in 2002 (Figure 103). Black cherry and ash were the dominant small sapling species among all the woodlots during the three inventories.

Seedling: The average seedling tree density in the unfenced subplots decreased from 20,917 stems/ha in 1990/92 to 14,665 stems/ha in 1996, then increased to 27,260 stems/ha in 2002 among the six woodlots (Figure 104). From 1990/92 to 2002, the density of seedling trees in the unfenced subplots decreased in two woodlots (Bushman Hill and Herr Ridge), but increased in four of the woodlots inventoried (Biesecker, Pitzer, Powers Hill, and Spangler). In 1990/92, the seedling tree density in the unfenced subplots ranged from 6,333 to 43,832 stems/ha. In 1996, the density ranged from 1,667 to 63,176 stems/ha, and in 2002 it ranged from 7,084 to 46,334 stems/ha. The average diversity of seedling trees decreased from ten species in 1990/92, to seven species in 1996, then increased to twelve species in 2002 (Figure 103).

The following woodlots experienced increases in seedling tree densities in the unfenced subplots from 1996 to 2002: Biesecker (2,500 to 7,084 stems/ha), Bushman Hill (26,500 to 41,166 stems/ha), Pitzer (7,500 to 16,667 stems/ha), Powers Hill (23,500 to 46,334 stems/ha), and Spangler (9,333 to 34,616 stems/ha). All woodlots except Herr Ridge experienced increases in seedling tree density after the implementation of the Deer Management Program in 1995. Seedling oak densities decreased in four of the six woodlots, ranging from 333 to 17,333 stems/ha in 1990/92, compared to 0 to 11,666 stems/ha in 1996, and 0 to 8,333 stems/ha in 2002. Bushman Hill had the greatest seedling oak densities during the three consecutive inventories. In 2002, ash was the most abundant seedling tree in four of the six woodlots (Bushman Hill, Herr Ridge, Powers Hill, and Spangler).

Goal Stocking Levels: The overall average density of overstory trees started out above the 60% stocking level goal (306 stems/ha) in 1990/92 (309 stems/ha), but then decreased to 280 and 290 stems/ha in 1996 and 2002, respectively (Figure 105). The overall average density of large sapling trees was consistently below the stocking level goal (935 stems/ha) during the 1990/92 (765 stems/ha), 1996 (715 stems/ha), and 2002 (456 stems/ha) inventories. The 60% stocking goal for small sapling trees was 2,806 stems/ha, however the average densities recorded in 1990/92 (116 stems/ha), 1996 (91 stems/ha), and 2002 (69 stems/ha) were small percentages of the goal density. The overall average seedling tree densities in the unfenced subplots during the 1990/92 and 2002 (20,917 and 27,260 stems/ha, respectively) inventories exceeded the stocking goal of 16,834 stems/ha. However, the seedling tree density in 1996 (14,665 stems/ha) was not adequate (Figure 104).

The woodlots exhibited the potential to reproduce a great diversity of seedling tree species at densities great enough to regenerate healthy woodlots. However, the densities of small sapling tree species were severely deficient, less than 2.5% of the stocking level goal density in 2002. The overall average densities of large saplings were also below the stocking level goal (Figure 105). This indicates a serious problem maintaining the woodlots under the existing conditions. Competition with overstory tree species and sapling shrub species were probably the reasons for the low tree species densities. The reduction in the white-tailed deer herd since 1995 has resulted in a positive response in seedling tree densities in the unfenced subplots. Continued white-tailed deer management, creating openings in the overstory to improve light filtration to the ground level, and control of non-native shrub species are the recommended practices for the park woodlots.

Shrub Species:
Overstory: From 1996 to 2002, the average density of overstory shrubs increased from four to eight stems/ha. The average number of overstory shrub species increased from two species in 1996 to four species in 2002 (Figure 103). Of the four woodlots inventoried in 1996 that had any overstory shrubs present, eastern redbud was dominant in Biesecker, and sassafras was dominant in Pitzer and Spangler. In 2002, all six woodlots were inventoried for overstory shrubs, but only four had any present. Sassafras was the dominant shrub among the woodlots in 2002.

Large Sapling: The average density of large sapling shrubs increased from 156 stems/ha in 1996 to 279 stems/ha in 2002. Large sapling shrub average diversity increased from four to six species between 1996 and 2002 (Figure 103). In 1996, smooth blackhaw was the dominant shrub in three of the four woodlots inventoried (Biesecker, Herr Ridge, and Pitzer). In 2002, smooth blackhaw was the dominant shrub in Biesecker, Herr Ridge, Pitzer, and Spangler, eastern redbud was dominant in Bushman Hill, and spicebush was dominant in Powers Hill.

Small Sapling: Small sapling shrub average density increased from 63 stems/ha in 1996 to 833 stems/ha in 2002. The average diversity of small sapling shrubs increased from four to seven species (Figure 103). Among the woodlots inventoried in 1996 (Biesecker, Herr Ridge, Pitzer, and Spangler), smooth blackhaw was the dominant small sapling shrub, followed by flowering dogwood and serviceberry. The distribution of species changed in 2002 when non-native species dominated the small sapling category in three of the six woodlots. In 2002, multiflora rose was the dominant small sapling shrub in Biesecker, Pitzer, and Spangler woodlots, and it was the second most prevalent species in Bushman Hill and Herr Ridge. In 2002, the dominant small sapling shrub in Bushman Hill was eastern redbud, in Herr Ridge it was smooth blackhaw, and in Powers Hill it was spicebush.

Seedling: Among all woodlots, the average seedling shrub density in the unfenced subplots was stable at 20,972 stems/ha in 1990/92 and 20,508 stems/ha in 1996, but then doubled to 41,251 stems/ha in

2002 (Figure 104). The density of seedling shrubs in the unfenced subplots increased in all six woodlots from 1990/92 to 2002. The seedling shrub density in the unfenced subplots ranged from 0 to 45,667 stems/ha in 1990/92, from 1,667 to 63,167 stems/ha in 1996, and from 15,417 to 74,167 stems/ha in 2002. The average number of seedling shrub species was six in 1990/92, five in 1996, and nine in 2002 (Figure 103). There was no consistent trend in shrub species dominance over time. Each woodlot had a unique species composition during the three inventories.

Herbaceous and Vine Vegetation: In 1996, the average total herbaceous coverage in the unfenced subplots ranged from 11 to 42% among the six woodlots surveyed. Average forb coverage was the greatest component of the total herbaceous coverage in five of the six woodlots, ranging from 8 to 22%. Average grass coverage ranged from <1 to 12%, while average vine coverage ranged from 1 to 13% over all woodlots.

In 2002, the average total herbaceous coverage in the unfenced subplots among the six woodlots ranged from 14 to 48%. Average forb coverage was the greatest component of the total herbaceous coverage in all of the woodlots, ranging from 9 to 37%. Average grass coverage ranged from 0 to 7%, while average vine coverage ranged from 2 to 10% among the woodlots. Powers Hill had the greatest average total (48%), grass (7%), and forb (37%) coverages of all the woodlots.

While no statistically significant differences were indicated for the species with the top ten IVs, either over time or between fence treatments within any of the woodlots, there were large changes in individual species. Virginia-creeper was the only species that significantly increased in growth among species with top ten IV ranks in all five woodlots during the ten-year period. However, in Biesecker it did not appear in the top ten in the unfenced subplots. It was only found in one subplot each of the unfenced and unfenced-control subplots, but its presence in one unfenced-control subplot moved it into the top ten rank. The following significant increases were also found: stiltgrass increased from tenth to first rank in Powers Hill, and Japanese honeysuckle increased from seventh to second rank in the fenced subplots at Pitzer. Significant decreases during the same time period included the following: sedge spp. went from first rank to less than tenth in the Biesecker unfenced subplots; rough bedstraw (*Galium asprellum*) went from first rank to less than tenth at Bushman Hill and from third to ninth in Pitzer unfenced subplots; smartweed spp. and stiltgrass went from first and second ranks, respectively, to less than tenth in the Pitzer unfenced subplots.

Major decreases in species in unfenced subplots occurred nearly as often as increases. One species would increase in one subplot and decrease in another, sometimes by large numbers. Most major changes in the fenced subplots were increases in rank. One of the species, rough bedstraw, decreased in the Pitzer fenced subplots and increased in the Bushman Hill unfenced subplots. This indicates that fencing out white-tailed deer had no demonstrable effect on the growth of herbaceous and vine species as a whole. Possibly the decrease in Virginia-creeper in the unfenced subplots at Biesecker was due to white-tailed deer, as the general lack of undergrowth in that woodlot would make it more visible and more likely to be browsed. Some references indicate that white-tailed deer may occasionally severely damage Virginia-creeper (Christoffel, 1998; Maryland Cooperative Fact Sheet 1997; Total Tree Health Care 2002). The large decrease in stiltgrass in the unfenced Pitzer subplots might be explained in the same way, but Tu (2000) states that deer and other ruminants do not eat stiltgrass. Another factor that would have contributed to the decrease in stiltgrass IV was that the 2002 inventory was completed earlier in the growing season, when less vegetation would have been present. Stiltgrass's large increase at Powers Hill unfenced subplots might be attributed to dense understory growth, which would make it less visible to the white-tailed deer, or more likely, there were more alternative food

sources. White-tailed deer may influence the presence of herbaceous and vine species, but their influence seems to be highly variable from place to place and from time to time (Storm et al., 1995).

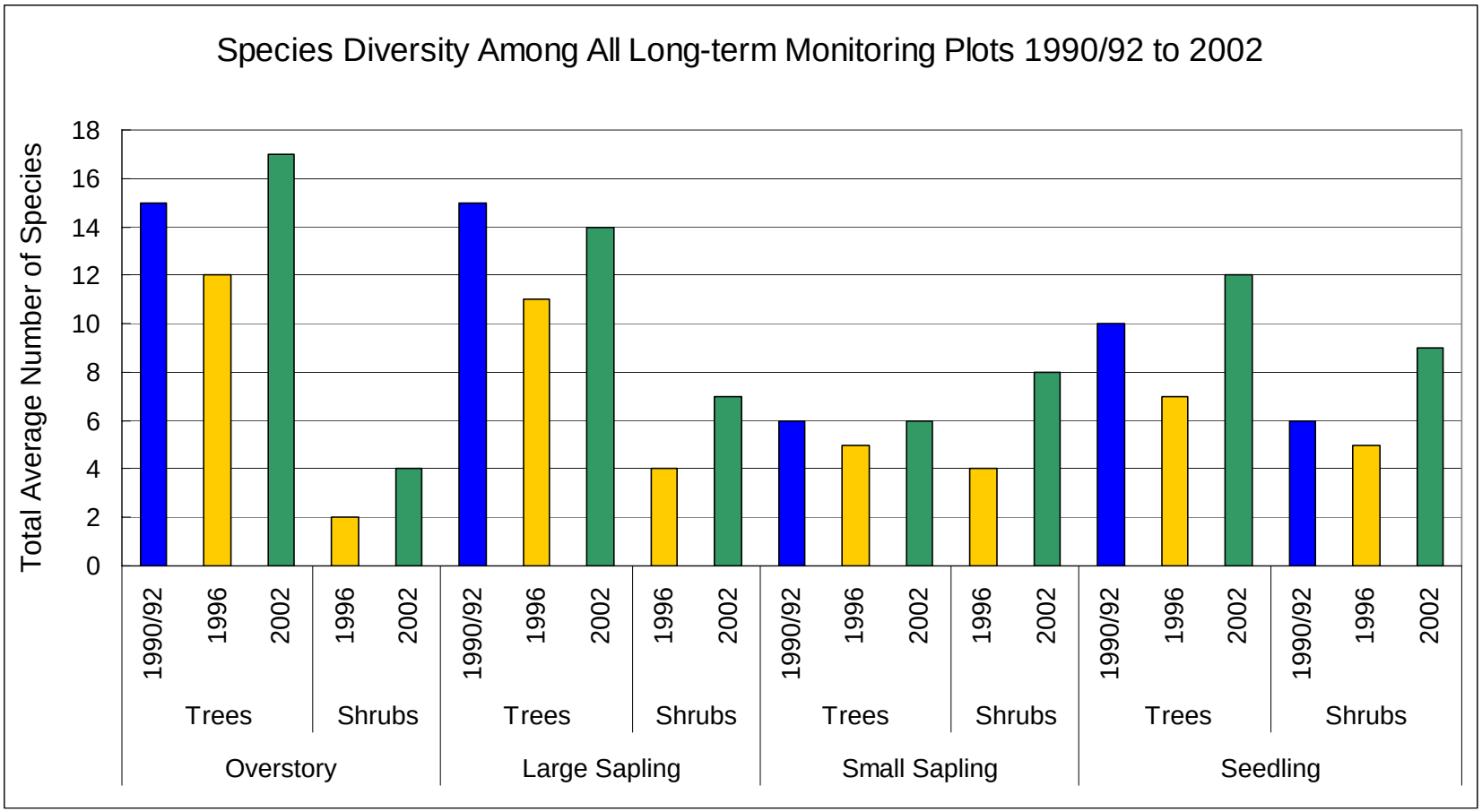


Figure 103. Number of overstory (>1.5 m in height and ≥12 cm dbh), large sapling (>1.5 m in height and 2-11.9 cm dbh), small sapling (>1.5 m in height and <2 cm dbh), and seedling (≤150 cm in height) tree and shrub species among all the Long-term Monitoring Plots, Gettysburg National Military Park, 1990/92 to 2002.

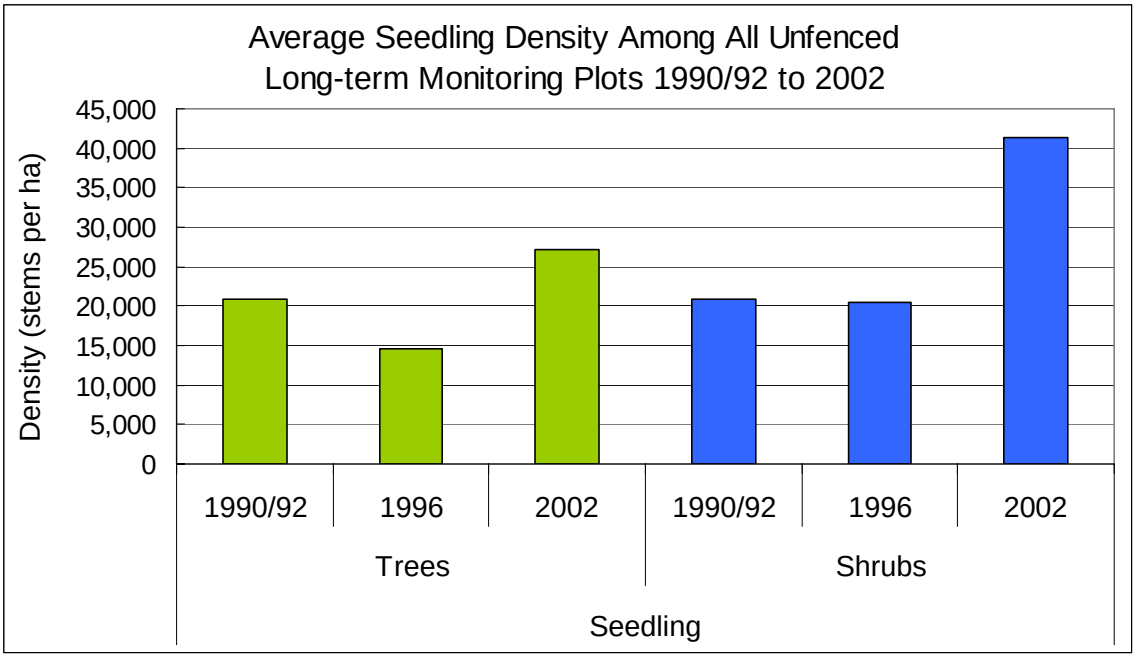


Figure 104. Average density of seedling (≤150 cm in height) tree and shrub species among all the unfenced 2 x 2 m subplots within the Long-term Monitoring Plots, Gettysburg National Military Park, 1990/92 to 2002.

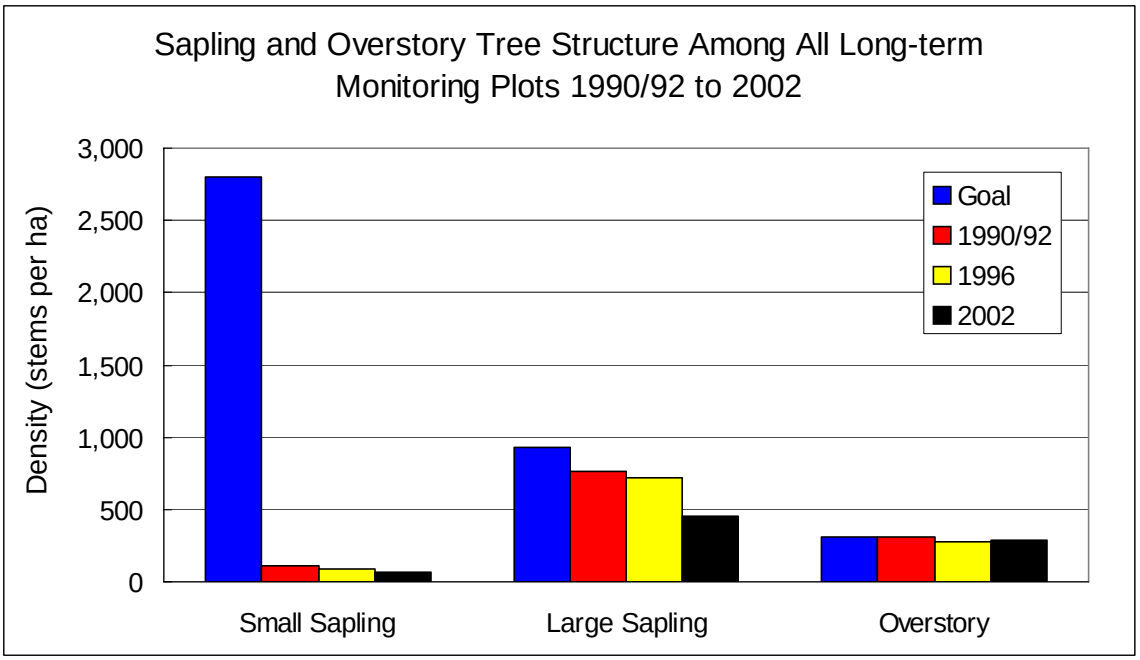


Figure 105. Average density of small sapling (>1.5 m in height and <2 cm dbh), large sapling (>1.5 m in height and 2-11.9 cm dbh), and overstory (>1.5 m in height and ≥12 cm dbh) tree species among all the Long-term Monitoring Plots, Gettysburg National Military Park, 1990/92 to 2002.

Fenced and Unfenced Treatment Comparisons Between Biesecker and Pitzer Woodlots

In 1996, statistically there was no significant difference between seedling tree densities in the fenced and unfenced subplots in either Biesecker or Pitzer (Bowersox et al 2004). In 2002, fence treatment and the interaction between woodlot and fence treatment were both significant predictors of seeding tree density. Between the woodlots, the density of seedling trees in the fenced subplots was significantly different than in the unfenced subplots. Seedling tree density in Biesecker fenced subplots was not significantly different than the seedling tree densities in either Pitzer fence treatment. The densities in either Pitzer fence treatment were not significantly different than in the Biesecker unfenced subplots. In the Biesecker woodlot during the 1990/92, 1996, and 2002 inventories, the density of seedling trees in the fenced subplots was greater than in the unfenced subplots. Conversely, in Pitzer woodlot during all three inventories the density of seedling trees in the unfenced subplots was greater than in the fenced subplots.

Statistically, there was no significant difference in seedling shrub density between the fenced and unfenced subplots in either woodlot in 1996 (Bowersox et al 2004). In 2002, there was a significant interaction between woodlot and fence treatment. The density of seedling shrubs in Biesecker fenced subplots was significantly different than in Pitzer fenced subplots. However, there were no significant differences between the fence treatments within Biesecker or within Pitzer.

Tree Species:
Seedling: In Biesecker, the density of seedling trees in the unfenced subplots decreased from 7,000 stems/ha in 1990/92 to 2,500 stems/ha in 1996, then increased to 7,084 stems/ha in 2002 (Figure 106). The number of tree species recorded in the subplots was eight, three, and four species in 1990/92, 1996, and 2002, respectively. Cherry were consistently the most abundant seedling tree species in the Biesecker unfenced subplots with densities of 4,167 stems/ha in 1990/92, 1,667 stems/ha in 1996, and 6,250 stems/ha in 2002.

In the Biesecker fenced subplots, the density of seedling tree species decreased from 43,501 stems/ha in 1990/92 to 20,833 stems/ha in 1996, then increased to 24,791 stems/ha in 2002 (Figure 106). The number of tree species recorded in the fenced subplots increased from eight in 1990/92 to thirteen in 2002. White oak was the dominant tree species in 1990/92 with 18,500 stems/ha. Black cherry was dominant in 1996 with 9,167 stems/ha. Oaks were also abundant in 1996 with a density of 8,125 stems/ha. In 2002, cherry remained the dominant seedling tree species with a density of 10,209 stems/ha, and the density of oak seedlings increased slightly to 8,542 stems/ha.

In the Pitzer woodlot unfenced subplots, the density of seedling trees decreased from 13,001 stems per ha in 1990/92 to 7,500 stems/ha in 1996, then doubled to 16,667 stems/ha in 2002 (Figure 106). The number of tree species decreased from seven to four species between 1990/92 and 1996, but then increased to ten species in 2002. There was no consistent trend in species dominance in the unfenced subplots over time. Ash were the dominant species in the unfenced subplots in 1990/92 with a density of 4,167 stems/ha. In 1996, hickories were dominant with 6,250 stems/ha. In 2002, red maple was the dominant species, comprising 50% of the seedling tree density in the unfenced subplots.

In the Pitzer woodlot fenced subplots, the density of seedling trees decreased from 9,999 stems/ha in 1990/92 to 5,833 stems/ha in 1996, then tripled to 16,500 stems/ha in 2002 (Figure 106). The diversity of seedling tree species in the fenced subplots undulated from eight to three to eight species, respectively. In 1990/92, ash were the dominant species with a density of 6,167 stems/ha. This changed in the 1996 inventory, when red maple comprised the greatest portion of the density with

3,056 stems/ha. However, ash were dominant again in 2002, with 10,250 stems/ha or 62% of the total seedling tree density among the fenced subplots.

Shrub Species:
Seedling: In the Biesecker unfenced subplots, the density and number of shrub species increased from 1990/92 to 1996. In 1990/92 there were no shrub species growing in the unfenced subplots, but in 1996 there were five species with a density of 17,917 stems/ha. From 1996 to 2002, the density decreased slightly from 17,917 to 15,417 stems/ha, respectively, and the number of species decreased from five to four. In 1996 and 2002, Japanese barberry was the dominant shrub with a density of 13,750 and 7,500 stems/ha, respectively. In 1996, flowering dogwood was the second most abundant seedling shrub (2,917 stems/ha), but in 2002 *Rubus* was more prevalent (7,083 stems/ha).

In the Biesecker fenced subplots, the density of seedling shrubs remained stable at 15,667 stems/ha in 1990/92 and 16,458 stems/ha in 1996, then increased substantially to 33,124 stems/ha in 2002. The diversity of seedling tree species followed a similar trend by remaining stable at four species in 1990/92 and 1996, then increasing to six species in 2002. Smooth blackhaw was the dominant shrub in 1990/92 with 7,167 stems/ha. Flowering dogwood was dominant in 1996 with 8,542 stems/ha. In 2002, *Rubus* was the dominant shrub with 20,625 stems/ha, comprising 62% of the total seedling shrub density in the fenced subplots.

In Pitzer woodlot from 1990/92 to 1996, the density of seedling shrubs in the unfenced subplots decreased from 8,667 to 3,500 stems/ha, then increased almost seven-fold to 21,112 stems/ha in 2002. The number of shrub species recorded in the subplots changed from three to four to ten species in the 1990/92, 1996, and 2002 inventories, respectively. Smooth blackhaw and flowering dogwood (4,500 and 3,500 stems/ha, respectively) were the most abundant seedling shrubs in the unfenced subplots in 1990/92. In 1996, flowering dogwood was the dominant shrub (1,750 stems/ha) and spicebush (750 stems/ha) was also abundant. In 2002, smooth blackhaw was the dominant species with a density of 16,389 stems/ha. Japanese barberry had not been recorded in the woodlot in 1990/92 or 1996, but had a density of 3,056 stems/ha in 2002.

In Pitzer woodlot, the density of seedling shrubs in the fenced subplots increased from 3,167 stems/ha in 1990/92 to 11,389 stems/ha in 1996, then remained stable at 12,000 stems/ha in 2002. Although the diversity of seeding shrub species remained the same from 1990/92 to 1996 (two species), it did increase to five species in 2002. The species composition of seedling shrubs in the fenced subplots changed over time. Smooth blackhaw was dominant in 1990/92 with 1,833 stems/ha. However, flowering dogwood became well established in the woodlot by 1996 and had the greatest density (9,167 stems/ha or 80% of the total fenced seedling shrub density). In 2002, *Rubus* was the dominant seedling shrub with a density of 8,500 stems/ha.

Analysis of the 2002 data indicated that the interaction between woodlot and fence treatment was a significant predictor of seedling tree density between the Biesecker and Pitzer woodlots. In Biesecker woodlot, the unfenced and fenced subplot densities of seedling trees were not becoming more equivalent over time. From 1990/92 to 2002, the trend of greater seedling densities in the fenced subplots than in the unfenced subplots remained the same. Biesecker fenced subplots had significantly different seedling tree densities than the unfenced subplots in 2002. Where deer foraging had been eliminated in the fenced subplots (artificial conditions), the density of seedling trees was significantly greater than where the deer foraging had been reduced in the unfenced subplots (natural conditions) due to the implementation of the Deer Management Program. Although there were significant differences among the Biesecker fence treatments, the density of seedling trees did increase in both the

fenced and unfenced subplots from 1996 to 2002. Conversely, in Pitzer woodlot there was a trend towards equivalency in the fenced and unfenced subplots from 1996 to 2002. There was no significant difference in seedling tree density between the Pitzer fenced and unfenced subplots in 2002. In 1996, the density of seedling trees in the Pitzer unfenced subplots (7,500 stems/ha) was slightly greater than in the fenced subplots (5,833 stems/ha). In 2002, the densities of seedling trees increased to 16,667 stems/ha in the unfenced subplots and 16,500 stems/ha in fenced subplots. From 1996 to 2002, the number of seedling tree species increased in both the fenced and unfenced subplots of Biesecker and Pitzer woodlots. However, the diversity in Pitzer unfenced subplots (ten species) was much greater than in the Biesecker unfenced subplots (four species) in 2002.

Herbaceous and Vine Vegetation: In 2002, analysis indicated that the average total herbaceous coverage in the fenced subplots was significantly different than in the unfenced subplots. Analysis indicated that woodlot, fence treatment, and the interaction between woodlot and fence treatment were significant predictors of average forb coverage in Biesecker and Pitzer woodlots. The average forb coverage in Pitzer was significantly different than in Biesecker. Average forb coverage was significantly different in the fenced subplots than in the unfenced subplots. The fenced and unfenced Pitzer subplots and the Biesecker fenced subplots had significantly different average forb cover than the Biesecker unfenced subplots.

In Biesecker woodlot from 1996 to 2002, the average total herbaceous coverage decreased in the fenced subplots (27 to 25%, respectively) and unfenced subplots (22 to 14%, respectively). The average grass coverage decreased in the fenced subplots (4 to 1%, respectively) and unfenced subplots (10 to 2%, respectively). Average forb coverage increased in the fenced subplots (13 to 20%, respectively) and remained stable in the unfenced subplots (9%). Average vine coverage decreased in the fenced subplots (10 to 4%, respectively) and remained stable in the unfenced subplots (3%).

In Pitzer woodlot from 1996 to 2002, the average total herbaceous coverage increased in the fenced subplots (10 to 26%, respectively) and decreased in the unfenced subplots (28 to 24%, respectively). The average grass coverage remained equal in the fenced subplots (1%) and increased in the unfenced subplots (1 to 2%, respectively). Average forb coverage increased in the fenced subplots (7 to 20%, respectively) and decreased in the unfenced subplots (22 to 20%, respectively). Average vine coverage increased in the fenced subplots (2 to 5%, respectively) and decreased in the unfenced subplots (5 to 2%, respectively).

No statistically significant differences were indicated by the Friedman F_r test in the top ten Importance Values over the time interval 1992 to 2002 within any of the woodlots for either the fenced or unfenced subplots. Nor were there any statistically significant differences indicated for comparisons between fenced and unfenced subplots or fenced and unfenced-control subplots within Biesecker and Pitzer.

Oak Species: There was no consistent trend in oak species seedling density between the two woodlots or the two fence treatments between 1996 and 2002. In Biesecker, the density of unfenced oak seedlings decreased from 1,001 stems/ha in 1990/92 to 417 stems/ha in 1996 to 0 stems/ha in 2002. The density of fenced oak seedlings decreased from 19,335 stems/ha in 1990/92 to 8,125 stems/ha in 1996 then increased slightly to 8,542 stems/ha in 2002. Oak seedling densities were consistently greater in the fenced Biesecker subplots than in the unfenced subplots from 1990/92 to 2002. All the 2002 Biesecker oak seedlings were under 75 cm in height.

In Pitzer, the density of unfenced oak seedlings decreased from 1,667 stems/ha in 1990/92 to 0 stems/ha in 1996, then increased slightly to 556 stems/ha in 2002. The white oak seedlings growing in Pitzer unfenced subplots were in the 0-25 cm height class. The density of fenced oak seedlings in Pitzer decreased from 1,666 stems/ha in 1990/92 to 556 stems/ha in 1996 to 0 stems/ha in 2002.

These data indicate a serious problem in regenerating the woodlots to the historic mixed-oak forest. The Deer Management Program has been successful in reducing the white-tailed deer populations to ¼ the pre-1995 implementation levels in both Biesecker and Pitzer areas. Therefore, white-tailed deer herbivory was not the significant source of oak species seedling decline in these two woodlots. Even with reduced deer foraging pressure, the oak species are not regenerating adequately. Other factors, such as light restrictions/ overstory canopy conditions, understory competition with shrub species, and small mammal predation are probably having negative impacts on the presence and growth of oak species. Reductions in white-tailed deer foraging will enable the woodlots to accumulate sufficient tree species seedlings to sustain the park woodlots. With continued white-tailed deer reductions, control of shrub species, and overstory management, the density of seedling and sapling oak species will probably improve.

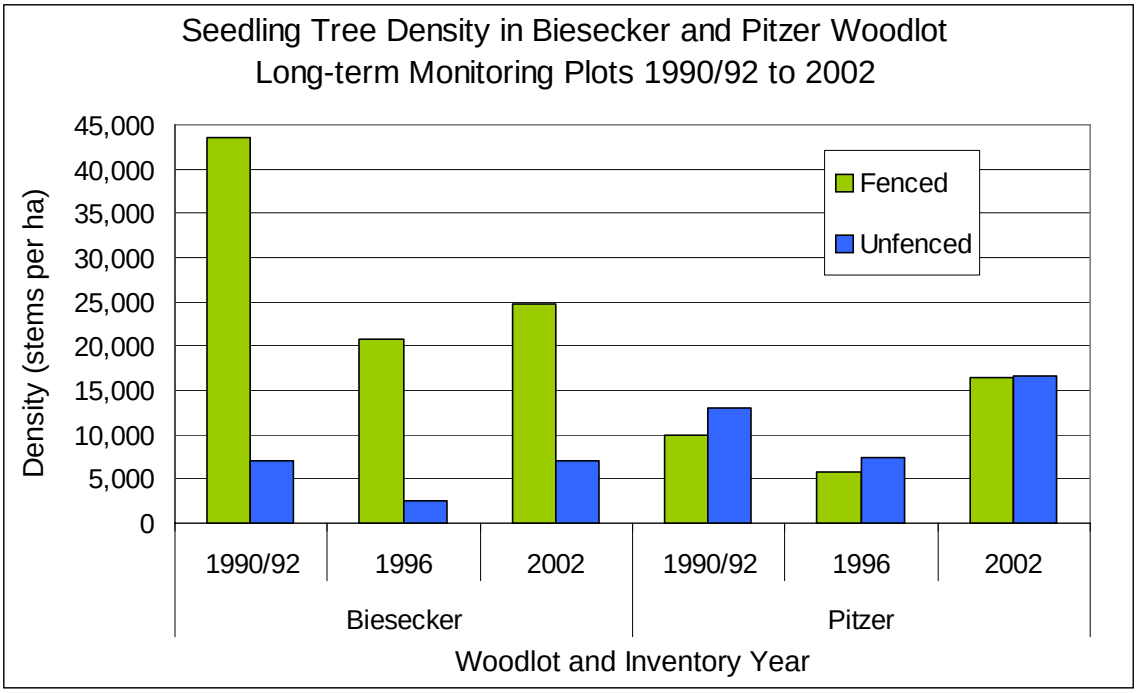


Figure 106. Density of seedling (≤150 cm in height) tree species in the fenced and unfenced 2 x 2 m subplots within the Long-term Monitoring Plots in Biesecker and Pitzer woodlots, Gettysburg National Military Park, 1990/92 to 2002.

Results

Overstory – Tree Species

In 2002, a total of 21 tree species were inventoried (within twenty seven 0.2 ha plots) in the Bushman Hill, Herr Ridge, and Powers Hill woodlot overstory (>1.5 m in height and ≥12 cm dbh), with a density of 95 stems/ha (Table 74). This included the open canopy treatments, in which all overstory-size stems had previously been cut down. The tree species with the greatest density were white oak (18%), mockernut hickory (15%), shagbark hickory (12%), and northern red oak (9%). The remaining seventeen species accounted for 46% of the total overstory tree density.

Canopy treatment and diameter size class were significant predictors of average number of overstory tree species (Table 75). There was no significant difference in number of overstory tree species among the woodlots. The closed canopy averaged 9.33 species per 0.2 ha plot, compared to 6.78 and 0.33 species per 0.2 ha plot in the partially open and open canopy treatments, respectively. The average number of overstory tree species was greatest in the 12-20.9 cm diameter class (3.26 species per 0.2 ha plot). Lowest average number of tree species occurred in the 61-70.9, 71-80.9, 81-90.9, 91-100.9 and >100.9 cm diameter classes (0.67, 0.37, 0.11, 0.19, and 0.07 species per 0.2 ha plot, respectively).

Significant predictors of overstory tree density were woodlot, canopy treatment, and diameter size class (Table 75). The overstory tree density in Herr Ridge (118 stems/ha) was significantly different than the density in Powers Hill (82 stems/ha), but was not significantly different than the density in Bushman Hill (86 stems/ha). Powers Hill and Bushman Hill densities were not significantly different from each other. Overstory tree density in the partially open canopy treatments (115 stems/ha) was 67% of that in the closed canopy (169 stems/ha) treatments. This was relatively the same value established by the deliberate partial cuts when the canopy treatments were established. In 2002, there were five overstory tree stems recorded among the open canopy treatments. Previously there were no overstory trees recorded in the open canopy treatments. The 12-20.9 cm diameter class had the greatest average overstory tree density (41 stems/ha), followed by the 21-30.9 cm diameter class (20 stems/ha). Lowest average densities occurred in the 41 to >100 cm diameter classes (0-9 stems/ha).

Overstory – Shrub Species

Among all of the 0.2 ha plots, three shrub species were recorded in the overstory (>1.5 m in height and ≥12 cm dbh) in the 2002 inventory (Table 74). The overstory shrub density was two stems/ha, and was comprised of flowering dogwood, eastern redbud, and sassafras.

Diameter size class was the only significant predictor of average number of overstory shrub species (Table 75). There were no significant differences in the average number of species among woodlots and canopy treatments. The average number of overstory shrub species in Powers Hill, Herr Ridge, and Bushman Hill woodlots was 0.56, 0.22, and 0 species per 0.2 ha plot, respectively. Similarly, the average number of overstory shrub species in the open, closed, and partially open canopy treatments was 0.00, 0.33, and 0.44 species per 0.2 ha plot, respectively. The 12-20.9 cm diameter class had a significantly different average number of shrub species (0.22 species per 0.2 ha plot) than all other diameter classes (0-0.04 species per 0.2 ha plot) (Table 75).

Woodlot and diameter size class were both significant predictors of overstory shrub density (Table 75). The density in Powers Hill (four stems/ha) was significantly different than in Bushman Hill (zero stems/ha), but not different than in Herr Ridge (one stem per ha). The closed and partially open canopy treatments had two stems/ha, while the open canopy treatments had zero stems/ha. The 12-20.9 cm diameter class had significantly different density (0.3 stems/ha) than all the other diameter classes (0-0.04 stems/ha).

Overstory – Combined Tree and Shrub

Analysis of the total (combined tree and shrub) average number of species and density reflected that of the average number of overstory tree species and tree density (Table 75). Canopy treatment and diameter size class were significant predictors of average number of total species. Among the three woodlots, the average number of total overstory species ranged from 5.67 to 5.89 species per 0.2 ha plot. Closed canopy conditions yielded significantly different average number of total species in the overstory (9.67 species per 0.2 ha plot), than both the partially open and open canopy treatments (7.22 and 0.33 species per 0.2 ha plot, respectively). The partially open treatments had significantly different average number of total species than the open treatments. The 12-20.9 cm diameter class (3.48 species per 0.2 ha plot) had significantly different average number of total species than all the other diameter classes, which ranged between 0.07 and 2.52 species per 0.2 ha plot.

Significant predictors of total (combined tree and shrub) overstory density were woodlot, canopy treatment, and diameter size class (Table 75). The total overstory density in Herr Ridge (119 stems/ha) was significantly different than in Bushman Hill (86 stems/ha), but was not significantly different than in Powers Hill (87 stems/ha). Powers Hill and Bushman Hill total overstory densities were not significantly different from each other. The closed, partially open, and open canopy treatments had significantly different total overstory densities. Total density in the partially open canopy (117 stems/ha) was 68% of that in the closed canopy (172 stems/ha) treatments. This was relatively the same value established by the deliberate partial cuts when the canopy treatments were established. The open canopy treatments had a total density of 3 stems/ha. The 12-20.9 cm diameter class had the greatest density (42 stems/ha), followed by the 21-30.9 cm diameter class (20 stems/ha). Lowest densities occurred in the 41 to >100.9 cm diameter classes (0-9 stems/ha).

Sapling – Tree Species

In 2002, over all plots there were a total of 25 tree species inventoried (within 108 0.01 ha subplots) in the sapling (>1.5 m in height and <12 cm dbh) category (Table 74). The total sapling tree density was 945 stems/ha. The sapling tree density was mostly comprised of black cherry (22%), northern red oak (15%), ash (14%), and pignut hickory (13%). Hickory, cherry, oak, and ash were the predominant sapling tree species among the canopy treatments (Figure 107). The remaining 21 species accounted for 36% of the total sapling tree density (Table 74).

Analysis indicated that woodlot, canopy treatment, and diameter size class were significant predictors of average number of species of sapling trees (Table 76). There was also a significant interaction between woodlot and canopy treatment. The average number of tree species in Herr Ridge (4.36 species per 0.01 ha subplot) was significantly different than in both Bushman Hill and Powers Hill (2.64 and 1.97 species per 0.01 ha subplot, respectively), which were not significant different from each other (Table 77). The open canopy treatment had significantly different average number of sapling tree species (4.08 species per 0.01 ha subplot) than both the closed and partially open

treatments (2.22 and 2.67 species per 0.01 ha subplot, respectively), which were not significantly different from each other. The smallest diameter class (0.5-1.9 cm dbh) had significantly different average number of tree species (1.25 species per 0.01 ha subplot) than the remaining nine diameter classes, which ranged from 0.26 to 3.10 species per 0.01 ha subplot (Table 77).

Woodlot, canopy treatment, diameter size class, and the interaction between woodlot and canopy treatment were significant predictors of sapling tree density in 2002 (Table 76). Herr Ridge had a significantly different sapling tree density (1,622 stems/ha) compared to the other two woodlots; there was no significant difference in density between Bushman Hill (633 stems/ha) and Powers Hill (581 stems/ha) woodlots (Table 77, Figure 108). The open canopy treatments had significantly different sapling tree density (1,653 stems/ha), compared to the closed canopy (583 stems/ha) and the partially open canopy (600 stems/ha) treatments (Table 77, Figure 109). Herr Ridge open canopy treatments had significantly different density of sapling trees (2,908 stems/ha) than all other woodlot and canopy treatment combinations. Lowest sapling tree densities occurred in Bushman Hill closed canopy treatments (225 stems/ha). In 2002, the 0.5-1.9 cm diameter class had 249 stems/ha, significantly different than the densities in the 3.0 to 11.9 cm diameter classes. The 2.0-2.9 cm diameter class had 204 stems/ha. Lowest average sapling tree densities occurred in the 5.0-11.9 cm diameter classes (9-76 stems/ha) (Table 77).

Sapling – Shrub Species

In 2002, a total of 16 shrub species were inventoried (within 108 0.01 ha subplots) in the sapling (>1.5 m in height and <12 cm dbh) category. The total sapling shrub density was 11,162 stems/ha (Table 74). The density was comprised mostly of spicebush (39%), honeysuckle (20%), Japanese barberry (13%), and multiflora rose (12%) (Figure 110).

In 2002, woodlot, canopy treatment, and diameter size class were statistically significant factors affecting the number of shrub species in the sapling category (Table 76). Bushman Hill had significantly different average number of shrub species (6.39 species per 0.01 ha subplot) than both Powers Hill (4.67 species per 0.01 ha subplot) and Herr Ridge (2.11 species per 0.01 ha subplot) (Table 77). The average number of shrub species in the open canopy treatments was significantly different (5.75 species per 0.01 ha subplot) than in both the partially open and closed canopy treatments (4.36 and 3.06 species per 0.01 ha subplot, respectively) (Table 77). There were also significant differences between the average number of shrub species in the partially open and closed canopy treatments. The 0.5-1.9 cm diameter class averaged 3.58 species per 0.01 ha subplot, significantly different than the 2.0-11.9 cm diameter classes, which had densities ranging between 0 and 1.95 species per 0.01 ha subplot (Table 77).

Analysis indicated that woodlot, canopy treatment, diameter size class, and the interaction between woodlot and canopy treatment were significant predictors of sapling shrub density (Table 76). Powers Hill sapling shrub density (17,328 stems/ha) was significantly different than Bushman Hill and Herr Ridge (13,864 and 2,294 stems/ha, respectively) (Table 77). The density in Bushman Hill was also significantly different than in Herr Ridge. Sapling shrub density increased with increasing light levels. The sapling shrub densities in the closed (2,525 stems/ha), partially open (8,828 stems/ha) and open (22,133 stems/ha) canopy treatments were all significantly different from each other (Figure 109). Powers Hill woodlot open canopy treatments (34,408 stems/ha) had significantly different sapling shrub densities compared to all other combinations of woodlot and canopy treatment, which ranged from 342 to 25,850 stems/ha. Bushman Hill open canopy treatments (25,850 stems/ha) had

significantly different densities than the remaining woodlot canopy treatment combinations (Table 77). The lowest densities were in the Herr Ridge treatments, and in Bushman Hill and Powers Hill closed canopy treatments. Sapling shrub density in the 0.5-1.9 cm diameter class was 9,130 stems/ha, significantly different than the other nine diameter classes, which ranged from 2 to 1,485 stems/ha (Table 77). The 2.0-2.9 cm diameter class density (1,483 stems/ha) was significantly different than in the 3.0-11.9 cm diameter classes (2-347 stems/ha).

Sapling – Combined Tree and Shrub

Woodlot, canopy treatment, and diameter size class were significant predictors of average number of total (combined tree and shrub) sapling species. In 2002, Bushman Hill had a significantly different average number of total species (8.97 species per 0.01 ha subplot), than both Powers Hill (6.64 species per 0.01 ha subplot) and Herr Ridge (6.47 species per 0.01 ha subplot) (Table 77). The average number of species increased with higher light levels. The three different canopy treatments resulted in significantly different average number of total species. The open canopy plots averaged 9.83 species per 0.01 ha subplot, significantly different than the partially open plots which averaged 6.97 species per 0.01 ha subplot. The closed canopy plots averaged only 5.28 species per 0.01 ha subplot (Table 77). Analysis of the total species data indicated a similar trend among the different diameter classes as for the shrub only data analysis. The 0.5-1.9 cm diameter class averaged 4.83 species per 0.01 ha subplot, significantly different than the average number of total species in the 2.0-11.9 cm diameter classes. The 2.0-2.9 cm diameter class averaged 3.10 species per 0.01 ha subplot, and was significantly different than the remaining eight diameter classes, which ranged from 0.20 to1.95 species per 0.01 ha subplot (Table 77).

Significant predictors of total sapling density were woodlot, canopy treatment, diameter size class, and the interaction between woodlot and canopy (Table 76). The total sapling density in Powers Hill (17,908 stems/ha) was significantly different than in both Bushman Hill and Herr Ridge (14,497 and 3,917 stems/ha, respectively) (Table 77). The total density in Bushman Hill was also significantly different than in Herr Ridge. There were significant differences in total sapling density between the canopy treatments. Total sapling density in the open canopy treatments (23,786 stems/ha) was significantly different than in the partially open treatments (9,428 stems/ha), which was also significantly different than in the closed treatments (3,108 stems/ha) (Table 77). Powers Hill open canopy treatments had significantly different total sapling density (35,333 stems/ha) than all other woodlot canopy treatment combinations, which ranged from 1,250-26,975 stems/ha. Bushman Hill open canopy treatments had significantly different total sapling density (26,975 stems/ha) than the remaining seven woodlot-canopy treatment combinations. The total sapling density in the 0.5-1.9 cm diameter class was 9,379 stems/ha, significantly different than in the 2.0-11.9 cm diameter classes (Table 77). Similarly, the 2.0-2.9 cm diameter class density was 1,687 stems/ha, significantly different than the density in the remaining eight diameter classes, which ranged from 20 to 494 stems/ha.

Table 74. Overall density of seedling (≤150 cm in height), sapling (>1.5 m in height and <11.9 cm in dbh), and overstory (>1.5 m in height and ≥12 cm dbh) tree and shrub species among all the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

	Seedling[a]	Sapling[b]	Overstory[c]
Tree Species	(----------stems/ha----------)		
Ailanthus	0	42	<1
Ash	11,481	133	7
Blackgum	1,852	6	7
Catalpa	0	2	<1
Cedar, eastern red	0	2	1
Cherry, sweet	185	5	1
Cherry, black	1,574	206	4
Elm, American	2,130	33	4
Elm, slippery	833	15	1
Hackberry	0	3	0
Hazelnut	185	1	0
Hickory, mockernut	278	65	14
Hickory, pignut	463	126	6
Hickory, shagbark	648	96	11
Locust	185	0	0
Maple, Norway	0	2	1
Maple, red	833	2	2
Mulberry	0	1	0
Oak, black	93	10	4
Oak, chestnut	0	0	<1
Oak, northern red	370	143	9
Oak, pin	0	8	<1
Oak, white	2,407	8	17
Poplar, yellow	185	23	4
Sycamore, American	0	1	0
Walnut, black	0	11	1
Willow	0	3	0
Total	23,704	945	95
Shrub Species			
Barberry, Japanese	6,204	1,456	0
Blackhaw, smooth	3,796	159	0
Boxelder	0	1	0
Dogwood, flowering	1,389	74	1
Euonymus	185	1	0
Grape	0	76	0
Greenbriar	0	3	0
Honeysuckle	185	2,247	0
Olive, autumn	741	130	0
Redbud, eastern	4,074	540	1
Ribes	370	0	0
Rose, multiflora	2,500	1,291	0
Rubus	24,352	747	0
Sassafras	0	12	<1
Serviceberry	185	11	0
Spicebush	20,463	4,381	0
Witch hazel	0	32	0
Total	64,444	11,162	2

[a]Based on 108 – 0.0001 ha subplots.
[b]Based on 108 – 0.01 ha subplots.
[c]Based on 27 – 0.2 ha plots.

Table 75. Average[a] number of species and density of overstory[b] tree, shrub, and total species by woodlot, canopy treatment, and diameter size class in the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

	Tree	Shrub	Total
Woodlot	(----------species per 0.2 ha plot----------)		
Bushman Hill	5.67a	0.00a	5.67a
Herr Ridge	5.67a	0.22a	5.89a
Powers Hill	5.11a	0.56a	5.67a
Canopy Treatment			
Closed	9.33a	0.33a	9.67a
Partially Open	6.78b	0.44a	7.22b
Open	0.33c	0.00a	0.33c
Diameter Class (cm)			
12 - 20.9	3.26a	0.22a	3.48a
21 - 30.9	2.48b	0.04b	2.52b
31 - 40.9	1.56c	0.04b	1.59c
41 - 50.9	0.93cd	0.00b	0.93cd
51 - 60.9	1.15cd	0.00b	1.15cd
61 - 70.9	0.67d	0.00b	0.67d
71 - 80.9	0.37d	0.00b	0.37d
81 - 90.9	0.11d	0.00b	0.11d
91 - 100.9	0.19d	0.00b	0.19d
>100.9	0.07d	0.00b	0.07d
Woodlot	(----------stems/ha----------)		
Bushman Hill	86ab	0b	86b
Herr Ridge	118a	1ab	119a
Powers Hill	82b	4a	87ab
Canopy Treatment			
Closed	169a	2a	172a
Partially Open	115b	2a	117b
Open	3c	0a	3c
Diameter Class (cm)			
12 - 20.9	41a	0.3a	42a
21 - 30.9	20b	0.04b	20b
31 - 40.9	12bc	0.04b	12bc
41 - 50.9	6c	0b	6c
51 - 60.9	9c	0b	9c
61 - 70.9	5c	0b	5c
71 - 80.9	2c	0b	2c
81 - 90.9	1c	0b	1c
91 - 100.9	1c	0b	1c
>100.9	0c	0b	0c

[a] Values within the same group with the same letter were not significantly different at the 0.05 probability level.

[b] Stems >1.5 m in height and ≥12 cm dbh

Table 76. Analysis of Variance results for seedling[a] and sapling[b] tree and shrub species densities by woodlot, canopy treatment, and diameter size class among the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

Vegetation Group/ Factors	Degrees of Freedom	ANOVA Significance[c] Seedling	Sapling
Tree			
Woodlot	2	Yes	Yes
Canopy	2	Yes	Yes
Size Class	1	Yes	Yes
Woodlot x Canopy	4	Yes	Yes
Woodlot x Size Class	2	No	Yes
Canopy x Size Class	2	Yes	Yes
Shrub			
Woodlot	2	No	Yes
Canopy	2	Yes	Yes
Size Class	1	No	Yes
Woodlot x Canopy	4	No	Yes
Woodlot x Size Class	2	Yes	Yes
Canopy x Size Class	2	Yes	Yes

[a] Stems ≤150 cm in height
[b] Stems >1.5 m in height and <12 cm dbh
[c] Significant differences are designated with a Yes (F value ≤ 0.5).

Table 77. Average[a] number of species and density of sapling[b] tree, shrub, and total species by woodlot, canopy treatment, and diameter size class in the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

Factor	Tree	Shrub	Total
Woodlot	(----------species per 0.01 ha subplot----------)		
Bushman Hill	2.64b	6.39a	8.97a
Herr Ridge	4.36a	2.11c	6.47b
Powers Hill	1.97b	4.67b	6.64b
Canopy Treatment			
Closed	2.22b	3.06c	5.28c
Partially Open	2.67b	4.36b	6.97b
Open	4.08a	5.75a	9.83a
Diameter Class (cm)			
0.5 - 1.9	1.25a	3.58a	4.83a
2.0 - 2.9	1.15ab	1.95b	3.10b
3.0 - 3.9	0.97ab	0.98c	1.95c
4.0 - 4.9	0.89b	0.69d	1.57c
5.0 - 5.9	0.51c	0.20e	0.71d
6.0 - 6.9	0.22cd	0.15e	0.37de
7.0 - 7.9	0.30cd	0.16e	0.45de
8.0 - 8.9	0.19d	0.07e	0.26e
9.0 - 9.9	0.19d	0.02e	0.20e
10.0 - 11.9	0.20cd	0.06e	0.26e
Woodlot	(----------stems/ha----------)		
Bushman Hill	633b	13,864b	14,497b
Herr Ridge	1,622a	2,294c	3,917c
Powers Hill	581b	17,328a	17,908a
Canopy Treatment			
Closed	583b	2,525c	3,108c
Partially Open	600b	8,828b	9,428b
Open	1,653a	22,133a	23,786a
Woodlot x Canopy Interaction			
Bushman x Closed	225c	2,150d	2,375d
Bushman x Part Open	550bc	13,592c	14,142c
Bushman x Open	1,125b	25,850b	26,975b
Herr x Closed	1,050b	400d	1,450d
Herr x Part Open	908bc	342d	1,250d
Herr x Open	2,908a	6,142d	9,050cd
Powers x Closed	475bc	5,025d	5,500d
Powers x Part Open	342bc	12,550cd	12,892c
Powers x Open	925bc	34,408a	35,333a
Diameter Class (cm)			
0.5 - 1.9	249a	9,130a	9,379a
2.0 - 2.9	204ab	1,483b	1,687b
3.0 - 3.9	147b	347c	494c
4.0 - 4.9	141b	128c	269c
5.0 - 5.9	76c	26c	102c
6.0 - 6.9	31c	16c	46c
7.0 - 7.9	36c	17c	53c
8.0 - 8.9	21c	7c	29c
9.0 - 9.9	19c	2c	20c
10.0 - 11.9	22c	6c	29c

[a] Values within the same group (tree, shrub or total) per factor with the same letter were not significantly different at the α=0.05 level.
[b] Stems >1.5 m in height and <12 cm dbh

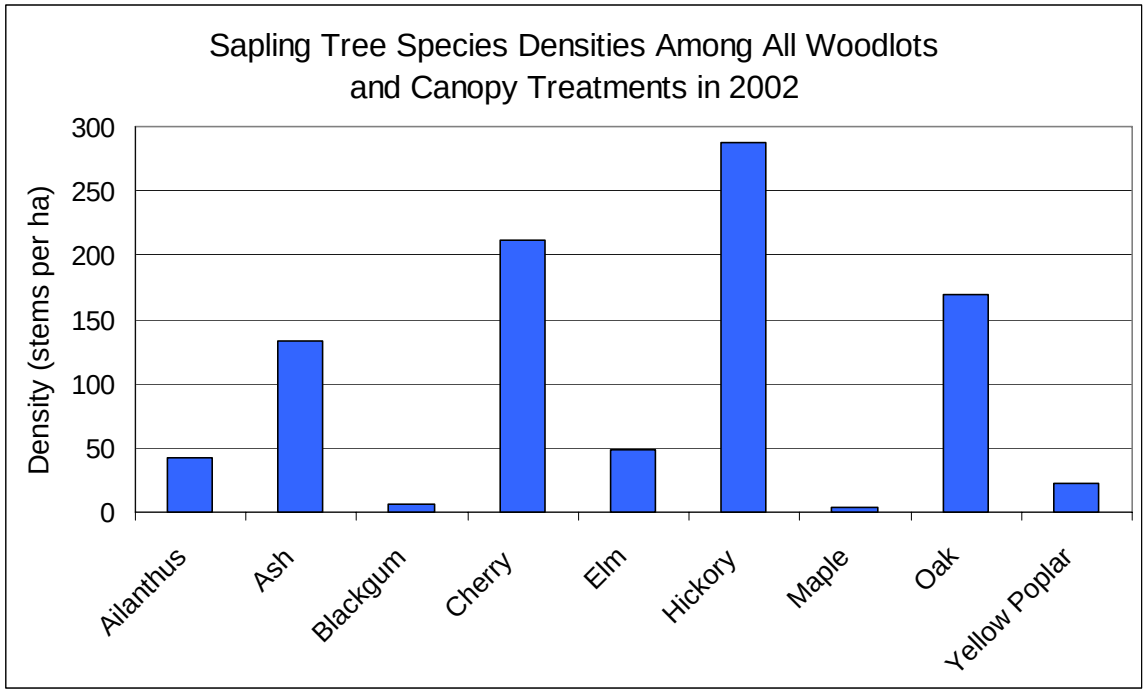


Figure 107. Density of sapling (>1.5 m in height and <12 cm dbh) tree species among all twenty-seven 20 x 20 m Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

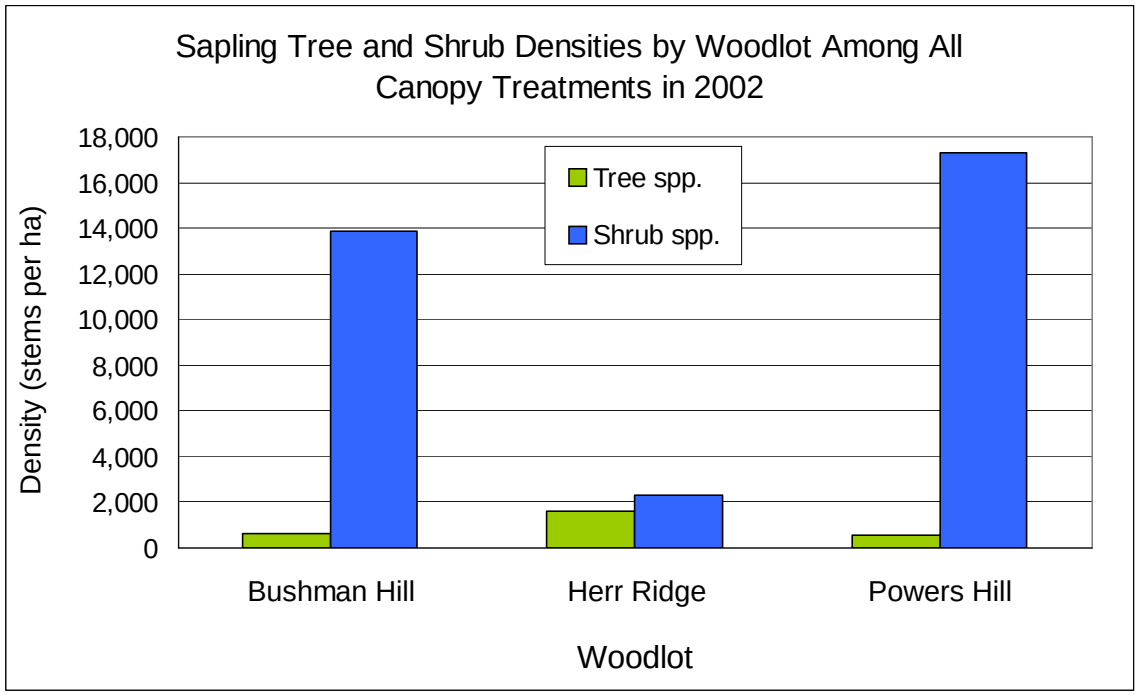


Figure 108. Density of sapling (>1.5 m in height and <12 cm dbh) tree and shrub species by woodlot among the 20 x 20 m Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

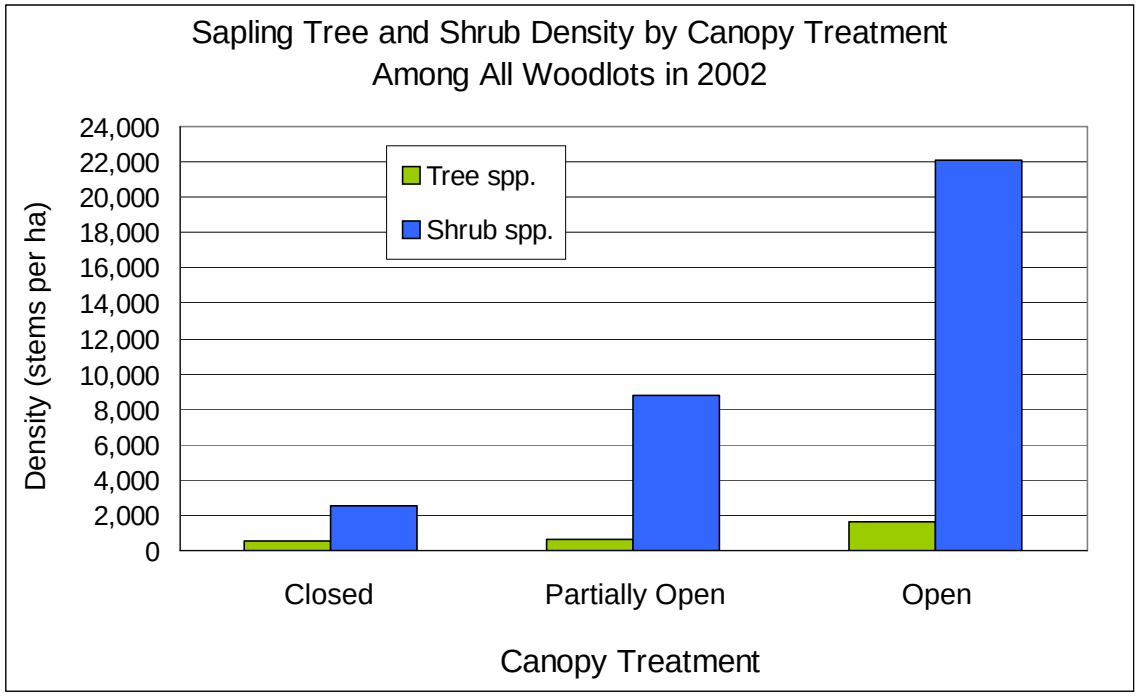


Figure 109. Density of sapling (>1.5 m in height and <12 cm dbh) tree and shrub species by canopy treatment among the 20 x 20 m Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

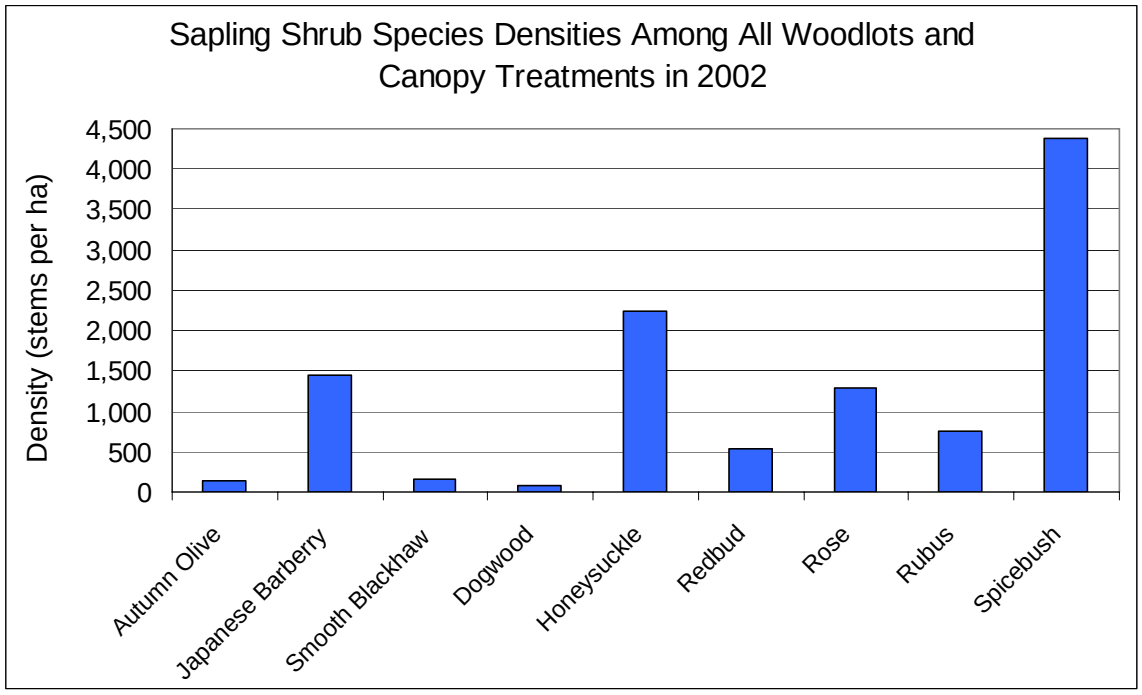


Figure 110. Density of sapling (>1.5 m in height and <12 cm dbh) shrub species among all twenty-seven 20 x 20 m Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

Seedling – Tree Species

Over all plots, a total of 16 species of trees were inventoried (within 108 0.0001 ha subplots) in the seedling category in 2002. The total seedling tree density among all woodlots and canopy treatments was 23,704 stems/ha (Table 74). Ash was the most abundant tree species with 11,481 stems/ha, or 48% of the total seedling tree density. White oak had the second greatest density with 2,407 stems/ha or 10% of the total seedling tree density. The oak species seedling density was 2,777 stems/ha. American elm, blackgum, and black cherry densities combined represented 23% of the total density. The remaining eleven tree species accounted for 19% of the total density (Table 74, Figure 111).

Analysis indicated woodlot, canopy treatment, and height class were significant predictors of the average number of seedling tree species in 2002. Bushman Hill woodlot had significantly different average number of tree species (1.97 species per 0.0001 ha subplot) than both Herr Ridge and Powers Hill (0.56 and 1.00 species per 0.0001 ha subplot, respectively) (Table 78). The closed and partially open canopy treatments (1.56 and 1.53 species per 0.0001 ha subplot, respectively) had significantly different average number of seedling tree species than the open canopy treatments (0.44 species per 0.0001 ha subplot). The 0-25 cm height class had significantly different average number of seedling tree species (0.83 species per 0.0001 ha subplot) than the 25.1-50 cm height class (0.44 species per 0.0001 ha subplot), which was also significantly different from the remaining four height classes (0.03 to 0.14 species per 0.0001 ha subplot) (Table 78).

Analysis indicated that woodlot, canopy treatment, height class, and the interaction between woodlot and canopy treatment were significant predictors of seedling tree density (Table 76). Bushman and Powers Hills had significantly different seedling tree densities (36,111 and 28,889 stems/ha, respectively) than Herr Ridge (6,111 stems/ha) (Table 78, Figure 112). Seedling tree densities were greatest in the closed and partially open canopy treatments. When the canopy was completely opened, fewer seedling trees were found. The partially open and closed canopy treatments seedling tree densities were not significantly different from each other (37,222 and 27,500 stems/ha, respectively), but were significantly different than in the open canopy treatments (6,389 stems/ha) (Table 78, Figure 113). Densities of seedling trees in Bushman Hill closed and Powers Hill partially open canopy treatments were significantly different (56,667 and 67,500 stems/ha, respectively) than all Herr Ridge treatments (1,667 to 8,333 stems/ha), Bushman Hill open (15,833 stems/ha), and Powers Hill closed and open canopy treatments (17,500 and 1,667 stems/ha, respectively) (Table 78). The 0-25 cm height class had significantly different seedling tree density (14,722 stems/ha) than the other height classes (278 to 6,296 stems/ha). Since there were so few seedling trees in the 25.1-150 cm height classes, analysis was completed on a condensed height class scheme (0-25 cm and 25.1-150 cm). Analysis of these data indicated that woodlot had no significant effect (Table 79, Figure 114), but that canopy treatment did make a significant difference in seedling tree density (Table 80, Figure 115). The density of seedling trees 0-25 cm in height in partially open treatments (26,389 stems/ha) was significantly different than the density of 0-25 cm seedling trees in open canopy treatments (1,944 stems/ha); and was significantly different than the density of seedling trees 25.1-150 cm in height in all three canopy treatments. There were no significant differences in the density of seedling trees 0-25 cm in the closed canopy (15,833 stems/ha) and partially open canopy treatments (Table 80).

Seedling – Shrub Species

Over all, a total of 12 species of shrubs were inventoried (within 108 0.0001 ha subplots) in the seedling category in 2002. The total seedling shrub density was 64,444 stems/ha (Table 74). *Rubus*

were dominant (24,352 stems/ha), comprising 38% of the total seedling shrub density; while spicebush (20,463 stems/ha) accounted for 32%. Three other shrubs were prevalent in the woodlots. Japanese barberry comprised 10%, eastern redbud 6%, and smooth blackhaw 6% of the seedling shrub density (Table 79, Figure 116).

Woodlot, canopy treatment, and height class were significant predictors of average number of shrub species in the seedling category. Bushman Hill and Powers Hill had significantly different average number of shrub species (2.25 and 1.89 species per 0.001 ha subplot, respectively) than Herr Ridge (1.03 species per 0.001 ha subplot) (Table 78). Canopy treatment had the same effect on the average number of seedling shrub species as on tree species. The closed and partially open canopy treatments resulted in significantly different average number of shrub species (2.03 and 1.83 species per 0.001 ha subplot, respectively) than the open canopy treatments (1.31 species per 0.001 ha subplot) (Table 78). The 0-25 cm height class had significantly different average number of shrub species (1.10 species per 0.001 ha subplot) than the other five height classes (0.12 to 0.72 species per 0.001 ha subplot) (Table 78). The 25.1-50 cm height class had significantly different average number of shrub species (0.72 species per 0.001 ha subplot) than the 75.1-150 cm height classes (0.12 to 0.31 species per 0.001 ha subplot) and there were no significant differences among the remaining four height classes.

Canopy treatment and height class were significant predictors of seedling shrub density in 2002 (Table 76). All three woodlots had similar seedling shrub density values and there was no significant interaction between woodlot and canopy treatment. Seedling shrub density ranged from 51,944 stems/ha in Herr Ridge to 77,778 stems/ha in Powers Hill woodlot (Figure 112, Table 78). The seedling shrub density was greatest in the closed and partially open canopy treatments and least within the open canopy treatments (Figure 113). When the canopy was completely opened up, significantly fewer seedling shrubs were found. The partially open and closed canopy treatments seedling shrub densities were not significantly different from each other (86,667 and 69,444 stems/ha, respectively), but both were significantly different than in the open canopy treatments (37,222 stems/ha) (Table 78). The seedling shrub density in the 0-25 cm height class was 33,519 stems/ha, significantly different than in the other five height classes. The 25.1-50 cm height class had 11,019 stems/ha, but this was only significantly different from the 125.1-150 cm height class, which had 1,667 stems/ha (Table 78). Again, analysis was completed on a condensed height class scheme where the 0-25 cm and 25.1-150 cm height classes were combined. These results indicated that woodlot and canopy treatment were both significant predictors of seedling shrub density. Densities of seedling shrubs in Bushman Hill (25.1-150 cm in height), Herr Ridge (0-25 cm in height), and Powers Hill (0-25 and 25.1-150 cm in height) were all significantly different than the density in Herr Ridge (25.1-150 cm in height) (Table 79, Figure 117). The density of Bushman Hill seedling shrubs 0-25 cm in height was not significantly different than in any other combination of woodlot and height class. The effect of canopy treatment was more complex to decipher because mean separations showed overlap among the height classes. The density of seedling shrubs 0-25 cm in height in the partially open canopy treatments was significantly different than the density of seedling shrubs 0-25 and 25.1-150 cm in height in the open canopy treatments. However, the seedling shrub densities in the open canopy treatment height classes were not significantly different from the densities of seedling shrubs in the closed canopy treatment height classes or from the density in the partially open canopy 25.1-150 cm height class (Table 80, Figure 118).

Seedling – Combined Tree and Shrub Species

Woodlot, canopy treatment, and height class were significant predictors of average total (combined tree and shrub) seedling species. The average number of total seedling species was significantly different between Bushman Hill (4.25 species per 0.0001 ha subplot) and Powers Hill (2.89 species per 0.0001 ha subplot). The average number of total species in Powers Hill was also significantly different than in Herr Ridge (1.58 species per 0.0001 ha subplot) (Table 78). Open canopy treatment conditions resulted in the fewest total species. The average number of total seedling species in the closed and partially open canopy treatments were not significantly different from each other (3.58 and 3.39 species per 0.0001 ha subplot, respectively). However, both were significantly different than the average number of total species in the open canopy treatments (1.75 species per 0.0001 ha subplot) (Table 78). The 0-25 cm height class averaged 1.94 total species per 0.0001 ha subplot, significantly different than the other five height classes, which ranged from 0.15 to 1.17 species per 0.0001 ha subplot. The average number of total seedling species in the 25.1-50 cm height class (1.17 species per 0.0001 ha subplot) was also significantly different than in the 75.1-150 cm height classes, which ranged from 0.15 to 0.38 species per 0.0001 ha subplot.

Significant predictors of total (combined tree and shrub) seedling density were woodlot, canopy treatment, height class, and the interaction between woodlot and canopy treatment. Powers Hill (106,667 stems/ha) and Bushman Hill (99,722 stems/ha) had significantly different total seedling densities than Herr Ridge (58,056 stems/ha) (Table 78). Total seedling density was greatest in moderate to low light levels. Fewer seedlings were found when the canopy was completely opened up. The partially open and closed canopy treatments yielded total seedling densities that were not significantly different from each other (123,889 and 96,944 stems/ha, respectively), but both were significantly different from the open canopy treatment density (43,611 stems/ha). The 0-25 cm height class had 48,241 stems/ha, which was significantly different than the other height classes. The total density of seedlings 25.1-50 cm in height (17,315 stems/ha) was significantly different than the densities in the tallest height classes (ranging from 1,944 to 5,741 stems/ha) (Table 78).

Analysis of the total seedling densities indicated a significant interaction between woodlot and canopy treatment. Bushman Hill closed and partially open canopy treatments (128,333 and 116,667 stems/ha, respectively) and Powers Hill partially open canopy treatments (172,500 stems/ha) yielded significantly different total seedling densities (Table 78) than in all of the Herr Ridge treatments, and both the Bushman Hill and Powers Hill open canopy treatments. The general trend was that Powers Hill and Bushman Hill closed and partially open canopy treatments resulted in the greatest total seedling densities.

Herbaceous and Vine Vegetation

Twenty-seven (2 x 2 m) subplots were inventoried for herbaceous coverage in 2002. The three types of vegetation inventoried were grass, forb, and vine. Over all the subplots, the average total herbaceous coverage was 40%, with forb species covering the greatest area (28%), followed by grass and vine coverage (6% each) (Table 81). Analysis indicated that woodlot and canopy treatment were significant factors in the average coverage of each type of herbaceous and vine vegetation. Bushman Hill had significantly different average forb coverage (44%) than both Powers Hill and Herr Ridge (24 and 16%, respectively), which were not significantly different from each other. Powers Hill had a significantly different average amount of grass (12%) than Bushman Hill (1%), but was equal to Herr Ridge (6%). Powers Hill had significantly different average vine (9%) coverage than Herr Ridge (1%). The average total herbaceous coverage was equal between Bushman Hill and Powers Hill woodlots (52 and 45%, respectively), and both were significantly different than in Herr Ridge (24%)

(Table 81). Canopy treatment was a significant contributor to the average amount of grass, vine, and total herbaceous coverage, but not to the average amount of forb coverage. There was a significant difference in average grass coverage among the canopy treatments. The open canopy resulted in significantly different average grass coverage (14%) than the closed canopy (1%), but was not statistically different from the partially open canopy (5%) treatments. The open canopy treatments had significantly different average vine coverage (10%) than the partially open canopy (2%), but was equal to the closed canopy treatment coverage (5%). The lowest total average herbaceous coverage occurred in closed canopy treatments (29%), which was significantly different than in the open canopy (52%) treatments. There was no statistical difference between open (52%) and partially open (40%) canopy treatments on the amount of total average herbaceous vegetation coverage (Table 81).

Line Transect Herbaceous Data:
Closed Canopy: In Bushman Hill woodlot, Virginia-creeper had the greatest Importance Value (IV) in 2002 (Table 82). Enchanter's-nightshade was second rank, and naked-flowered tick-seed was third rank in 2002. The Shannon Diversity Index value was 1.22, and the Evenness Index value was 0.97 in 2002 (Table 83).

In Herr Ridge woodlot, enchanter's-nightshade dominated the transects in 2002 at nearly four times the second-ranked species, wild licorice, and the third-ranked species, Japanese honeysuckle (Table 82). The Shannon Diversity Index value was 0.65, and the Evenness Index value was 0.93 in 2002 (Table 83).

In Powers Hill woodlot, stiltgrass had an IV double that of Japanese honeysuckle in 2002 (Table 82). Japanese honeysuckle was second rank and Jack-in-the-pulpit was third rank in 2002. The Shannon Diversity Index value was 0.70, and the Evenness Index value was 0.77 in 2002 (Table 83).

Partially Open Canopy: In the Bushman Hill woodlot, grass spp. (all grasses except panic-grass [*Panicum boscii*] had the greatest IV in 2002 (Table 84). Japanese honeysuckle was second-ranked, and panic-grass was third-ranked in 2002. The Shannon Diversity Index value was 0.97, and the Evenness Index value was 0.81 in 2002 (Table 83).

In Herr Ridge woodlot, sedge spp. had the greatest IV in 2002, with white-snakeroot and wild licorice ranked second and third, respectively (Table 84). The Shannon Diversity Index value and the Evenness Index value were both 0.81 in 2002 (Table 83).

In Powers Hill woodlot, Japanese honeysuckle had the greatest IV by a small margin over stiltgrass, enchanter's-nightshade, and white-snakeroot in 2002 (Table 84). The Shannon Diversity Index value was 1.06, and the Evenness Index value was 0.88 in 2002 (Table 83).

Open Canopy: In Bushman Hill woodlot, enchanter's-nightshade had the greatest IV in 2002 (Table 85). Jewelweed and Virginia-creeper were ranked second and third, respectively, in 2002. The Shannon Diversity Index value was 0.76, and the Evenness Index value was 0.80 in 2002 (Table 83).

In Herr Ridge woodlot, white-snakeroot had the greatest IV in the transects in 2002 (Table 85). Enchanter's-nightshade was second rank, and stiltgrass was third rank in 2002. The Shannon Diversity Index value was 0.79, and the Evenness Index value was 0.71 in 2002 (Table 83).

In the Powers Hill woodlot, stiltgrass had the greatest IV in 2002, at more than three times the value of the second rank species, Japanese honeysuckle (Table 85). Common smartweed was ranked third in 2002. The Shannon Diversity Index value was 0.32, and the Evenness Index value was 0.33 in 2002 (Table 83).

Subplot Herbaceous Data: Comparisons of the Coefficients of Community Similarity (CCS) for 2002 between the different treatments within the three woodlots showed three different patterns of change depending on the woodlot. In Bushman Hill, the CCS decreased in value with increased opening of the canopy. The least similarity was between the partially open and open canopy treatments. In Herr Ridge, similarity between the closed and open canopy treatments was greater than between the closed and partially open canopy treatments. The largest CCS of all the comparisons was between the partially open and open canopy treatments. In Powers Hill, the CCS increased in value with increased opening of the canopy, with the greatest similarity between the partially open and open canopy treatments (Table 86).

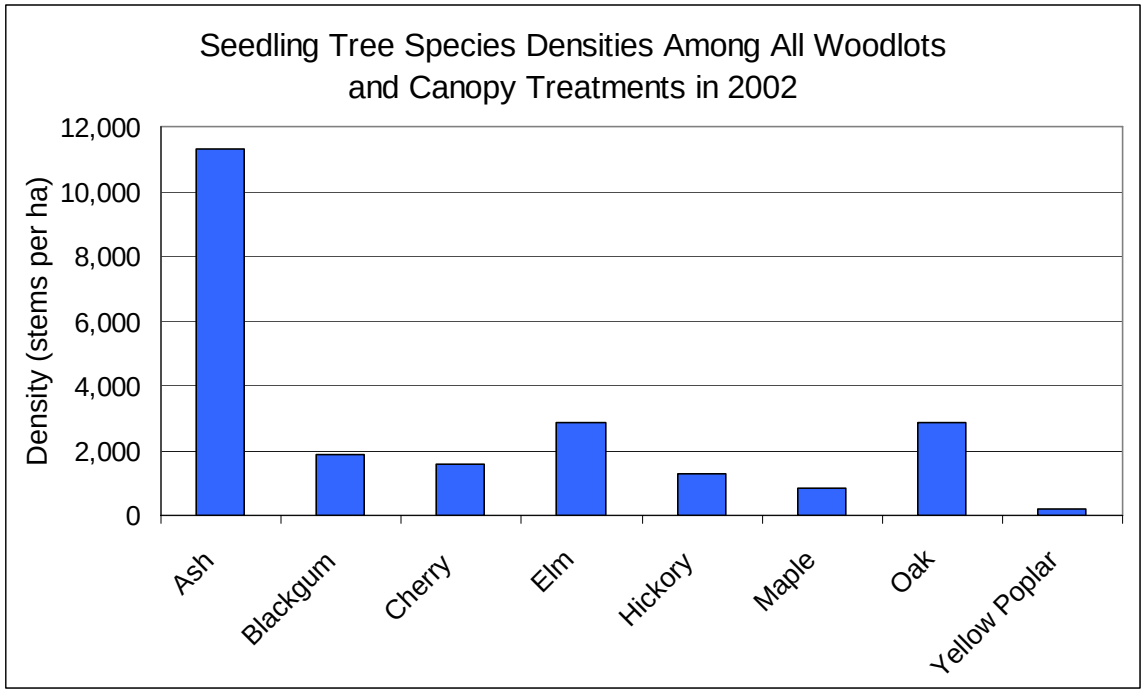


Figure 111. Density of seedling (≤150 cm in height) tree species among the twenty-seven 2 x 2 m subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

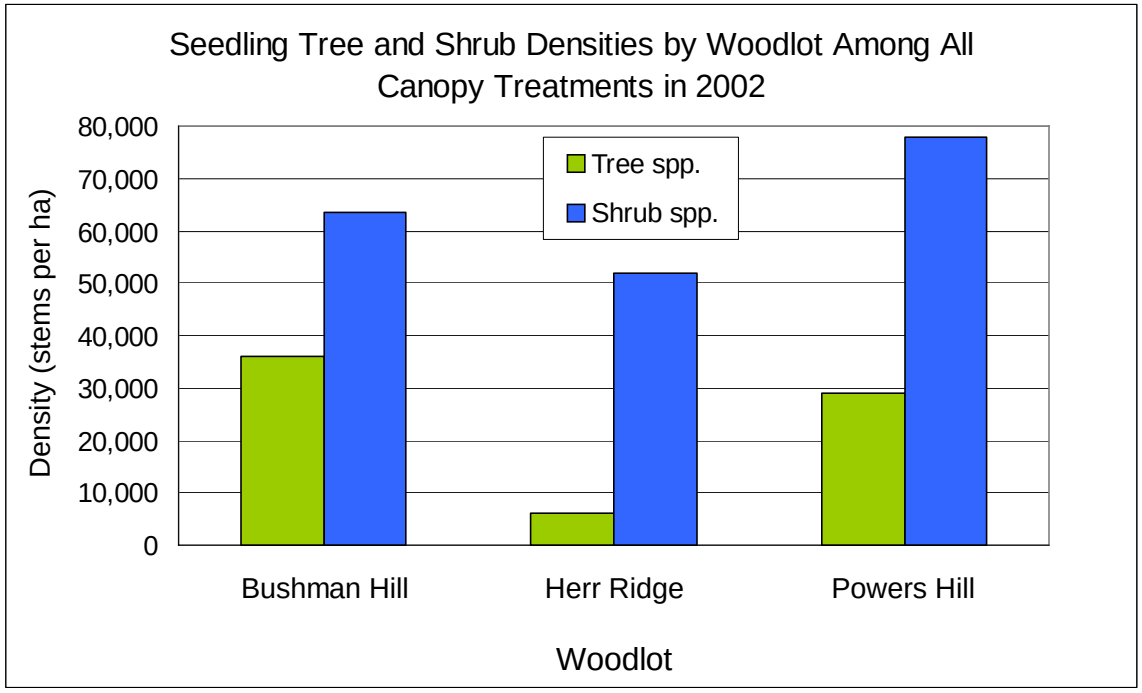


Figure 112. Density of seedling (≤150 cm in height) tree and shrub species by woodlot among the 2 x 2 m subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

Table 78. Average[a] number of species and density of seedling[b] tree, shrub, and total species by woodlot, canopy treatment, and height class in subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

	Tree	Shrub	Total
Woodlot	(----------species per 0.0001 ha subplot----------)		
Bushman Hill	1.97a	2.25a	4.25a
Herr Ridge	0.56b	1.03b	1.58c
Powers Hill	1.00b	1.89a	2.89b
Canopy Treatment			
Closed	1.56a	2.03a	3.58a
Partially Open	1.53a	1.83a	3.39a
Open	0.44b	1.31b	1.75b
Height Class (cm)			
0.0 – 25.0	0.83a	1.10a	1.94a
25.1 – 50.0	0.44b	0.72b	1.17b
50.1 – 75.0	0.14c	0.54bc	0.68bc
75.1 – 100.0	0.03c	0.31c	0.34c
100.1 – 125.0	0.04c	0.34c	0.38c
125.1 – 150.0	0.03c	0.12c	0.15c
Woodlot	(----------stems/ha----------)		
Bushman Hill	36,111a	63,611a	99,722a
Herr Ridge	6,111b	51,944a	58,056b
Powers Hill	28,889a	77,778a	106,667a
Canopy Treatment			
Closed	27,500a	69,444a	96,944a
Partially Open	37,222a	86,667a	123,889a
Open	6,389b	37,222b	43,611b
Woodlot x Canopy Interaction			
Bushman x Closed	56,667a	71,667a	128,333a
Bushman x Part Open	35,833ab	80,833a	116,667a
Bushman x Open	15,833b	38,333a	54,167b
Herr x Closed	8,333b	43,333a	51,667b
Herr x Part Open	8,333b	74,167a	82,500b
Herr x Open	1,667b	38,333a	40,000b
Powers x Closed	17,500b	93,333a	110,833ab
Powers x Part Open	67,500a	105,000a	172,500a
Powers x Open	1,667b	35,000a	36,667b
Height Class (cm)			
0.0 – 25.0	14,722a	33,519a	48,241a
25.1 – 50.0	6,296b	11,019b	17,315b
50.1 – 75.0	1,574c	7,870bc	9,444bc
75.1 – 100.0	370c	5,370bc	5,741c
100.1 – 125.0	463c	5,000bc	5,463c
125.1 – 150.0	278c	1,667c	1,944c

[a] Values within the same group (tree, shrub or total) per factor with the same letter were not significantly different at the α=0.05 level.
[b] Stems ≤150 cm in height

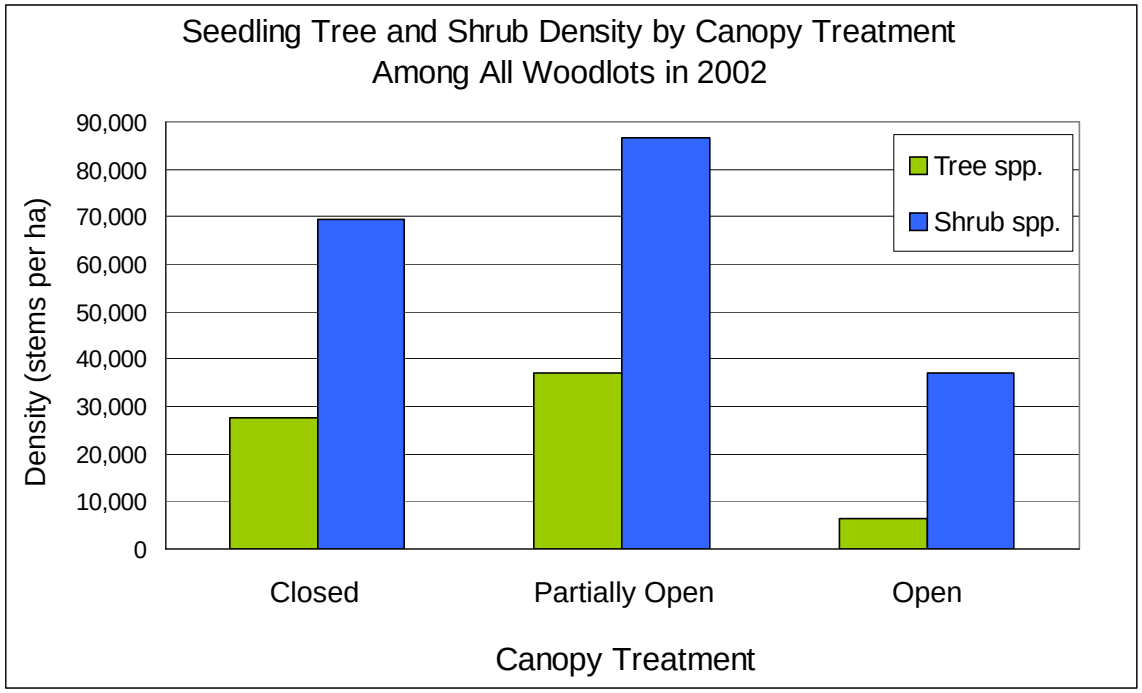


Figure 113. Density of seedling (≤150 cm in height) tree and shrub species by canopy treatment among the 2 x 2 m subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

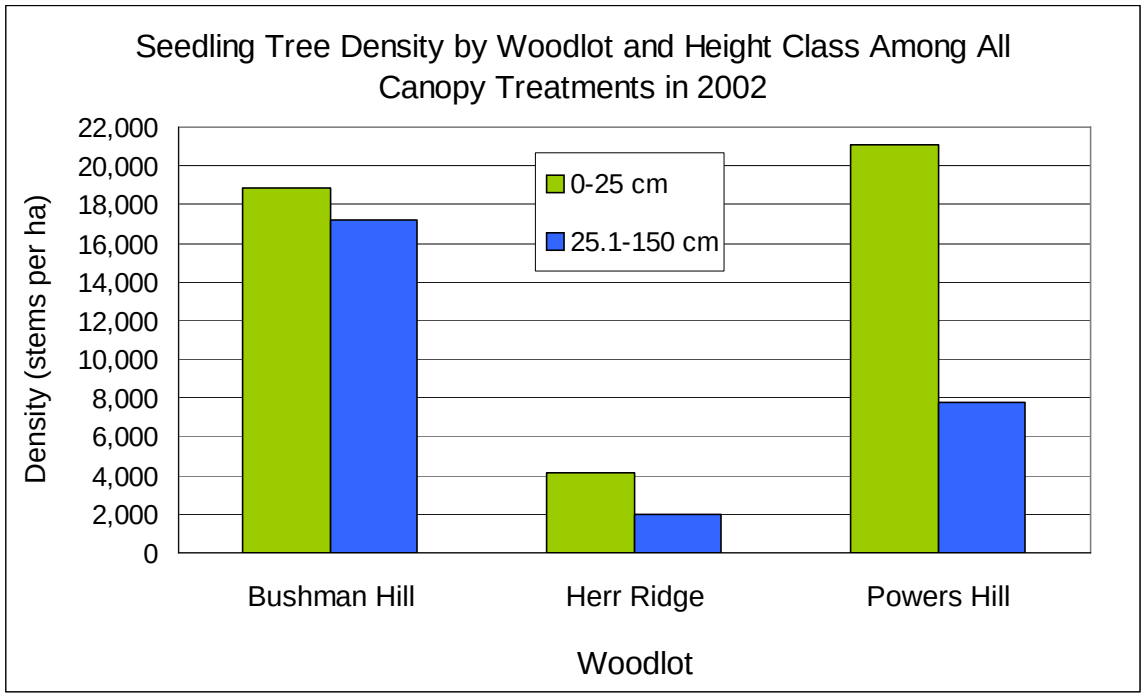


Figure 114. Density of seedling (≤150 cm in height) tree species by woodlot and height class among the 2 x 2 m subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

Table 79. Density[a] of seedling[b] tree, shrub, and total species by height class and woodlot in subplots[c] within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

	Tree Height Class		Shrub Height Class		Total Height Class	
	0-25 cm	25.1-150 cm	0-25 cm	25.1-150 cm	0-25 cm	25.1-150 cm
	(----------stems/ha----------)					
Woodlot						
Bushman Hill	18,889a	17,222a	21,389ab	42,222a	40,278ab	59,444a
Herr Ridge	4,167a	1,944a	38,611a	13,333b	42,778ab	15,278b
Powers Hill	21,111a	7,778a	40,556a	37,222a	61,667a	45,000a

[a] Values within each of the vegetation types (tree, shrub, or total) with the same letter were not significantly different at α=0.05 level.
[b] Stems ≤150 cm in height
[c] a 2 x 2 m subplot was located at the center of each 10 x 10 m Canopy Treatment Plot in all three woodlots

Table 80. Density[a] of seedling[b] tree, shrub, and total species by height class and canopy treatment in subplots[c] within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

	Tree Height Class		Shrub Height Class		Total Height Class	
	0-25 cm	25.1-150 cm	0-25 cm	25.1-150 cm	0-25 cm	25.1-150 cm
	(----------stems/ha----------)					
Canopy Treatment						
Closed	15,833ab	11,667b	37,222ab	32,222ab	53,056ab	43,889b
Partially Open	26,389a	10,833b	52,500a	34,167ab	78,889a	45,000b
Open	1,944b	4,444b	10,833b	26,389b	12,778c	30,833bc

[a] Values within each of the vegetation types (tree, shrub or total) with the same letter were not significantly different at α=0.05 level.
[b] Stems ≤150 cm in height
[c] a 2 x 2 m subplot was located at the center of each 10 x 10 m Canopy Treatment Plot in all three woodlots

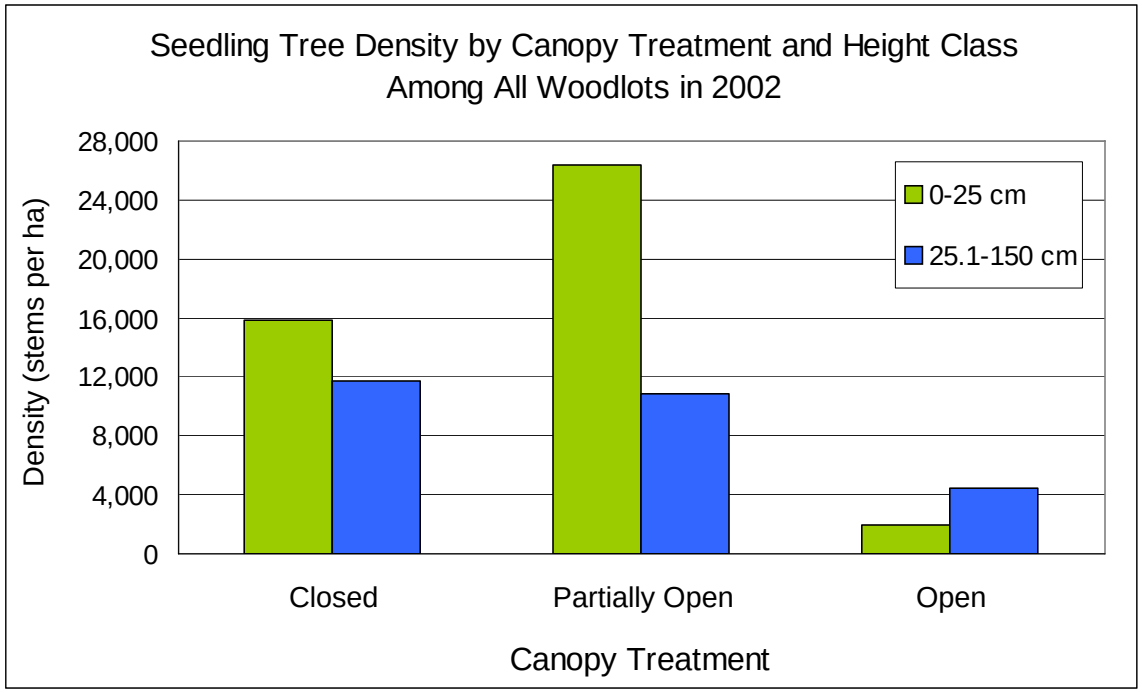


Figure 115. Density of seedling (≤150 cm in height) tree species by canopy treatment and height class among the 2 x 2 m subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

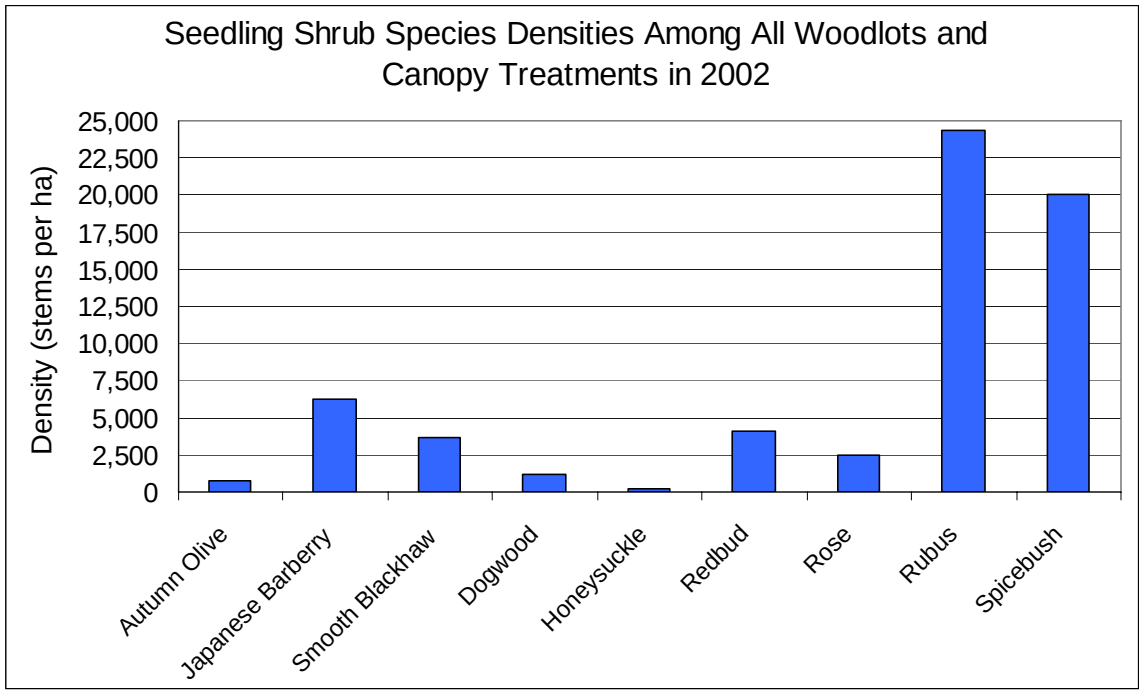


Figure 116. Density of seedling (≤150 cm in height) shrub species among all twenty-seven 2 x 2 m subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

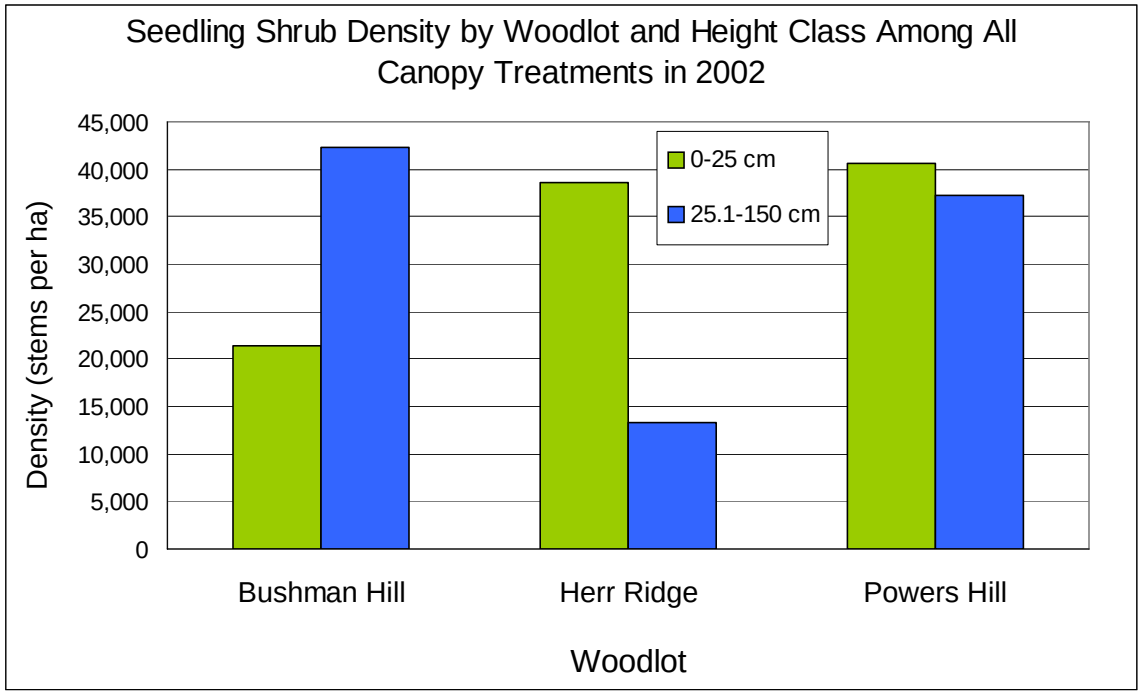


Figure 117. Density of seedling (≤150 cm in height) shrub species by woodlot and height class among the 2 x 2 m subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

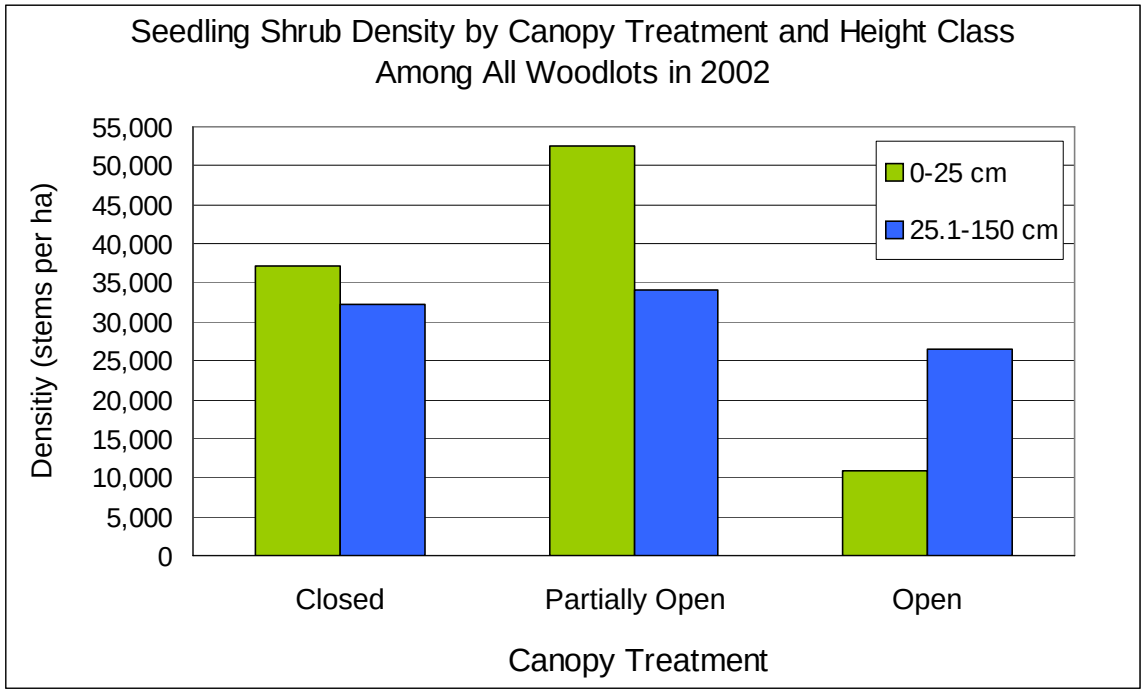


Figure 118. Density of seedling (≤150 cm in height) shrub species by canopy treatment and height class among the 2 x 2 m subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

Table 81. Average[a] percent herbaceous and vine species coverage overall, by woodlot, and by canopy treatment in subplots[b] within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

Factor	Forb	Grass	Vine	Total
	(----------% coverage----------)			
Overall	28	6	6	40
Woodlot				
Bushman Hill	44a	1b	7ab	52a
Herr Ridge	16b	6ab	1b	24b
Powers Hill	24b	12a	9a	45a
Canopy Treatment				
Closed	24a	1b	5ab	29b
Partially Open	33a	5ab	2b	40ab
Open	28a	14a	10a	52a

[a] Values within the same vegetation type and factor with the same letter were not significantly different at the 0.05 probability level.
[b] a 2 x 2 m subplot was located at the center of each 10 x 10 m Canopy Treatment Plot in all three woodlots

Table 82. Comparison of Importance values (IV) for herbaceous and vine species with the ten greatest IVs in subplots within the closed Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park. Data were collected from line transects in the summer of 2002.

Bushman Hill		Herr Ridge		Powers Hill	
Species	IV	Species	IV	Species	IV
Virginia-creeper	90.1	Enchanter's-nightshade	169.0	Stiltgrass	114.9
Enchanter's-nightshade	56.9	Wild licorice	44.0	Japanese honeysuckle	67.0
Naked-flowered tick-seed	32.9	Japanese honeysuckle	43.0	Jack-in-the-pulpit	49.9
White-snakeroot	25.3	White-snakeroot	35.4	Virginia-creeper	18.4
Cinquefoil	19.3	Common blue violet	8.6	Rough bedstraw	18.3
Wild-comfrey	14.7			Hog-peanut	15.5
Agrimony	13.9			Cinquefoil	8.0
Wild licorice	11.2			Naked-flowered tick-seed	7.9
Rough bedstraw	10.4				
Summer grape	7.9				

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

Table 83. A comparison of the 1992 and 2002 Shannon Diversity Index (SDI) and Evenness (EI) Index values for the herbaceous and vine species in subplots within the closed, partially open, and open Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park. Values were calculated from line transect data.

	Closed		Partially Open		Open	
	1992	2002	1992	2002	1992	2002
Bushman Hill						
SDI	0.86	1.22	1.09	0.97	0.80	0.76
EI	0.73	0.97	0.85	0.81	0.64	0.80
Herr Ridge						
SDI	0.50	0.65	0.68	0.81	0.59	0.79
EI	0.71	0.93	0.68	0.81	0.62	0.71
Powers Hill						
SDI	1.14	0.70	0.92	1.06	0.82	0.32
EI	0.87	0.77	0.80	0.88	0.74	0.33

Table 84. Comparison of Importance values (IV) for herbaceous and vine species with the ten greatest IVs in subplots within the partially open Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park. Data were collected from line transects in the summer of 2002.

Bushman Hill		Herr Ridge		Powers Hill	
Species	IV	Species	IV	Species	IV
Grass spp.	67.8	Sedge spp.	86.0	Japanese honeysuckle	38.6
Japanese honeysuckle	47.8	White-snakeroot	67.2	Stiltgrass	37.0
Panic-grass	45.9	Wild licorice	34.7	Enchanter's-nightshade	35.9
Virginia-creeper	30.5	Rough bedstraw	26.9	White-snakeroot	34.0
White-snakeroot	23.7	Enchanter's-nightshade	24.9	Sedge spp.	32.3
Wild-comfrey	16.0	Grass spp.	20.0	Jack-in-the-pulpit	24.0
Agrimony	12.6	Virginia-creeper	16.6	Wild licorice	21.9
Wood geranium	9.5	Jack-in-the-pulpit	9.8	Jumpseed	19.6
Rue-anemone	8.8	Forked chickweed	8.2	Virginia-creeper	18.8
Common blue violet	7.7	American pennyroyal	5.8	Common blue violet	13.6

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

Table 85. Comparison of Importance values (IV) for herbaceous and vine species with the ten greatest IVs in subplots within the open Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park. Data were collected from line transects in the summer of 2002.

Bushman Hill		Herr Ridge		Powers Hill	
Species	IV	Species	IV	Species	IV
Enchanter's-nightshade	87.2	White-snakeroot	100.7	Stiltgrass	193.3
Jewelweed	60.8	Enchanter's-nightshade	70.0	Japanese honeysuckle	61.9
Virginia-creeper	43.8	Stiltgrass	50.8	Common smartweed	20.6
Japanese honeysuckle	39.5	Grass spp.	17.9	Cinquefoil	10.9
Jack-in-the-pulpit	39.1	Poison-ivy	17.4	Common blue violet	3.5
White-snakeroot	11.0	Pokeweed	11.4	White-snakeroot	2.8
Garlic-mustard	10.2	Japanese honeysuckle	11.0	Rue-anemone	2.1
Summer grape	4.8	Common smartweed	6.5	Grass spp.	1.6
Hepatica	3.6	Three-seeded mercury	3.7	Enchanter's-nightshade	1.3
		Common yellow wood-sorrel	3.6		

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

Table 86. Coefficient of Community Similarity Indices for the herbaceous and vine species between the closed, partially open, and open Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 2002.

	Closed vs. Partially Open	Closed vs. Open	Partially Open vs. Open
Woodlot			
Bushman Hill	0.57	0.37	0.23
Herr Ridge	0.40	0.33	0.61
Powers Hill	0.33	0.35	0.48

Discussion

In the early 1990's the existing natural conditions in woodlots throughout Gettysburg NMP were regarded as not adequate for long-term increases in tree species diversity, density, and height of tree stems to. This study was designed to test the hypothesis that reductions in the overstory canopy would have no effect on seedling densities and/or size of seedling and sapling trees.

Overstory – Tree

Overstory trees were not inventoried in 1994. It is difficult to make comparisons of average number of overstory (>1.5 m in height and ≥12 cm dbh) species and density between the 1996 and 2002 data because the averages were calculated using different numbers of inventory plots. In 1996, the average number of overstory tree and shrub species were based on 18 – 0.2 ha plots, because the open canopy treatment plots did not contain any overstory trees or shrubs. However in 2002, the averages were calculated based on 27 – 0.2 ha plots, because a few overstory trees were inventoried in the open canopy treatments for the first time.

The total number of overstory tree species increased from 16 species in 1996 to 20 species in 2002. In 1996 and 2002, there was no difference in average number of tree species among the three woodlots. However, there was a significant difference in the average number of tree species among the different canopy treatments in both inventories. In 1996, the closed canopy yielded significantly different average number of overstory tree species (1.96 species per 0.2 ha plot) compared to the partially open canopy (1.41 species per 0.2 ha plot) treatments (Bowersox et al 2004). In 2002, the closed canopy yielded significantly different average number of overstory tree species (9.33 species per 0.2 ha plot) compared to the partially open canopy treatments (6.78 species per 0.2 ha plot), which were also significantly different than the open canopy (0.33 species per 0.2 ha plot) treatments (Table 75). In the 1996 inventory, there was no significant difference in the average number of tree species growing in the 11-20.9 and 21-30.9 cm diameter classes (4.72 and 3.83 species per 0.2 ha plot, respectively), which were both significantly different than the remaining eight diameter classes (0.00-2.17 species per 0.2 ha plot) (Bowersox et al 2004). In 2002, the average number of tree species growing in the 12-20.9 cm diameter class (3.26 species per 0.2 ha plot) was significantly different than the other diameter classes (0.07-2.48 species per 0.2 ha plot) (Table 75).

In 1996, Bushman Hill (130 stems/ha), Herr Ridge (180 stems/ha), and Powers Hill (160 stems/ha) had similar densities of overstory trees (Bowersox et al 2004). However, this changed in the 2002 inventory when Herr Ridge had significantly different density of overstory trees (118 stems/ha) than Powers Hill (82 stems/ha) (Table 75). There was no significant difference between the density in Herr Ridge and in Bushman Hill (86 stems/ha) or between Bushman Hill and Powers Hill. All three woodlots experienced declines in overstory density in the six years between inventories. Bushman Hill decreased from 130 to 86 stems/ha, Herr Ridge went from 180 to 118 stems/ha, and Powers Hill decreased from 160 to 82 stems/ha. The difference between the 1996 and 2002 density values were mainly due to the database. The 1996 values did not include the open canopy treatments, which had no overstory stems at the time. The 2002 values included the open canopy treatments since overstory stems were recorded in some plots during that inventory.

In 1996 and 2002, there were significant differences in overstory tree density among the canopy treatments. In 1996, the density in the closed canopy treatments (200 stems/ha) was significantly different than in the partially open canopy (120 stems/ha) treatments. There were no overstory trees

growing in the open canopy treatments that year (Bowersox et al 2004). In 2002, the density of overstory trees in the closed canopy treatments (169 stems/ha) was significantly different than in the partially open (114 stems/ha) treatments, which was also significantly different than in the open canopy (3 stems/ha) treatments (Table 75). These differences were the result of the cutting regimes when the experimental treatment sites were established. However, there were declines in overstory density within the closed and partially open canopy treatments between 1996 and 2002. The closed canopy density decreased from 200 to 169 stems/ha, and the partially open canopy treatments dropped from 120 to 114 stems/ha. The density decline in the closed canopy treatments was a reflection of the normal aging process of the woodlots. There is a need to develop replacements as the current overstory trees reach their normal life span. The limited density decline in the partially open canopy treatments was likely due to the remove of less vigorous or healthy trees during the installation of the treatments. The 2002 density in the open canopy treatments was the result of a few saplings of black cherry, *Ailanthus*, and catalpa maturing into overstory trees. *Ailanthus* and catalpa are non-native species.

Overstory – Shrub

A few shrub species were large enough to be inventoried in the overstory (>1.5 m in height and ≥12 cm dbh) category. In 1996, boxelder and eastern redbud each had overstory densities of one stem per ha. There were no significant differences in the average number of overstory shrub species between woodlots or canopy treatments in 1996 (Bowersox et al 2004). No shrubs were recorded in the open canopy treatments in 1996 or 2002. In 2002, there were three shrub species (flowering dogwood, eastern redbud, and sassafras) inventoried as overstory shrubs in the closed and partially open canopy treatments with an overall density of two stems/ha (Table 74). There was no significant difference in the average number of overstory shrub species between the woodlots or canopy treatments. However, there was a significant difference in the density of overstory shrubs among the woodlots. In 2002, Powers Hill (four stems/ha) had significantly different overstory shrub density than Bushman Hill (zero stems/ha). There was no significant difference between Powers Hill and Herr Ridge (one stem per ha) or Bushman Hill and Herr Ridge. Canopy treatment had no significant effect on density of overstory shrubs in 2002 (Table 75).

Sapling – Tree

Overall, there was an increase in the total number of sapling (>1.5 m in height and <12 cm dbh) tree species recorded from 1994 to 2002. The number of tree species decreased from 15 in 1994 to 12 in 1996, then increased to 24 species in 2002. In 1994, mockernut hickory (239 stems/ha) was the dominant sapling tree, followed by black cherry (182 stems/ha) and ash (74 stems/ha). The same trend occurred in 1996, when mockernut hickory remained the dominant sapling tree (220 stems/ha), and black cherry and ash (128, and 27 stems/ha, respectively) were the next most prevalent species (Bowersox et al 2004). In 2002, the most abundant sapling tree was black cherry (206 stems/ha), followed by northern red oak (143 stems/ha), and ash (133 stems/ha) (Table 74). It was very encouraging to see the density of sapling northern red oaks increase from 7 stems/ha in 1996 to 143 stems/ha in 2002. The distribution of sapling northern red oaks was fairly even among the woodlots in 2002; Bushman Hill, Herr Ridge, and Powers Hill had 128, 167, and 133 stems/ha, respectively. However, the sapling white oak density was greatest in Bushman Hill (22 stems/ha), compared to Herr Ridge (3 stems/ha), and Powers Hill (zero stems/ha).

In 1994, Herr Ridge (0.55 species per 0.01 ha subplot) had significantly different average number of sapling tree species than Bushman Hill and Powers Hill (0.13 and 0.08 species per 0.01 ha subplot, respectively). This trend remained the same in the 1996 and 2002 data. In 2002, the average number of sapling tree species in Herr Ridge (4.36 species per 0.01 ha subplot) was significantly different than in Bushman Hill and Powers Hill (2.64 and 1.97 species per 0.01 ha subplot, respectively) (Table 77). In 1994, the average number of sapling tree species in the closed and partially open treatments (0.36 and 0.29 species per 0.01 ha subplot, respectively) were significantly different than in the open canopy treatments (0.11 species per 0.01 ha subplot) (Bowersox et al 2004). In 1996, there was no significant difference in average number of sapling tree species among the three canopy treatments. This changed in 2002, when there was an increase in the number of species growing in the open canopy treatments. The average number of sapling tree species in the open canopy treatments (4.08 species per 0.01 ha subplot) was significantly different than in both the partially open and closed canopy treatments (2.67 and 2.22 species per 0.01 ha subplot, respectively) (Table 77).

Analysis of the 1994 data indicated that woodlot and diameter class were significant predictors of sapling tree density, but not canopy treatment. In 1996, all three main effects were significant. In 2002, all three main effects were significant, plus the interaction between woodlot and canopy treatment. The baseline data from 1992 (one year prior to treatment) showed the density of sapling tree species was 300 stems/ha in Bushman Hill, 1,417 stems/ha in Herr Ridge, and 300 stems/ha in Powers Hill (Storm et al 1995). In 1994, the density in Herr Ridge (1,330 stems/ha) was significantly different than in both Bushman Hill and Powers Hill (140 and 150 stems/ha, respectively) (Figure 119). The same trend occurred in the 1996 and 2002 inventories. In 1996, Herr Ridge had significantly different density of sapling trees (950 stems/ha) than Bushman Hill and Powers Hill (160 and 140 stems/ha, respectively) (Bowersox et al 2004). All three woodlots experienced increased sapling tree growth in 2002. Herr Ridge (1,622 stems/ha) still had a significantly different density compared to Bushman Hill (633 stems/ha) and Powers Hill (581 stems/ha) (Table 77, Figure 119). In 2002, the predominant sapling tree species in Herr Ridge were black cherry, ash, shagbark hickory, pignut hickory, northern red oak, and mockernut hickory. In Bushman Hill, northern red oak, ash, and elm were the predominant tree species. In Powers Hill, most of the sapling trees were either northern red oak, black cherry, or pignut hickory. All three woodlots experienced increases in sapling tree densities after 1996, with the greatest densities over the ten-year inventory period recorded in 2002 (Figure 119). Overall, the increases in sapling tree density between 1996 and 2002 were due to increased seedling tree recruitment in 1994, and the decrease in the deer browse after 1995.

The canopy treatment plots were established in 1992. In 1994, there was no significant difference in sapling tree density among the canopy treatments. The closed, partially open, and open treatments had 590, 420, and 600 stems/ha, respectively (Figure 120). However, in 1996, sapling tree density in the open canopy treatments (560 stems/ha) was significantly different than in both the closed and partially open treatments (380 and 310 stems/ha, respectively) (Bowersox et al 2004). This trend continued in 2002, but the densities increased to 1,653 stems/ha in the open canopy treatments, and to 600 and 583 stems/ha in the partially open and closed canopy treatments, respectively (Table 77, Figure 120). The reasons sapling trees were not adequately being recruited, in the closed and partially open canopy treatments, may be a combination of intense competition with shrub species and poor growing conditions due to light restrictions, and continued foraging by white-tailed deer. In 2002, there was no native spicebush recorded in Herr Ridge. However, it was the dominant shrub in both Bushman Hill (1,098 stems/ha) and Powers Hill (3,634 stems/ha) woodlots, and may have been a cause for decreased seedling tree density in these two woodlots. This was especially noticeable in Powers Hill where there were thick stands of spicebush.

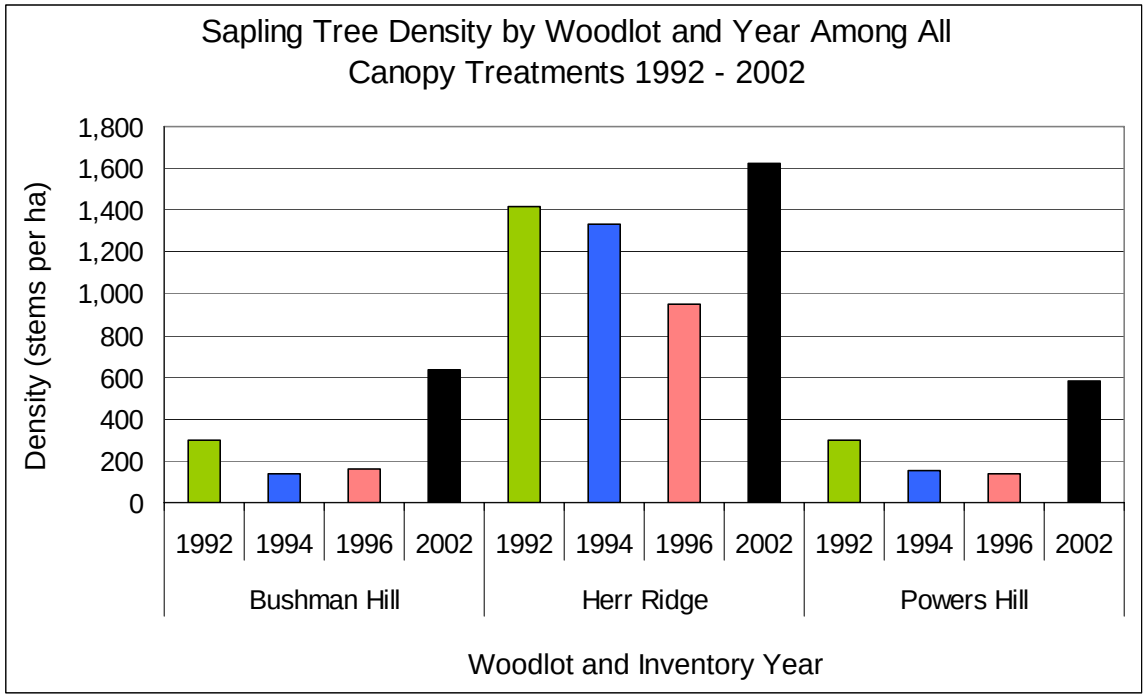


Figure 119. Sapling (>1.5 m in height and <12 cm dbh) tree species density by woodlot and inventory year among the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 1994 to 2002. The 1992 baseline data for the woodlots were collected from Long-term Monitoring Plots within the respective woodlots (Storm et al. 1995).

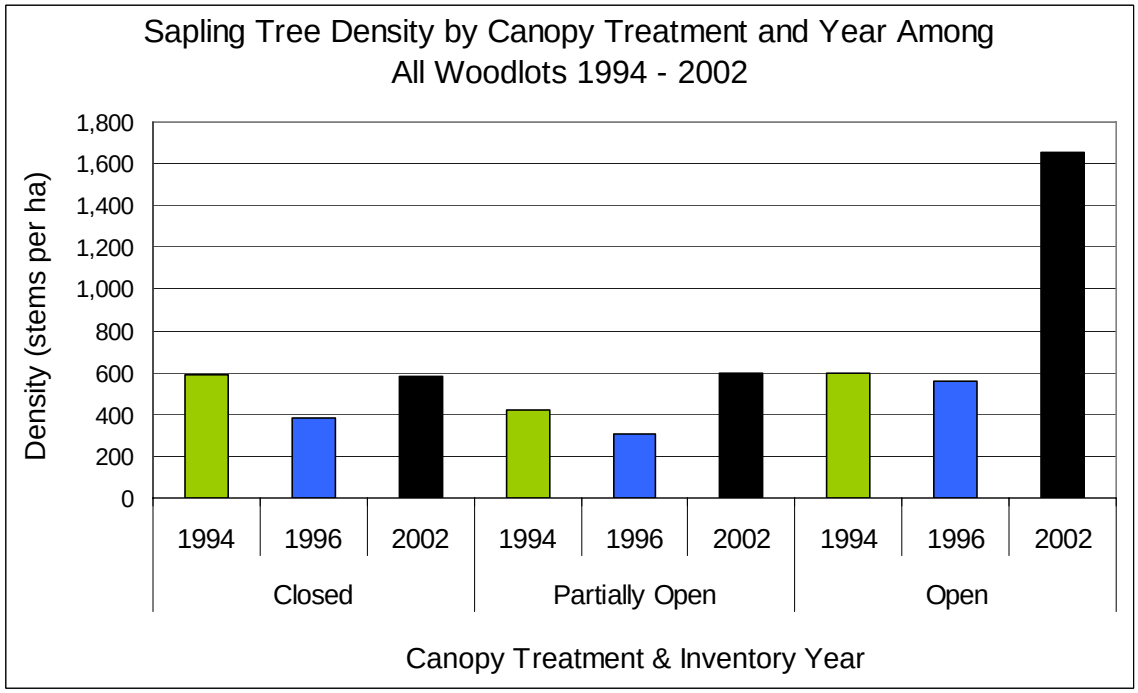


Figure 120. Sapling (>1.5 m in height and <12 cm dbh) tree species density by canopy treatment and inventory year from the Canopy Treatment Plots among Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 1994 to 2002.

Analysis of the 2002 data indicated a significant interaction between woodlot and canopy treatment. The Herr Ridge open canopy treatments (2,908 stems/ha) had significantly different sapling tree density than all other woodlot and canopy treatment combinations (ranging from 225 to 1,125 stems/ha) (Table 77).

Over time, the 0.5-1.9 and 2.0-2.9 cm diameter classes had consistently greater sapling tree densities than all the other diameter classes. However, there was a decline in density within the 0.5-1.9 cm diameter class from 1994 to 2002 (311 to 249 stems/ha, respectively). In 2002, there were more saplings in the larger diameter classes than in the previous inventories. The 0.5-4.9 cm diameter classes had the greatest average number of species and density. The 0.5-1.9 cm diameter class had the greatest average number of species present (1.25 per 0.01 ha subplot), which was 2.8 times greater than the 1996 value, and 1.6 times greater than the 1994 value. In 2002, the 2.0-4.9 cm diameter classes exhibited similar trends with the average number of tree species being two to four times greater than what was reported in 1996.

Over all in 2002, the density of sapling (large and small combined) trees in Bushman Hill (633 stems/ha), Herr Ridge (1,622 stems/ha), and Powers Hill (581 stems/ha) were not adequate to meet the 60% stocking level goal (3,741 stems/ha) for the woodlots. The sapling tree densities in the closed (583 stems/ha), partially open (600 stems/ha), and open canopy (1,653 stems/ha) treatments were also not adequate.

Sapling – Shrub

The total number of sapling (>1.5 m in height and <12 cm dbh) shrub species changed from 11 in 1994 to eight in 1996 to 16 species in 2002. The most abundant shrub in 1994 was spicebush, followed by flowering dogwood, and smooth blackhaw (Bowersox et al 2004). This changed slightly in the 1996 inventory, when flowering dogwood was the dominant shrub, followed by eastern redbud, and smooth blackhaw. In 2002, spicebush was the dominant shrub with 4,381 stems/ha. The biggest change over time was in the abundance of non-native species. Honeysuckle (2,247 stems/ha), Japanese barberry (1,456 stems/ha), and multiflora rose (1,291 stems/ha) were prevalent species in the sapling shrub inventory in 2002 (Table 74).

In 1994, Powers Hill had significantly different average number of sapling shrub species (0.28 species per 0.01 ha subplot) than both Bushman Hill and Herr Ridge (0.19 and 0.16 species per 0.01 ha subplot, respectively). In 1996, the average number of sapling shrub species in Powers Hill (0.25 species per 0.01 ha subplot) was significantly different than in Herr Ridge (0.13 species per 0.01 ha subplot), but Bushman Hill (0.19 species per 0.01 ha subplot) was not significantly different from either Powers Hill or Herr Ridge (Bowersox et al 2004). In 2002, the average number of sapling shrub species in Bushman Hill (6.39 species per 0.01 ha subplot) was significantly different than in Powers Hill (4.67 species per 0.01 ha subplot), which was also significantly different than in Herr Ridge (2.11 species per 0.01 ha subplot) (Table 77).

Between 1994 and 1996, the average number of sapling shrub species in the closed canopy treatments (0.34 and 0.29 species per 0.01 ha subplot, respectively) was significantly different than in the partially open treatments (0.21 and 0.20 species per 0.01 ha subplot). The average number of shrub species in the partially open treatments was significantly different than in the open canopy treatments (0.09 and 0.08 species per 0.01 ha subplot, respectively) (Bowersox et al 2004). Analysis of the 2002 data indicated a reverse trend. The average number of sapling shrub species in the open canopy treatments

(5.75 species per 0.01 ha subplot) was significantly different than in the partially open treatments (4.36 species per 0.01 ha subplot), which was significantly different than in the closed canopy (3.06 species per 0.01 ha subplot) treatments (Table 77). Sapling shrubs benefited from open canopy conditions more than sapling trees. In 2002, there were more sapling shrub species than trees species in all three canopy treatments.

The density of sapling shrubs recorded among all woodlots and canopy treatments increased substantially between the 1994 and 2002 inventories, from 408 to 11,162 stems/ha, respectively. Analysis of the 1994 data indicated that woodlot and diameter class were significant predictors of sapling shrub density, but not canopy treatment. In 1996, all three main effects were significant. In 2002, all three main effects were significant, plus the interaction between woodlot and canopy treatment (Table 77).

The density of sapling shrubs in Powers Hill was significantly different than in both Bushman Hill and Herr Ridge from 1994 through 2002. In 1994, the density in Powers Hill (608 stems/ha) was significantly different than in both Herr Ridge and Bushman Hill (367 and 250 stems/ha, respectively) (Figure 121). In 1996, sapling shrub density in Powers Hill (381 stems/ha) was significantly different than in both Bushman Hill and Herr Ridge (219 and 175 stems/ha, respectively) (Bowersox et al 2004). In 2002, the density in Powers Hill (17,328 stems/ha) was significantly different than in Bushman Hill (13,864 stems/ha), which was significantly different than in Herr Ridge (2,294 stems/ha) (Figure 121). In 2002, there was no spicebush, a native species, recorded in Herr Ridge. However it was the dominant shrub in both Bushman Hill (1,098 stems/ha) and Powers Hill (3,634 stems/ha), which may have been the cause for decreased seedling tree density in these two woodlots. This was especially noticeable in Powers Hill where there were thick stands of spicebush.

During the 1994 and 1996 inventories, the density of sapling shrubs was greatest in the closed canopy treatments, but that changed in 2002. In 1994, the density in the closed canopy treatments (597 stems/ha) was significantly different than in both the partially open and open canopy treatments (358 and 269 stems/ha, respectively) (Figure 122). In 1996, the sapling shrub density in the closed canopy treatments (417 stems/ha) was significantly different than in the partially open treatments (236 stems/ha), which was also significantly different than in the open canopy treatments (122 stems/ha). A dramatic change was evident in the 2002 data. The density of sapling shrubs in the open canopy treatments increased to 22,133 stems/ha, significantly different than the 8,828 stems/ha in the partially open canopy treatments. The closed canopy treatments had the lowest density with 2,525 stems/ha (Table 77, Figure 122). Analysis also indicated a significant interaction between woodlot and canopy treatment. The sapling shrub density in Powers Hill open canopy treatments (34,408 stems/ha) was significantly different than in any other combination of woodlot and canopy treatment (Table 77). Bushman Hill open canopy treatments (25,850 stems/ha) had the second greatest density compared to all other combinations, which ranged from 342 to 13,592 stems/ha. All three Herr Ridge canopy treatments had the lowest sapling shrub densities (342 to 6,142 stems/ha).

The substantial increase in sapling density in the one and two cm diameter classes was evidence that previously recorded seedlings had recruited into the sapling category. The density of shrubs in the 0.5-1.9 cm diameter class was 9,130 stems/ha in 2002. This was an increase from 240 stems/ha in 1994 and from 60 stems/ha in 1996. The greatest increases in sapling shrub density from 1996 to 2002 were spicebush (25 to 4,381 stems/ha, respectively), honeysuckle (0 to 2,247 stems/ha, respectively), Japanese barberry (0 to 1,456 stems/ha, respectively), multiflora rose (0 to 1,291 stems/ha, respectively), and *Rubus* (0 to 747 stems/ha, respectively). Although spicebush and *Rubus* are native

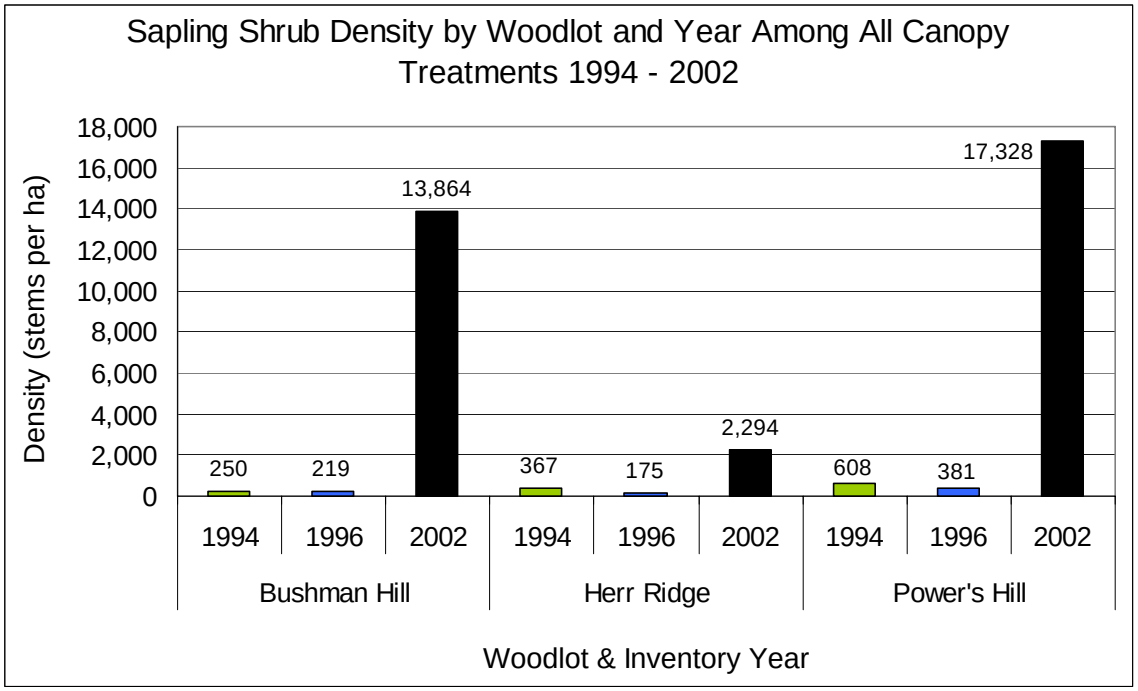


Figure 121. Sapling (>1.5 m in height and <12 cm dbh) shrub species density by woodlot and inventory year among the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 1994 to 2002.

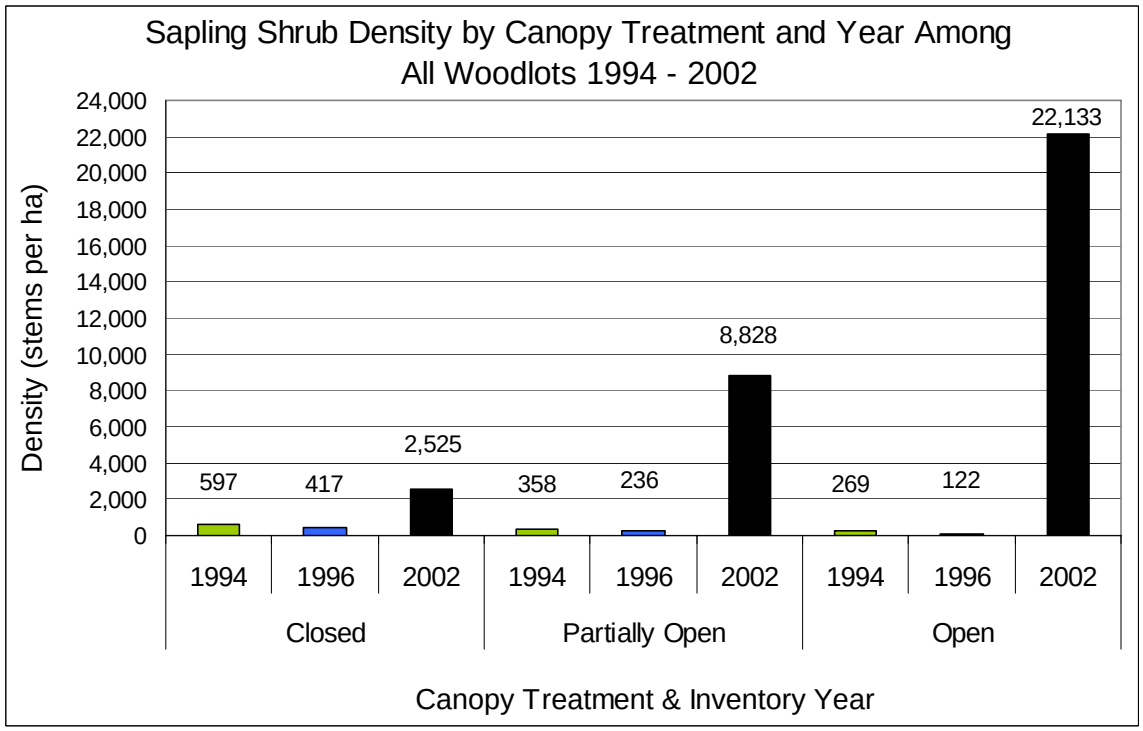


Figure 122. Sapling (>1.5 m in height and <12 cm dbh) shrub species density by canopy treatment and inventory year from the Canopy Treatment Plots among Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 1994 to 2002.

shrub species, the other three are not. Non-native, invasive shrubs comprised 46% of the total sapling shrub density in 2002.

The shrubs were opportunistic of the favorable conditions provided by the reduced white-tailed deer population and the removal of the overstory in the open canopy treatments over time. They were able to exploit the resources and grow faster than the tree species. The abundance of sapling shrubs, especially in the open canopy treatments, may have had a deleterious effect on the recruitment of seedling tree and shrub species. It took ten years for the shrubs to dominate all of the open canopy treatments, which had the highest density of sapling shrubs. The vigorous growth habits of these species resulted in a complete take-over of the treatment area. The shrubby vegetation was almost impenetrable, and the center of the plots was accessed by crawling on hands and knees, and cutting paths with clippers. In the open canopy treatments, most of the ground was bare underneath the shrubs. The amount of total herbaceous vegetation cover in the open canopy treatments in 2002 was half of what was recorded in 1996.

Seedling – Tree

The number of seedling tree species recorded among all the woodlots and canopy treatments changed little between the 1994 and 2002 inventories. The total number of species present decreased from 14 species in 1994 to 8 species in 1996, then increased to 15 species in 2002. Ash was the dominant species over time, with densities decreasing from 21,204 stems/ha in 1994 to 11,296 stems/ha in 2002. The second most abundant trees were yellow poplar and white oak in 1994, and mockernut hickory and black oak in 1996 (Bowersox et al 2004). In the 2002 inventory, the second most abundant species were elm and white oak, with densities of 2,870 and 2,407 stems/ha, respectively (Table 74).

The three woodlots were selected to represent a range of physical and community conditions in the park. There was considerable variation among the woodlots and canopy treatments in average number of tree species and density of seedling trees. The Storm et al (1995) report did not include the average number of species per plot, but it did include the seedling densities in the Long-term Monitoring plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots. These experimental plots were not the precise locations of the Canopy Treatment sites, but were indicative of the seedling conditions within the perspective woodlots, and provided the baseline data for comparison of pre-treatment conditions (1992) to post-treatment conditions (1994, 1996, and 2002). The 1992 inventory was completed one year prior to the Canopy Treatments being established.

In 1994, Bushman Hill had significantly different average number of seedling tree species (0.57 species per 0.0001 ha subplot) than Powers Hill (0.43 species per 0.0001 ha subplot). The average number of tree species in Powers Hill was also significantly different than in Herr Ridge (0.19 species per 0.0001 ha subplot). There was a shift in the 1996 data, when the average number of tree species among all three woodlots was not significantly different. Herr Ridge, Bushman Hill, and Powers Hill had 0.17, 0.22, and 0.13 species per 0.0001 ha subplot, respectively (Bowersox et al 2004). Analysis of the 2002 data indicated the average number of seedling tree species in Bushman Hill (1.97 species per 0.0001 ha subplot) was significantly different than in Powers Hill (1.00 species per 0.0001 ha subplot) and Herr Ridge (0.56 species per 0.0001 ha subplot) (Table 78).

In 1994, there was no significant difference in average number of seedling tree species among the three canopy treatments. The closed, partially open, and open canopy treatments averaged 0.42, 0.43, and 0.34 species per 0.0001 ha subplot, respectively (Bowersox et al 2004). However that changed in

1996, when the average number of tree species in the closed canopy treatments (0.30 species per 0.0001 ha subplot) was significantly different than in the partially open treatments (0.16 species per 0.0001 ha subplot), which was significantly different than in the open canopy treatments (0.06 species per 0.0001 ha subplot) (Bowersox et al 2004). In 2002, the average number of seedling tree species in the closed and partially open canopy treatments (1.56 and 1.53 species per 0.0001 ha subplot, respectively) were significantly different than in the open canopy (0.44 species per 0.0001 ha subplot) treatments (Table 78). The <26 cm height class had significantly different average number of tree species than the other height classes in all three inventories.

In 1994, seedling tree and shrub densities over all woodlots were similar at 57,222 and 54,722 stems/ha, respectively (Bowersox et al 2004). This changed in 2002, when the seedling tree density decreased to 23,704 stems/ha, but the seedling shrub density increased to 64,444 stems/ha (Table 74).

Analysis of the 1994 data indicated that woodlot, canopy treatment, and height class were all significant predictors of seedling tree density. In the 1996 inventory, woodlot was not a significant predictor of seedling tree density, but canopy treatment and height class were (Bowersox et al 2004). In 2002, all three main effects were significant, plus the interaction between woodlot and canopy treatment.

In 1992, Herr Ridge had a lower seedling tree density (22,833 stems/ha) than Powers Hill (32,502 stems/ha) and Bushman Hill (43, 832 stems/ha) (Storm et al 1995). Lower seedling tree densities in Herr Ridge continued through all inventories. In 1994, Bushman Hill and Powers Hill seedling tree densities (79,998 and 75,000 stems/ha, respectively) were significantly different from Herr Ridge (16,668 stems/ha). The 1996 seedling tree densities in Bushman Hill, Herr Ridge, and Powers Hill were 20,280, 13,056, and 15,558 stems/ha, respectively (Bowersox et al 2004). In 2002, Bushman Hill and Powers Hill densities (36,111 and 28,889 stems/ha, respectively) were significantly different from Herr Ridge (6,111 stems/ha) (Figure 123). Despite the increasing sapling tree densities in Herr Ridge, the woodlot had continuously decreasing seedling tree densities from 1992 through 2002 (Figure 123).

From 1994 to 2002, Bushman Hill and Powers Hill woodlots experienced greater seedling tree presence and growth than in Herr Ridge woodlot, probably due to the decreased white-tailed deer herbivory. Deer reduction efforts have been successful in the Bushman Hill and Powers Hill regions of the park, but have not been possible in the Herr Ridge region. Herr Ridge is an isolated woodlot in the northwestern part of the park where white-tailed deer reduction efforts have not been possible due to the lack of safe shooting distance from the surrounding residences. As a result, the seedling trees in Herr Ridge were under continual deer forage pressure. The main reason for the lower seedling tree densities in Herr Ridge was white-tailed deer foraging. In Herr Ridge, the density of seedling trees decreased from 1992 to 2002 (Figure 123), and the density of sapling trees decreased from 1992 to 1996, but then increased in 2002 (Figure 121).

From 1994 to 2002, Herr Ridge continually had greater sapling tree densities than either Bushman Hill or Powers Hill (Figure 119). This may have been due to significantly lower sapling shrub densities in Herr Ridge (Table 77) resulting in less competition between sapling tree and shrub species, and the composition of sapling tree species that dominated the woodlot. Black cherry, the predominant sapling tree species in Herr Ridge, is not preferred or avoided by to deer (Horsley et al. 2003). Increasing deer

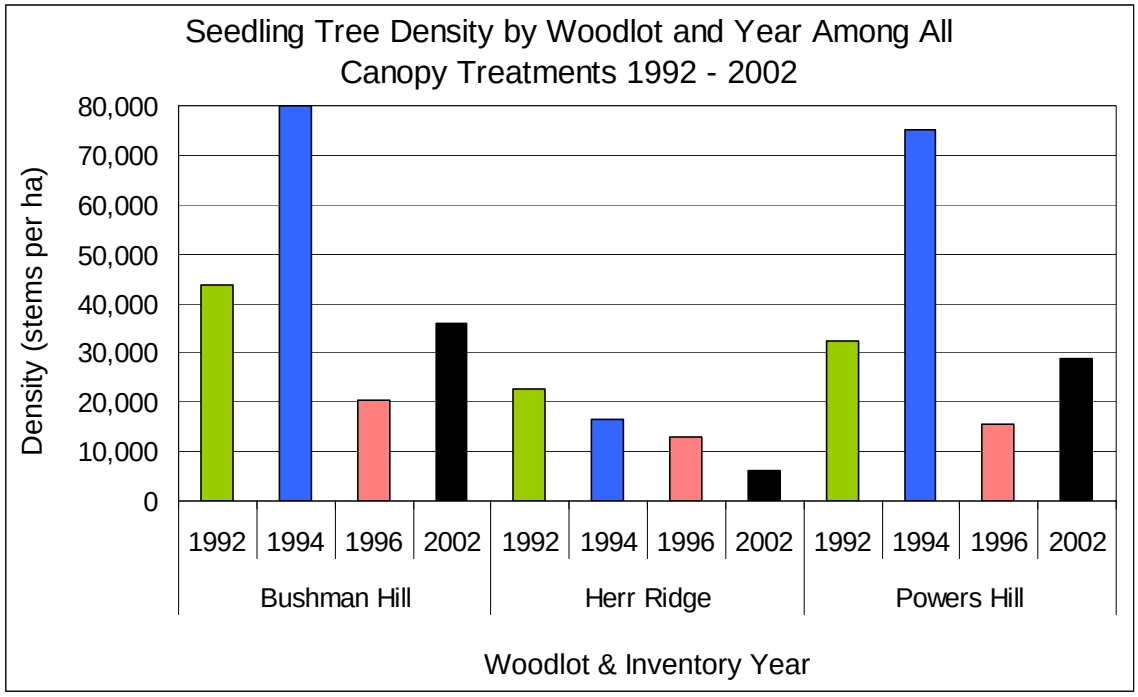


Figure 123. Seedling (≤150 cm in height) tree species density by woodlot and inventory year among subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 1994 to 2002. The 1992 baseline data for the woodlots were collected from Long-term Monitoring Plots within the respective woodlots (Storm et al. 1995).

density led to decreasing stem density of most species over time with the exception of black cherry, which increased in dominance (Horsley et al. 2003).

Powers Hill woodlot is in the southeastern part of the park and had white-tailed deer populations consistent with the southern part of the park. Powers Hill also had a woodlot-wide presence of stilt grass (*Microstegium vimineum*) throughout the study. In 1992, Bowersox (2003) reported that 4% of the woodlot was covered by grass species. Grass species expanded to cover 17% and 58% of the woodlot in 1994 and 1996, respectively (Bowersox et al 2004). The 1996 inventory was the last to reflect the conditions prior to initiating the 1995 Deer Management Program. In Powers Hill, the increases in average number of species and average density were mainly due to a reduction in average grass coverage to 12% in 2002, and a reduction in the white-tailed deer population to about ¼ of the pre-1995 Deer Management Program levels.

Bushman Hill is in the southern part of the park, and had a history of favorable conditions for establishing seedling trees. Bushman Hill and Powers Hill had similar white-tailed deer populations before and after the start of the 1995 deer management program. Bushman Hill also has had a low presence of non-native, invasive plants. In 2002 and after the white-tailed deer population was reduced to about ¼ the pre-1995 deer management program levels, there were increases in average number of tree species and density of seedling trees. Although Japanese barberry and multiflora rose were more prevalent in 2002 and particularly in the open canopy treatments, a diversity of tree species became established in the Bushman Hill woodlot.

There was a shift over time in the density of seedling trees among the canopy treatments. There was no consistently better canopy treatment for seedling tree densities. In 1992, the three woodlots together averaged 33,056 seedling trees per ha (Storm et al 1995). In 1994, the density of seedling trees increased substantially among the canopy treatments. The 1994 data showed that seedling tree density in the partially open canopy treatments (77,502 stems/ha) was significantly different than in both the closed and open canopy treatments (47,502 and 46,668 stems/ha, respectively). Between 1994 and 1996, there was a major reduction in densities of seedling trees and a shift in which canopy treatments had the greater value. In 1996, the closed canopy treatments had significantly different seedling tree densities (28,614 stems/ha) than the partially open treatments (15,276 stems/ha), which had significantly different densities than the open canopy treatments (4,998 stems/ha) (Bowersox et al 2004). In 1996, the lower densities of seedling trees in the partially open and open canopy treatments were in conjunction with an increase in coverage of herbaceous vegetation and continued frequent foraging by white-tailed deer. In 1994, the closed canopy had an average herbaceous coverage of 11%, as compared to 34% and 101% in the partially open and open canopy treatments, respectively (Bowersox et al 2004). In 1996, the closed canopy had an average herbaceous coverage of 29% and the partially open and open canopy treatments averaged 65% and 101%, respectively (Bowersox et al 2004). In 2002, the herbaceous coverage in the closed canopy treatments continued to average 29%, but dropped in the partially open and open canopy treatments to 40% and 52%, respectively. As of 2002, the park-wide white-tailed deer population was reduced to about ¼ the pre-1995 levels. As a result, in 2002 the density of seedling trees in the closed canopy treatments remained stable at 27,500 stems/ha, and the seedling tree densities in the partially open and open canopy treatments increased to 37,222 and 6,389 stems/ha, respectively. In 2002, the closed and partially open canopy treatments afforded the greatest seedling tree densities. Seedling tree densities in the partially open and closed canopy treatments were significantly different than in the open canopy treatments (Figure 124). There was no significant difference in seedling tree density between the partially open and closed canopy treatments (Table 78).

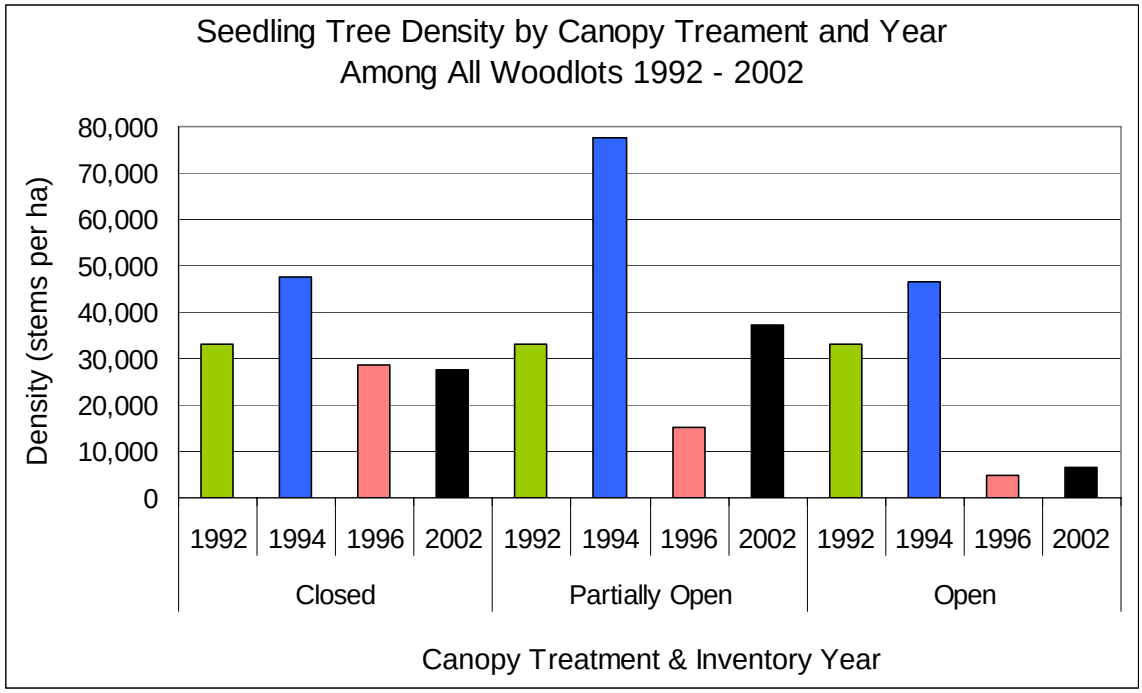


Figure 124. Seedling (≤150 cm in height) tree species density by canopy treatment and inventory year from subplots within the Canopy Treatment Plots among Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 1994 to 2002. The 1992 baseline data for the woodlots were collected from Long-term Monitoring Plots within the respective woodlots (Storm et al. 1995).

The 2002 data analysis indicated a significant interaction between woodlot and canopy treatment. The Powers Hill partially open treatments and Bushman Hill closed canopy treatments had greater seedling tree densities than all Herr Ridge treatments, Powers Hill closed and open canopy treatments, and Bushman Hill open canopy treatments. These differences may have been due to unique features of the woodlots, including available seed source, white-tailed deer forage pressure, and competition with shrub and herbaceous species.

For all inventories, the distribution of seedling trees across the six height classes was skewed to the shorter heights, and analysis indicated a significantly different density of 0-25 cm stems than all other height classes. In 2002, the 25.1-50 cm height class had the second greatest seedling tree density, significantly different than the remaining four height classes. Between 1996 and 2002 there were increases in all height classes except for the 125.1-150 cm class, which dropped from 833 to 278 stems/ha, respectively.

The 2002 data was condensed into two height categories (0-25 and 25.1-150 cm) and further analyzed. There were no significant differences in seedling tree density among the woodlots, however canopy treatment did have a significant effect (Table 79). When comparing the two height classes, the density of 0-25 cm seedling trees in partially open treatments was significantly different than 0-25 cm seedling trees in the open canopy treatments, and significantly different than all the 25.1-150 cm seedling trees under the three canopy conditions. The 0-25 cm seedling tree density in the closed canopy treatments was not significantly different from any other treatment (Table 80).

Although seedling tree densities were lower in the open canopy treatments than in either the closed or the partially open canopy treatments, the more favorable growing conditions in the open canopy treatments when they were first established enabled the initial seedlings to achieve greater height growth from 1994 and 1996. In 2002, the closed and partially open canopies had 42% and 29%, respectively, of the seedling trees in the ≥25.1 cm height classes. The open canopy had 70% of the seedling trees in the ≥25.1 cm height classes. Furthermore, a greater number seedling trees grew into the sapling size category in the open canopy treatments than in either of the other two canopy treatments.

Overall in 2002, the seedling tree densities in Bushman Hill (36,111 stems/ha) and Powers Hill (28,889 stems/ha) exceeded the 60% stocking level goal (16,834 stems/ha), but the seedling density in Herr Ridge (6,111 stems/ha) was not adequate. Seedling tree densities in the closed (27,500 stems/ha) and partially open (37,222 stems/ha) canopy treatments exceeded the stocking level goal, but the density in the open canopy treatments (6,389 stems/ha) was not adequate. Seedling trees were not surviving or growing into the upper height classes at densities sufficient to achieve the historic forest overstory.

Seedling – Shrub

The total number of seedling shrub species recorded among all the woodlots and canopy treatments varied between the 1994 and 2002 inventories. The total number of species present went from 15 species in 1994 to 11 species in 1996 to 12 species in 2002. In 1994, Powers Hill had significantly different average number of seedling shrub species (0.54 species per 0.0001 ha subplot) than both Bushman Hill and Herr Ridge (0.35 and 0.31 species per 0.0001 ha subplot, respectively). There was a shift in 1996, when the average number of shrub species in Powers Hill (0.63 species per 0.0001 ha subplot) and Bushman Hill (0.66 species per 0.0001 ha subplot) were not significantly different from each other, but were significantly different than in Herr Ridge (0.21 species per 0.0001 ha subplot)

(Bowersox et al 2004). Analysis of the 2002 data indicated the average number of seedling shrub species in Bushman Hill (2.25 species per 0.0001 ha subplot) and Powers Hill (1.89 species per 0.0001 ha subplot) were not significantly different from each other, but were both significantly different from Herr Ridge (1.03 species per 0.0001 ha subplot). In 1994 and 1996, there were no significant differences in average number of shrub species among the three canopy treatments (Bowersox et al 2004). In 2002, the average number of shrub species in the closed (2.03 species per 0.0001 ha subplot) and partially open (1.83 species per 0.0001 ha subplot) canopy treatments were significantly different than in the open canopy (1.31 species per 0.0001 ha subplot) treatments (Table 78). The 0-25.9 cm height class had significantly different average number of seedling shrub species than the other height classes in all three inventories.

Analysis of the 1994 data indicated that woodlot and height class were significant predictors of seedling shrub density, but not canopy treatment. In 1996, all three main effects were significant. In 2002, canopy treatment and height class were significant, but not woodlot.
In 1994, Powers Hill seedling shrub density (74,724 stems/ha) was significantly different than both Bushman Hill and Herr Ridge (45,558 and 43,890 stems/ha, respectively) (Figure 125). In 1996, Bushman Hill and Powers Hill densities (76,110 and 67,224 stems/ha, respectively) were significantly different from Herr Ridge (26,664 stems/ha) (Bowersox et al 2004). In 2002, there was no significant difference among the woodlots. Bushman Hill, Herr Ridge, and Powers Hill had seedling shrub densities of 63,611, 51,944, and 77,778 stems/ha, respectively (Figure 125, Table 78).

There were slight changes in the density of seedling shrubs within each canopy treatment from 1994 to 1996, but between 1996 and 2002 more moderate changes occurred. In 1994, the seedling shrub densities in the closed (51,666 stems/ha), partially open (53,886 stems/ha), and open canopy (58,614 stems/ha) treatments were all very similar with no significant difference among treatments. This shifted in 1996, when the open canopy (70,002 stems/ha) had a significantly different density than the closed canopy (47,502 stems/ha) treatments. The density in the partially open canopy (52,500 stems/ha) treatments was not significantly different than either the closed or open canopy treatments (Bowersox et al 2004). In 2002, the partially open and closed canopy treatments afforded the greatest seedling shrub densities (86,667 and 69,444 stems/ha, respectively), significantly different than in the open canopy (37,222 stems/ha) treatments (Figure 126).

Overall in 2002, the density of seedling shrubs in the 0-25 cm height class was 33,519 stems/ha, a slight increase from the 22,870 stems/ha in 1996, but equivalent to the 33,981 stems/ha in 1994. In every inventory there were significant differences in density between the 0-25 cm height class and all other height classes. Analysis of the condensed 2002 height class data (0-25 and 25.1-150 cm in height) indicated that woodlot and canopy treatment were both significant predictors of seedling shrub density. The density of 0-25 cm seedlings was equal in all three woodlots. There were no significant differences in the density of 25.1-150 cm seedlings in Bushman Hill and Powers Hill. However, the lower density of 25.1-150 cm seedlings in Herr Ridge (13,333 stems/ha) was significantly different than in Bushman Hill (42,222 stems/ha) and Powers Hill (37,222 stems/ha). Results of the mean separations procedures on canopy treatment effects were more difficult to decipher. The density of seedling shrubs 0-25 cm in height in the partially open treatments was significantly different than the density of seedlings 0-25 and 25.1-150 cm in the open canopy treatments. Competition with mature sapling shrubs was probably the reason for fewer seedlings in the open canopy treatments. Seedling shrubs were regenerating at far greater rates than seedling trees, and growing into the taller height classes more quickly than the trees.

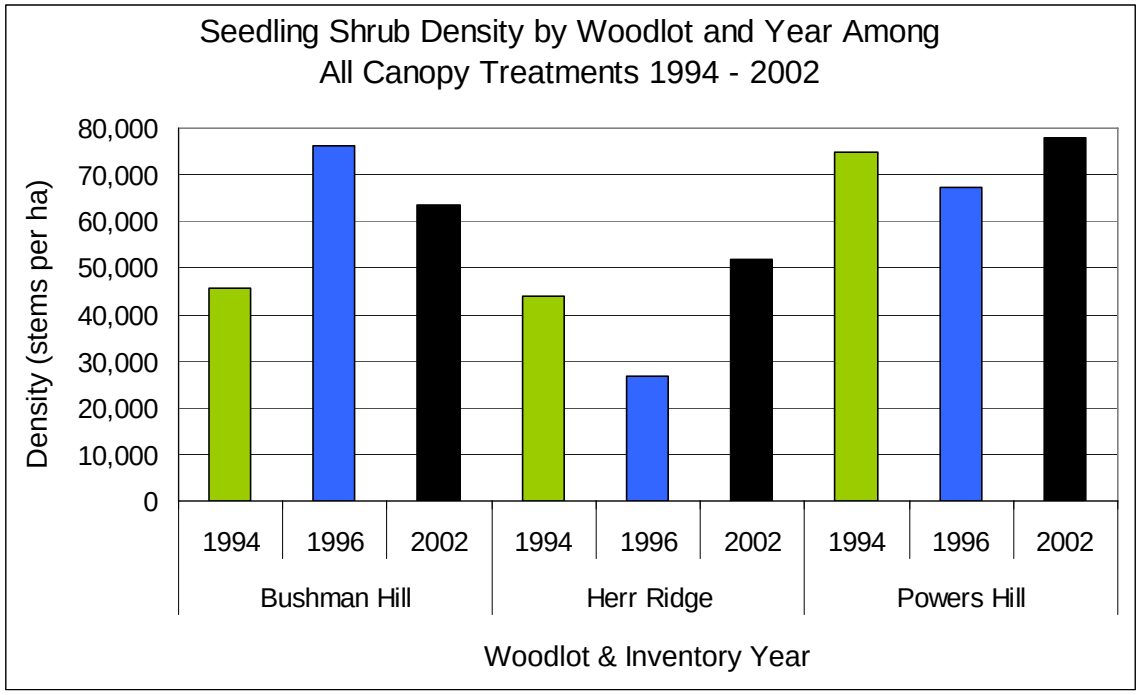


Figure 125. Seedling (≤150 cm in height) shrub species density by woodlot and inventory year among subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 1994 to 2002.

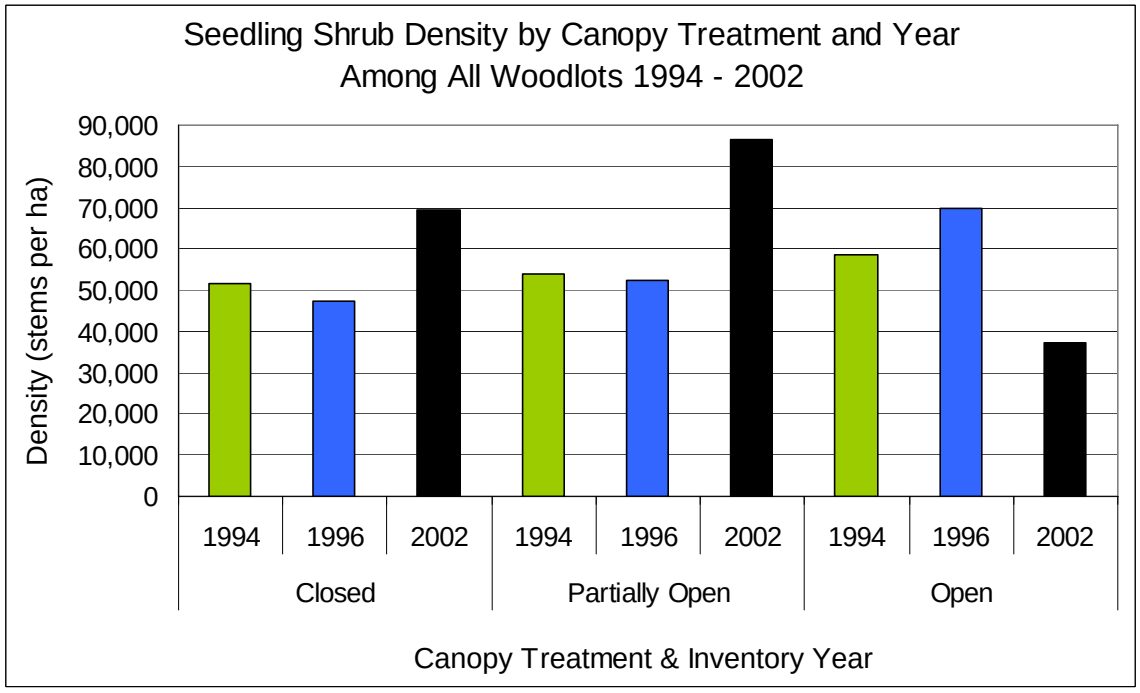


Figure 126. Seedling (≤150 cm in height) shrub species density by canopy treatment and inventory year from subplots within the Canopy Treatment Plots among Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 1994 to 2002.

It is likely that the density of seedling shrubs influenced the recruitment of seedling trees. The seedling shrub density increased from 37,834 stems/ha in 1992 to 56,667 stems/ha in 1996 and to 64,444 stems/ha in 2002. The extent to which the seedling shrubs were competitive with the initial seedling trees is not known and probably dependent on the architecture of the shrubs and the growth characteristics of the trees. The greatest increases in seedling shrub density from 1994 to 2002 were for autumn olive (185 to 741 stems/ha, respectively), spicebush (18,704 to 20,000 stems/ha, respectively), honeysuckle (0 to 185 stems/ha, respectively), Japanese barberry (93 to 6,204 stems/ha, respectively), multiflora rose (556 to 2,500 stems/ha, respectively), and *Rubus* (18,889 to 24,352 stems/ha, respectively). Although spicebush and *Rubus* are native shrubs, the other four are not. Non-native, invasive shrubs comprised 15% of the total seedling shrub density in 2002.

The density of the sapling shrubs and trees had a direct effect on the density of the seedling shrubs and trees in the open canopy treatments. The single cohort of shrub and tree stems in the 0.2 ha treatment areas are passing through the stand initiation stage and into the stem exclusion stage. The stand initiation stage of single cohort communities is when new and existing stems of all life forms (herbaceous, shrub, and tree) become established and start to increase in size. During this stage, the densities are increasing and there is limited competition within, but strong competition among, life forms. In the stem exclusion stage, new stems cease to appear and existing stems drop out of the community due to competition. During this stage the following things occur: stem densities are decreasing, the largest shrub and tree stems control the allocation of resources, the herbaceous plants are replaced by shrubs and trees, and shrubs are replaced by trees.

Herbaceous and Vine Vegetation

Over all woodlots, there was a decrease in total average herbaceous coverage between 1994 and 2002. During the 1994, 1996, and 2002 inventories, the total average herbaceous coverage among all woodlots went from 49 to 65 to 40%, respectively. The average forb coverage increased from 19 to 27 to 28%, respectively. The average grass coverage went from 11 to 26 to 6%, respectively, and average vine coverage steadily decreased from 19 to 13 to 6%, respectively (Bowersox et al 2004).

There were different trends among the woodlots and canopy treatments over time. Herbaceous composition changes varied between the woodlots. In Bushman Hill, average forb coverage increased steadily between 1994 and 2002 from 18 to 44%, respectively, resulting in an increase in average total herbaceous coverage from 47 to 52%, respectively. Conversely, the grass and vine species average coverage decreased from 1994 to 2002. Average grass coverage declined from nine to one percent, respectively, and average vine species coverage decreased from 20 to seven percent, respectively (Figure 127). In Herr Ridge, there was a different pattern of herbaceous vegetation growth from 1994 to 1996 to 2002. Average forb coverage went from 19 to 38 to 16%, respectively. Average grass coverage went from six to 13 to six percent, respectively. Between 1994 and 2002, there was a steady decline in average vine coverage from 17 to two percent, respectively (Figure 127). In Powers Hill, the average vine coverage showed the same decreasing trend over time from 20 to nine percent, respectively. In the 1994, 1996, and 2002 inventories, the average forb coverage went from 19 to 12 to 24%, respectively. Average grass coverage jumped from 17 to 58% between 1994 and 1996, but then decreased again to 12% in 2002 (Figure 127).

Herbaceous vegetation changes also varied among the canopy treatments during the inventories completed in 1994, 1996, and 2002. In the closed canopy treatments, the average forb coverage increased steadily between 1994 and 2002 from six to 24 percent, respectively, resulting in an overall

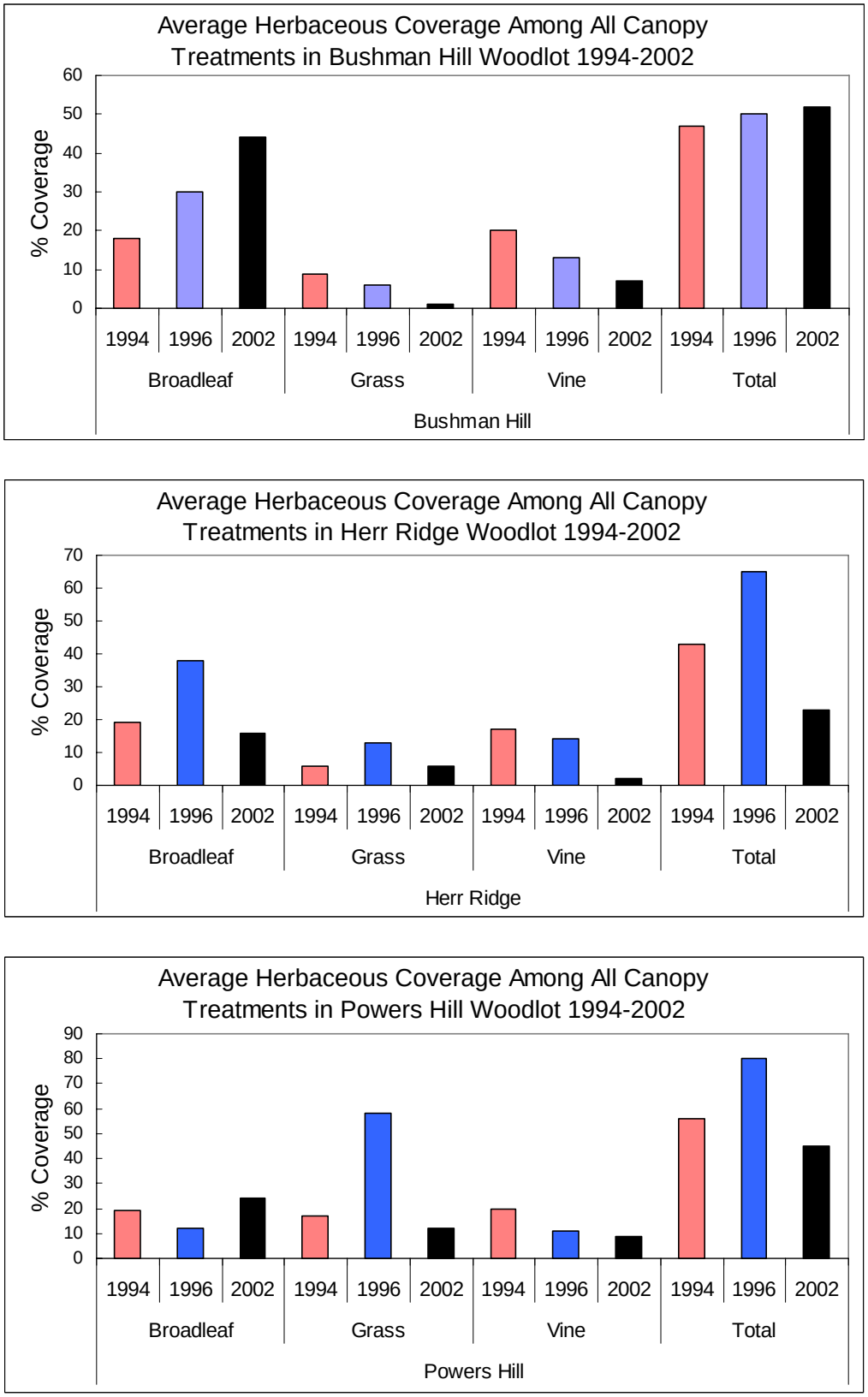


Figure 127. Average herbaceous and vine species coverage in subplots within the Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 1994 to 2002.

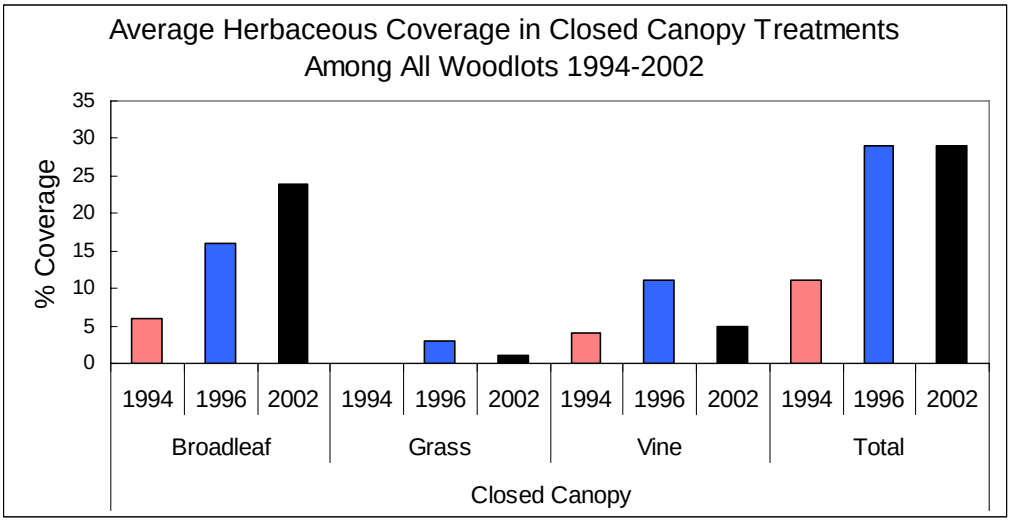
increase in average total herbaceous coverage from 11 to 29%, respectively. The amount of average grass coverage changed little over time from zero to one percent, respectively. The average vine coverage went from four to 11 to five percent in 1994, 1996, and 2002, respectively (Figure 128). In the partially open canopy treatments, the average forb coverage increased steadily between 1994 and 2002 from 15 to 33%, respectively. The average grass coverage went from 11 to 30 to 5% in 1994, 1996, and 2002, respectively. Average vine coverage went from eight to nine to two percent, respectively. The average total herbaceous coverage in the partially open canopy treatments went from 34 to 65 to 40%, respectively (Figure 128). In the open canopy treatments, similar trends occurred in the grass and vine coverage, but the forb coverage decreased over time, unlike in the closed and partially open canopy treatments. In the 1994, 1996, and 2002 inventories, the average forb coverage went from 35 to 38 to 28%, respectively. Average grass coverage changed from 20 to 45 to 14%, respectively. The same decreasing trend of vine coverage was recorded in the open canopy treatments as in the other two canopy treatments. In 1994, 1996, and 2002, the average vine coverage went from 46 to 18 to 10 percent, respectively. Average total herbaceous coverage in the open canopy treatments went from 101% in both 1994 and 1996 to 52% in 2002 (Figure 128).

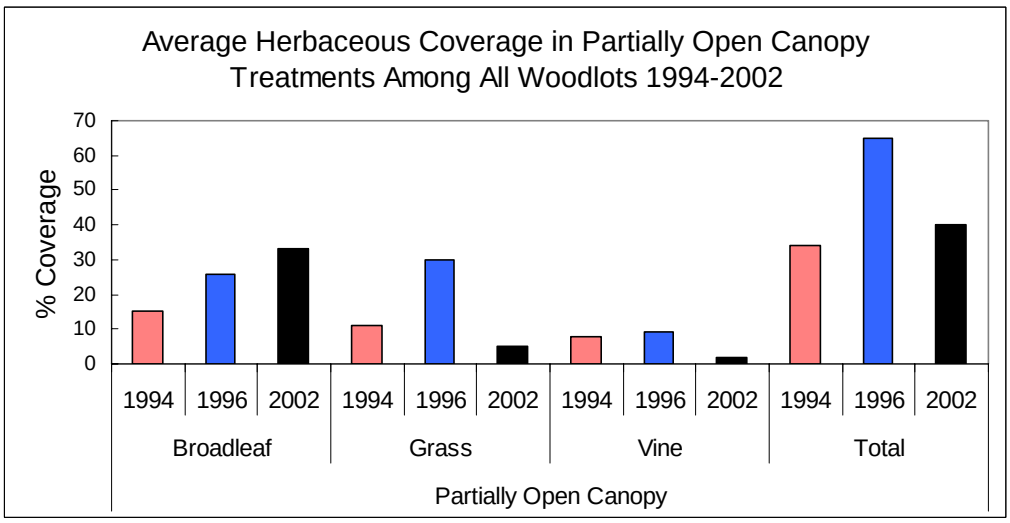
Line Transect Herbaceous and Vine Data:
Closed Canopy: Within the Bushman Hill woodlot, Virginia-creeper had the greatest Importance Value (IV) in the 2002 inventory (Table 82). In 1992, it ranked fifth (Table 87). Naked-flowered tick-seed had the greatest IV in 1992, but dropped to third rank in 2002. Enchanter's-nightshade increased dramatically from eighth rank in 1992 to second rank in 2002. Eight of the ten top-ranked species present in 1992 were also present in 2002. The total number of species encountered in the subplot increased from fifteen to eighteen in the ten-year period. The Shannon Diversity Index values were 0.86 and 1.22 in 1992 and 2002, respectively. The Evenness Index values were 0.73 and 0.97 in the same years, respectively (Table 83).

Enchanter's-nightshade dominated the Herr Ridge transects in 2002 at nearly four times the second-ranked species, wild licorice, and the third-ranked species, Japanese honeysuckle (Table 82). Only five species were present in both the 1992 and 2002 surveys, within the subplots (Tables 82 and 87). Three of the five (the three previously mentioned) were present in both surveys. Enchanter's-nightshade had nearly the same IV during both surveys. Japanese honeysuckle decreased at the expense of wild licorice. The Shannon Diversity Index values were 0.50 and 0.65 in 1992 and 2002, respectively. The Evenness Index values were 0.71 and 0.93 in the same years, respectively (Table 83).

In Powers Hill, stiltgrass had an IV double that of Japanese honeysuckle in 2002, whereas in 1992, stiltgrass was not found anywhere within the quadrants from which the line transects were completed (Tables 82 and 87). Japanese honeysuckle increased from third rank in 1992 to second rank in 2002 at nearly double the value. The IVs were more uniform in 1992 than in 2002, and the number of species within the subplots decreased by more than half between 1992 and 2002. Six species present in the top ten rankings in 1992 were also included in the eight present in 2002. The Shannon Diversity Index values were 1.14 and 0.70 for 1992 and 2002, respectively. The Evenness Index values were 0.87 and 0.77 in the same years, respectively (Table 83).

Between 1992 and 2002, the IVs of both Virginia-creeper and enchanter's-nightshade increased dramatically in the closed canopy treatments in Bushman Hill woodlot (Tables 82 and 87). Virginia-creeper increased three-fold, enchanter's-nightshade increased six-fold. Both species are perennials. Virginia-creeper is a vine with large leaves that enable it to cover a large surface area. Enchanter's-





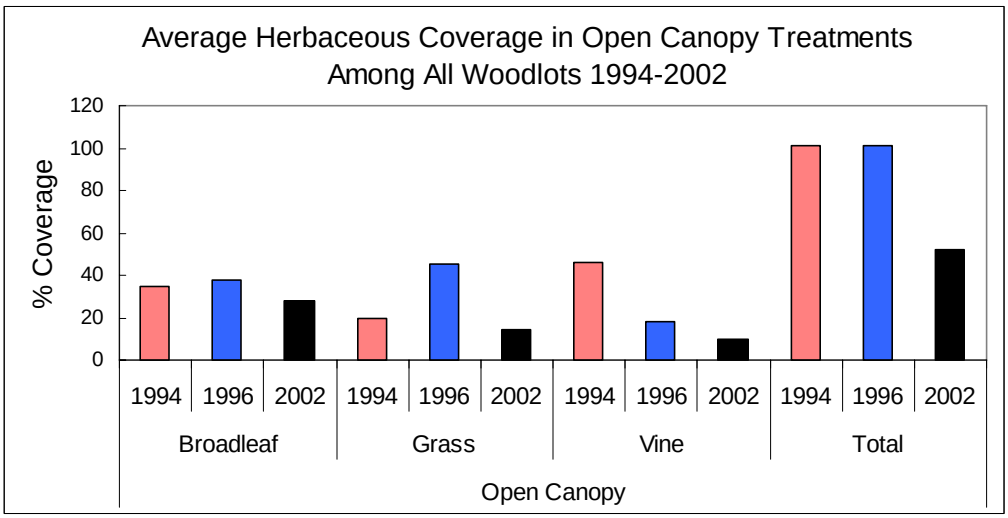


Figure 128. Average herbaceous and vine species coverage in subplots within the closed, partially open, and open Canopy Treatment Plots among the Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 1994 to 2002.

Table 87. Comparison of Importance values (IV) for herbaceous and vine species with the ten greatest IVs in subplots within the closed Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park. Data were collected from line transects in the summer of 1992.

Bushman Hill		Herr Ridge		Powers Hill	
Species	IV	Species	IV	Species	IV
Naked-flowered tick-seed	71.6	Enchanter's-nightshade	162.9	White-snakeroot	37.2
Sedge spp.	52.0	Japanese honeysuckle	92.2	Jack-in-the-pulpit	34.6
Rough bedstraw	48.8	Wild licorice	19.3	Japanese honeysuckle	32.7
Wild-comfrey	34.7	Virginia-creeper	13.0	Wild licorice	31.0
Virginia-creeper	32.8	Rough bedstraw	12.6	Common smartweed	29.3
Cinquefoil	13.7			Rough bedstraw	22.0
Wild licorice	9.5			Cinquefoil	20.8
Enchanter's-nightshade	9.1			Enchanter's-nightshade	20.2
Hog-peanut	8.3			Virginia-creeper	12.3
Agrimony	5.6			Hog-peanut	9.2

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot

nightshade produces an abundance of small, bristly fruits that are easily disseminated by animals and people. Very little change occurred in Herr Ridge over the ten years. The top three species remained the same. In Powers Hill, the dominance of stiltgrass apparently eliminated several species since 1992, even though the canopy was not altered. Stiltgrass is an invasive, non-native species that is rapidly spreading across Pennsylvania. Japanese honeysuckle and jack-in-the-pulpit maintained a strong presence and Virginia-creeper increased in importance.

The species in Bushman Hill woodlot maintained the greatest stability, with eight out of the top ten ranking species in 1992 still present after ten years. A Friedman's F_r test performed on the IVs showed no significant difference ($p = .05$) in the herbaceous and vine species between 1992 and 2002 in any of the woodlots.

Between 1992 and 2002, the Shannon Diversity Index (SDI) and Evenness Index (EI) values increased in the closed canopy treatments in Bushman Hill and Herr Ridge woodlots (Table 83). However, in Powers Hill woodlot both SDI and EI values decreased. The increase in the SDI for Bushman Hill was due to the addition of three more species. The increase in Herr Ridge was due to a more even distribution of individuals among the species. The decrease in the SDI and EI in Powers Hill was due to a decrease in the number of species from twenty to eight.

Partially Open Canopy: In Bushman Hill woodlot, grass spp. (all grasses except panic-grass [*Panicum boscii*] which was ranked third) had the greatest IV in 2002 (Table 84). Japanese honeysuckle was second-ranked in 2002. Grass spp. and Japanese honeysuckle were not in the top ten ranking in 1992 (Table 88). Rough bedstraw was top ranked in 1992. Hog-peanut (*Amphicarpa bracteata*) and white-snakeroot ranked second and third in 1992. White-snakeroot was the only species in the top three ranking that was also present in 2002. However, rough bedstraw was present in the quadrants in which the line transects were completed. Only four species in the top ten in 1992 were also present in 2002. The Shannon Diversity Index values were 1.09 and 0.97, in 1992 and 2002, respectively. The Evenness Index values were 0.85 and 0.81 in the same years, respectively (Table 83).

In Herr Ridge woodlot in 2002, sedge spp. had the greatest IV, with white-snakeroot and wild licorice ranked second and third, respectively (Table 84). Sedge spp. were third-ranked in 1992, below wild licorice and enchanter's-nightshade. Enchanter's-nightshade had an IV five times the level of wild licorice (Table 88). Six species within the top eight ranking in 1992 were also within the top ten in 2002. The Shannon Diversity Index values were 0.68 and 0.81 for 1992 and 2002, respectively. The Evenness Index values were the same, 0.68 and 0.81, in the same years, respectively (Table 83).

In Powers Hill woodlot, Japanese honeysuckle had the greatest IV by a small margin over stiltgrass, enchanter's-nightshade, and white-snakeroot in 2002 (Table 84). The species with the top three rankings in 1992 (white-snakeroot, wild licorice, and sedge spp.) decreased in importance by 2002 (Tables 84 and 88). There was a much greater uniformity of IVs in 2002, with only six units of difference between the first and fifth rank species. Six of the species in the top ten in 1992 were also present in the top ten in 2002. The Shannon Diversity Index values were 0.92 and 1.06, respectively, in 1992 and 2002, respectively. The Evenness Index values were 0.80 and 0.88 in the same years, respectively (Table 83).

In 2002, in Bushman Hill woodlot the species with the greatest IV were grass spp. (unidentified grass species not including panic grass) and Japanese honeysuckle. Neither species were included in the top ten ranking in 1992, nor were they present in the quadrants from which the line transects were

Table 88. Comparison of Importance values (IV) for herbaceous and vine species with the ten greatest IVs in subplots within the partially open Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park. Data were collected from line transects in the summer of 1992.

Bushman Hill		Herr Ridge		Powers Hill	
Species	IV	Species	IV	Species	IV
Rough bedstraw	60.1	Enchanter's-nightshade	169.4	White-snakeroot	77.1
Hog-peanut	44.4	Wild licorice	33.2	Wild licorice	49.9
White-snakeroot	36.8	Sedge spp.	31.0	Sedge spp.	37.1
Cinquefoil	21.8	Virginia-creeper	18.5	Rough bedstraw	25.0
Naked-flowered tick-seed	18.6	Grass spp.	14.6	Grass spp.	23.4
Agrimony	17.8	Early blue violet	14.5	Common blue violet	23.2
Virginia-creeper	17.3	Jewelweed	9.9	Enchanter's-nightshade	23.1
Wild licorice	14.4	White-snakeroot	9.1	Cinquefoil	9.8
Sedge	10.7			Virginia-creeper	9.0
Panic-grass	10.3			Wild-comfrey	8.6

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

completed (Tables 84 and 88). Of the four species ranked in the top ten during both sampling times, only panic-grass and Virginia-creeper increased in importance. Six species included in the top ten IV in Herr Ridge in 1992 were also present in 2002. Enchanter's-nightshade declined nearly seven-fold, while white-snakeroot increased seven-fold. Sedge spp. increased to number one rank in 2002, by a factor of three. Sedge spp. (*Carex laxiflora*) and white-snakeroot are perennials and white-snakeroot is listed as poisonous by Gleason and Cronquist (1963). Sedges can spread rapidly by rhizomes, which may account for their large increase. Enchanter's-nightshade grows in more moist habitats, so the droughts between 1999 and 2002 (PA DEP website) may have had a strong influence on its development. Within Powers Hill, white-snakeroot decreased by more than half since 1992, while Japanese honeysuckle and stiltgrass, which were not in the top ten in 1992, increased to first and second rank in 2002. Enchanter's-nightshade increased from ninth to third rank.

Conflicting changes occurred among the three woodlots. These changes were random or due to factors not accounted for (i.e., soil fertility and texture, drainage, animals, diseases, variation in white-tailed deer browsing pressure). The only factor accounted for was fence treatment and the resulting absence or presence of white-tailed deer foraging.

The SDI and EI values decreased for Bushman Hill woodlot mainly due to two fewer species in 2002, but partially due to a less even representation between species (Table 83). There were slight increases in the SDI and EI for Herr Ridge and Powers Hill woodlots. There were two additional species present in both woodlots. In Herr Ridge, there was a much greater evenness of distribution among the species in 2002, because of less dominance by enchanter's-nightshade (Table 84).

Open Canopy: In Bushman Hill woodlot, enchanter's-nightshade had the greatest IV in 2002 (Table 85). In 1992, rough bedstraw had the greatest IV, with enchanter's-nightshade second-ranked (Table 89). Geum spp. and grass spp. which were third and fourth-ranked in 1992, were not present in the transects in 2002. Only four species in the top ten rankings in 1992 were also present in 2002. The Shannon Diversity Index values were 0.80 and 0.76 in 1992 and 2002, respectively. The Evenness Index values were 0.64 and 0.80 in the same years, respectively (Table 83).

In Herr Ridge woodlot transects, white-snakeroot had the greatest IV in 2002, whereas Japanese honeysuckle had the greatest IV in 1992 (Tables 85 and 89). White-snakeroot was not present in the transects in 1992. Japanese honeysuckle dominated the transects in 1992, having an IV more than seven times the second-ranked species, enchanter's-nightshade. Enchanter's-nightshade increased in importance while Japanese honeysuckle decreased from first to seventh rank in 2002. Stiltgrass, which was not present in the transects in 1992, increased to third rank in 2002. The decrease in Japanese honeysuckle resulted in a more uniform representation of the other species in 2002. Only three species present in the line transects in 1992 were present in 2002. The Shannon Diversity Index values were 0.59 and 0.79 in 1992 and 2002, respectively. The Evenness Index values were 0.62 and 0.71 in the same years, respectively (Table 83).

In the Powers Hill woodlot transects, stiltgrass had the greatest IV, at more than three times the value of the second rank species, Japanese honeysuckle, in 2002 (Table 85). Japanese honeysuckle dominated in the 1992 inventory with an IV more than four times the next ranked species, wild licorice (Table 89). Five species present in the top ten in 1992 were also present in 2002. The Shannon Diversity Index values were 0.82 and 0.32 in 1992 and 2002, respectively. The Evenness Index values were 0.74 and 0.33 in the same years, respectively (Table 83).

Table 89. Comparison of Importance values (IV) for herbaceous and vine species with the ten greatest IVs in subplots within the open Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots in Gettysburg National Military Park. Data were collected from line transects in the summer of 1992.

Bushman Hill		Herr Ridge		Powers Hill	
Species	IV	Species	IV	Species	IV
Rough bedstraw	99.6	Japanese honeysuckle	192.5	Japanese honeysuckle	141.6
Enchanter's-nightshade	40.8	Enchanter's-nightshade	25.3	Wild licorice	32.9
Geum spp.	38.2	Jack-in-the-pulpit	21.4	Rough bedstraw	31.3
Grass spp.	25.0	Sedge spp.	18.0	White-snakeroot	22.5
White-snakeroot	17.3	Poison-ivy	17.4	Poison-ivy	13.5
Common smartweed	17.0	Hog-peanut	7.5	Sedge spp.	13.4
Cinquefoil	16.3	Jewelweed	6.8	Enchanter's-nightshade	12.9
Wild licorice	10.6	Buttercup spp.	6.0	Common blue violet	9.4
Virginia-creeper	8.2	Cinquefoil	5.4	Wood geranium	7.0
Jack-in-the-pulpit	7.1			Common smartweed	5.2

[a] Data were collected in two 0.981 m^2 quadrants in the 2 x 2 m subplot.

In Bushman Hill woodlot, enchanter's-nightshade doubled its IV between 1992 and 2002, to become first-ranked (Tables 85 and 89). Rough bedstraw, which was first in rank in 1992, dropped out of the top ten in 2002. Virginia-creeper and Jack-in-the-pulpit showed significant increases over time. In Herr Ridge, the IV for enchanter's-nightshade nearly tripled, but it remained at second rank from 1992 to 2002. Japanese honeysuckle's IV decreased by a factor of seventeen. No other species changed to that degree among the combination of treatments and woodlots. In Powers Hill, common smartweed (*Polygonum hydropiper*) and stiltgrass, which were not present in the top ten ranking in 1992, increased to first and third rank, respectively, in 2002. Both species are annuals. The IV for Japanese honeysuckle decreased by more than half, and wild licorice and rough bedstraw dropped out of the top ten ranking by 2002. For the open canopy treatments, Powers Hill had the greatest number of species present (five) during both sampling periods.

Between 1992 and 2002, the number of species declined by half at Bushman Hill woodlot, causing the SDI to decrease. However, the distribution was more uniform among the species, so the EI increased (Table 83). For Herr Ridge, both the SDI and EI increased due to an increase in four species and a greater uniformity of distribution between species. Both the SDI and EI decreased for Powers Hill due to a decrease of four species, but more importantly, due to the very low uniformity among the species present.

Herbaceous and Vine Data from Subplot Inventories: In Bushman Hill woodlot between 1992 and 2002, the Coefficients of Community Similarity (CCS) for the three different canopy treatments decreased in value with increased opening of the overstory canopy. For both Herr Ridge and Powers Hill woodlots, the coefficients increased in value from the closed to partially open canopy treatments, but the coefficient for the open canopy treatments was below that of the closed canopy treatments (Table 90).

In Bushman Hill, the average percent cover of herbaceous and vine species decreased among all canopy treatments between 1992 and 2002 (Table 91). The changes were more varied for Herr Ridge and Powers Hill. In Herr Ridge, the coverage decreased slightly in the closed treatments, but increased slightly for the partially open and open canopy treatments. In Powers Hill, the coverage decreased by 26% in the closed treatments and decreased slightly in the partially open treatments, but increased by 24% in the open canopy treatments.

Closed Canopy: The average percent cover of herbaceous and vine species in the subplots in the closed canopy treatments decreased in all three woodlots between 1992 and 2002 (Table 91). Some of that decrease might be attributed to the drought that was ongoing at the time of the 2002 survey, but much of the decrease was due to the increased growth of woody shrubs, such as barberry, blackberry, multiflora rose, and spicebush. These species effectively out-compete the herbaceous species. Japanese honeysuckle and Virginia-creeper can successfully compete, and even dominate in some plots.

Partially Open Canopy: A decrease occurred in the average percent cover between 1992 and 2002 for the subplots in Bushman Hill and Powers Hill woodlots, but a slight increase occurred in the Herr Ridge woodlot (Table 91). In Bushman Hill and Powers Hill, there were more woody shrubs, contributing to the decrease in herbaceous and vine coverage. Barberry, *Rubus*, and multiflora rose were very abundant in Bushman Hill woodlot. They were present, but less abundant in Powers Hill, and only *Rubus* was present in significant amounts at Herr Ridge.

Open Canopy: The average percent cover decreased in the Bushman Hill open canopy treatment plots by half between 1992 and 2002 (Table 91). Coverage remained almost the same in Herr Ridge, and nearly doubled in Powers Hill between 1992 and 2002. Barberry was very abundant in the Bushman Hill plots in 2002, accounting for the decrease in herbaceous and vine coverage. *Rubus* was the only woody species of any significance in Herr Ridge, but its presence was much less than in Bushman Hill. Woody shrubs were present in limited amounts at Powers Hill. The difference in woody shrub coverage was probably the reason for the variation between woodlots.

The Coefficients of Community Similarity (CCS) between 1992 and 2002 for the subplots of different treatments and locations were generally low. The greatest CCS was 0.73 for the partially open canopy treatment in Powers Hill woodlot (Table 90). The low coefficients indicate that changes were occurring over time. The lowest CCS were for the open canopy treatments in all three woodlots. The greater disturbance and the greater change in light, temperature, and moisture conditions with total removal of the canopy would be expected to produce greater changes in the plant community present.

When comparing the CCSs within a woodlot, it might be expected that there would be less similarity between the species present in the closed and open canopy treatments than between those present in the closed and partially open canopy treatments after a ten-year time period. That was true for Bushman Hill and Herr Ridge woodlots, but not for Powers Hill woodlot (Table 91). Interestingly, the CCS between the partially open and open canopy treatments were greater in both Herr Ridge and Powers Hill than in Bushman Hill.

Table 90. Coefficient of Community Similarity Indices for the herbaceous and vine species in subplots within the closed, partially open, and open Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, between 1992 and 2002.

	Closed	Partially Open	Open
Woodlots			
Bushman Hill	0.54	0.50	0.37
Herr Ridge	0.60	0.67	0.36
Powers Hill	0.43	0.73	0.36

Table 91. Average percent cover of herbaceous and vine species from line transect inventories within subplots in the closed, partially open, and open Canopy Treatment Plots in Bushman Hill, Herr Ridge, and Powers Hill woodlots, Gettysburg National Military Park, 1992 to 2002.

	Closed		Partially Open		Open	
	1992	2002	1992	2002	1992	2002
Woodlots						
Bushman Hill	45.7	36.8	32.2	20.9	58.8	27.3
Herr Ridge	16.5	12.5	11.8	16.8	24.3	24.7
Powers Hill	41.3	15.6	24.5	18.0	30.0	54.4

Summary Herbaceous and Vine Discussion: There have been a number of studies that investigated the impact of deer on vegetation. There seems to be general agreement that large deer herds have a significant effect on survival of certain tree species in that they chew off the terminal buds of the stems. The degree of impact on a particular species seems to vary with palatability, differences in growing conditions, and availability of other palatable species. There is less agreement on the feeding behavior of deer on shrubs, woody vines, grasses, and forbs (Chinery, 1993; Cristoffel, 1998; Hunter, 1998; Perdomo et al, 2003; Stribling, 2003). Japanese honeysuckle is a good example of this diversity of opinion. It is touted as a nutritious, high-protein food source for white-tailed deer by the Alabama Cooperative Extension Service (Stribling, 2003) and by the Arkansas Game and Fish Commission (Hunter, 1998), but the Rutgers (Perdomo et al, 2003) and University of Wisconsin Cooperative Extension Services (Cristoffel, 1998) describe it as being avoided by deer or suffering little damage from their browsing. Virginia creeper is another woody vine in which there is conflicting information on the degree to which deer feed upon it, although more sources indicate that it is browsed than those indicating it is avoided. Stiltgrass, white snakeroot, and mayapple are three species encountered in this study in which there is good agreement that deer avoid feeding on them. Jack-in-the-pulpit generally is seen as not being much affected by deer browse, but deCalesta (1994) indicates that it was eliminated from study sites in northeastern Pennsylvania along with 50 other species. Fletcher (1999) found minimal effect on the number of Jack-in-the-pulpit plants found inside or outside deer exclosures in Virginia, but did find statistically significant differences in the reproductive success due to the removal of reproductive structures by deer browse. Chinery (1993) lists it as a plant rarely or never eaten by deer. Variability in browsing pressure from time to time and from place to place likely accounts for much of the lack of a correlation between deer access and changes in a species coverage or importance value.

In addition to the impact of deer browse on vegetation, their disturbance of the soil can be significant where they are present in large numbers. Disturbance tends to favor invasive species. The rapid increase of stiltgrass in Powers Hill woodlot is likely due to its ability to spread rapidly and to grow well in a variety of habitats, and the fact that deer avoid it. Stiltgrass fruit and seeds are spread readily by animals, water, and people (Tu, 2000). While it is normally found in moderate to dense shade, it was very successful in the open canopy treatment plots at Powers Hill and Herr Ridge woodlots where the greatest disturbance occurred during the treatment operation.

Four species tended to dominate within the various plots surveyed, no matter what the treatment. They were Virginia creeper, Japanese honeysuckle, Enchanter's nightshade, and White snakeroot. As discussed previously, there does not seem to be any demonstrable effect of deer on these species. Virginia creeper, Japanese honeysuckle, enchanter's nightshade, cinquefoil, jewelweed, common smartweed, sedge spp., and wild licorice were found in all quadrants surveyed in 2002 and in all but one or two quadrants in 1992. While their numbers may have increased or decreased in various treatments, they were consistently present.

Stiltgrass was a major colonizer between 1992 and 2002, increasing to where it had the greatest IV in the closed and open canopy treatments in Powers Hill, the second greatest rank in Powers Hill partially open canopy treatments, and third-ranked in the Herr Ridge open canopy treatments. This annual, non-native, invasive species is rapidly spreading across the state by seed dispersal. Powers Hill woodlot was most affected, either because of its location on the east side of the park, the direction from which the weed is spreading, or because conditions there are favorable for growth. Since it increased more in the closed canopy plots than in the partially open canopy plots, disturbance was presumably not the

major cause for the increased growth. However, disturbance may have been the major factor in Herr Ridge, where it only appeared in significant amounts in the open canopy treatments.

Species present in small numbers were examined in more detail to see if they might be more susceptible to herbivory or disturbance. No apparent pattern emerged from examination of line-transect and coverage data of those species either. Nearly as many species increased as decreased in the fenced and unfenced long-term and demonstration plots over the ten-year period.

General Comments/ Recommendations

Openings in the overstory canopy of Bushman Hill, Herr Ridge, and Powers Hill woodlots resulted in substantial changes in the seedling and sapling components of those woodlots. Since none of the plots were fenced to exclude white-tailed deer, the effects of canopy opening and deer foraging were difficult to isolate over the inventory period (1992 to 2002). However, the Deer Management Program was implemented in 1995-96, and there appears to be some consistent trends in the responses to the canopy treatments.

Woodlot management at Gettysburg National Military Park has relied on natural forces to control species composition and the density of tree and shrub stems in the various size classes. The result has been woodlot communities that were dominated by an aging overstory. Park woodlot structures were summarized by Fairweather and Cavanaugh (1990). Stocking levels in the closed canopy treatments in the three woodlots in this study ranged from 99 to 115% in 1992 (Bowersox et al. 1993). At these fully stocked levels there is little, if any, plant growth resources available to enable seedlings to become replacements for stems lost from the overstory. Under these closed canopy levels, the densities of seedlings rise and fall in response to changing weather conditions. Saplings tolerate the changing weather conditions but achieve little increase in size.

The partially open canopy treatment plots established in 1992/93 reduced the stocking to a range of 52 to 55% of the levels prior to the 1993 growing season (Bowersox et al. 1993). In 2002, the partially open and closed canopy treatments had similar average number of seedling and sapling tree species. However, the density of seedling and sapling trees was greater in the partially open canopy treatments than in the closed canopy treatments (Tables 77 and 78). In 2002, the average number of seedling shrub species in the partially open and closed canopy treatments was similar. In the 2002 inventory, the partially open canopy treatments had a greater average number of sapling shrub species and sapling shrub density than the closed canopy treatments (Table 77). In 2002, the seedling shrub density in the partially open canopy treatments was greater than in the closed canopy treatments (Table 78). It is likely that the abundance of seedling and sapling shrub stems were major competitors with the tree species stems. Herbaceous plants initially responded (1996) to the partially open canopy treatment by having nearly twice the average total coverage than in the closed canopy treatments (Figure 128). By 2002, the average coverage of herbaceous plants in the partially open canopy treatments were similar to the closed canopy treatment levels (Figure 128).

The open canopy treatments enabled the ground level plants to develop without interference from the overstory. The species that flourish in full direct sunlight conditions (*Rubus*, rose, barberry, honeysuckle, ailanthus, black cherry, yellow poplar, and red oak) were able to out-compete the more shade tolerant species (blackgum, ash, hickory, oak, maple, dogwood, redbud, blackhaw, and spicebush). Thus, the average number of sapling tree and shrub species present in 2002 was greater in the open canopy treatments than in the closed or the partially open canopy treatments (Table 77). It

was clear that the open canopy treatments provided the best opportunity for seedlings to grow into the sapling size category. In 2002, the density of sapling trees in the open canopy treatments (1,653 stems/ha) was nearly three times the density in the closed canopy (583 stems/ha) and the partially open canopy (600 stems/ha) treatments (Table 77). It is very likely that the rapid development of the sapling shrubs in the open canopy treatments from 120 stems/ha in 1996 to 22,133 stems/ha in 2002 limited the density of tree species. In time, it is expected that the tree species will overtop and shade-out some of the shrub species, but the 13-to-1 shrub-to-tree ratio suggests that these open canopy treatments will be dominated by shrubs for a longer than acceptable time period.

The 2002 Canopy Treatment inventory results were negatively influenced by the expansion of non-native plants. Overall, shrub species benefited the most from opening the canopy. Multiflora rose, Japanese barberry, and honeysuckle produced numerous, branching stems that covered more area than a single-stem seedling or sapling tree could. This growth habit and the avoidance by white-tailed deer enabled the shrubs to out-compete the tree species for light and moisture. This was particularly a problem in the open canopy treatments.

After implementing the Deer Management Program in 1995, there was a desirable increase in native tree species diversity and height of tree stems in the partially open and closed canopy treatments. The abundance of desirable, seedling tree species in the partially open and closed canopy treatments was due to the combination of reduced white-tailed deer herbivory and less competition with shrub species than in the open canopy treatments. Overall, there was good potential for tree species to regenerate the woodlots at Gettysburg National Military Park. The majority of overstory tree species were represented in the seedling component in all inventories in the Bushman Hill, Herr Ridge, and Powers Hill woodlots. In each inventory there were some overstory tree species not present as seedling trees, and there were some seedling tree species not found in the overstory. In all cases, these were uncommon species and they may have been present within the woodlot but not within the inventory plots. For example, *Ailanthus*, black walnut, catalpa, chestnut oak, eastern red cedar, Norway maple, and pin oak were overstory species that were not recorded in the 2002 seedling inventory, but there was only one or less overstory stems/ha of each of these species. Hazelnut and black locust (*Robinia pseudoacacia*) were not found in the overstory but were recorded as seedlings in 2002 with densities of 185 stems/ha each.

The partially open canopy conditions created by removing individual trees were effective in increasing seedling tree species diversity and density. Multiple tree openings in the canopy were effective in providing the conditions for seedlings to grow into saplings. Overall, in 2002 there was good potential for tree species to regenerate the woodlots at Gettysburg NMP. Although these studies were not designed to evaluate the effects of invasive plants on the understory tree species, there were strong implications that these plants were poised to expand their presence if not controlled.

Therefore, to sustain healthy tree and shrub species that will perpetuate the historic 1863 woodlots in the Gettysburg National Military Park, it is recommended to:

1. Continue to implement the Deer Management Program to reach the goal of 25 deer/forested sq. mile for four to five years (USDI NPS 1995).
2. Continue executing the Exotic Plant Management Program within the park to control the non-native, invasive plant species.
3. Fully implement the park-wide plan for increasing the sustainability of woodlots (Bowersox 2002) where the removal of individual non-sustainable overstory trees will create openings in

the canopy to improve the health, vigor and density of desirable seedling tree species. Woodlot stocking should be maintained between the 60% and 80% level.

4. Develop a plan to recruit seedling stems into sapling stems and then into the overstory to replace the aging trees where there is a desirable mixture of vigorous tree species seedlings that have a competitive advantage over the herbaceous and shrub plants. Although canopy openings of 0.2 ha (radius 21 m) were tested, it is believed that similar opportunities for seedlings to become canopy tree replacements can be achieved with a combination of single-tree and multiple-tree openings (0.05 to 0.1 ha) to reduce the stock to the 45 to 55% level.
5. Develop a long-term vegetation monitoring program for all wooded areas that are ≥2 ha. The program should be designed to document changes in plant diversity and density for all sizes of tree and shrub species, and in forb, grass, grass-like, and vine species groups. When choosing plot locations, take into consideration the effect of moisture on regeneration. Inventory frequency need not be greater than once every five years, but not less than once every ten years.

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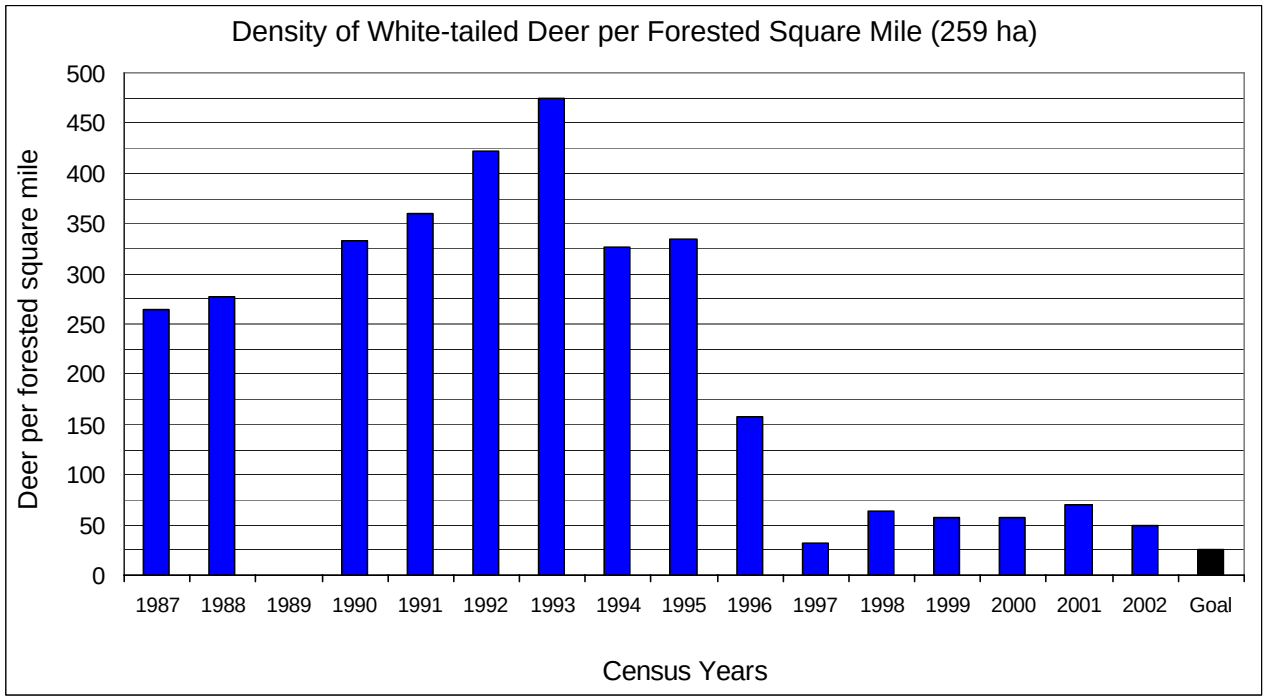
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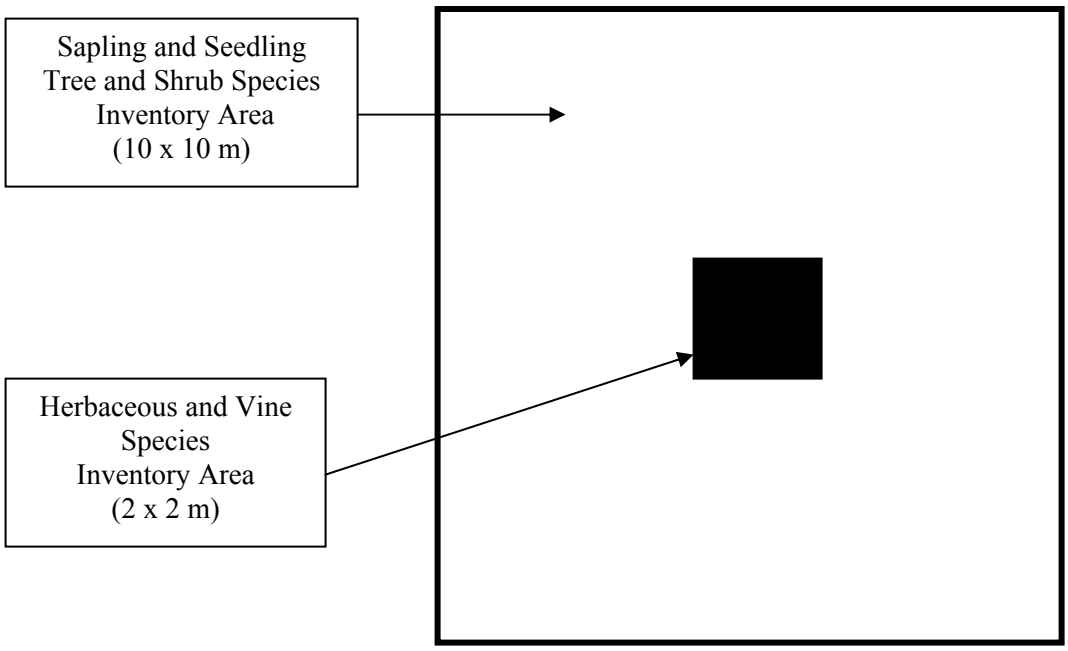
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Appendix A. Estimated population of white-tailed deer in the Gettysburg study area (2,862 ha) March-April, 1987-2002 (Storm 2004).



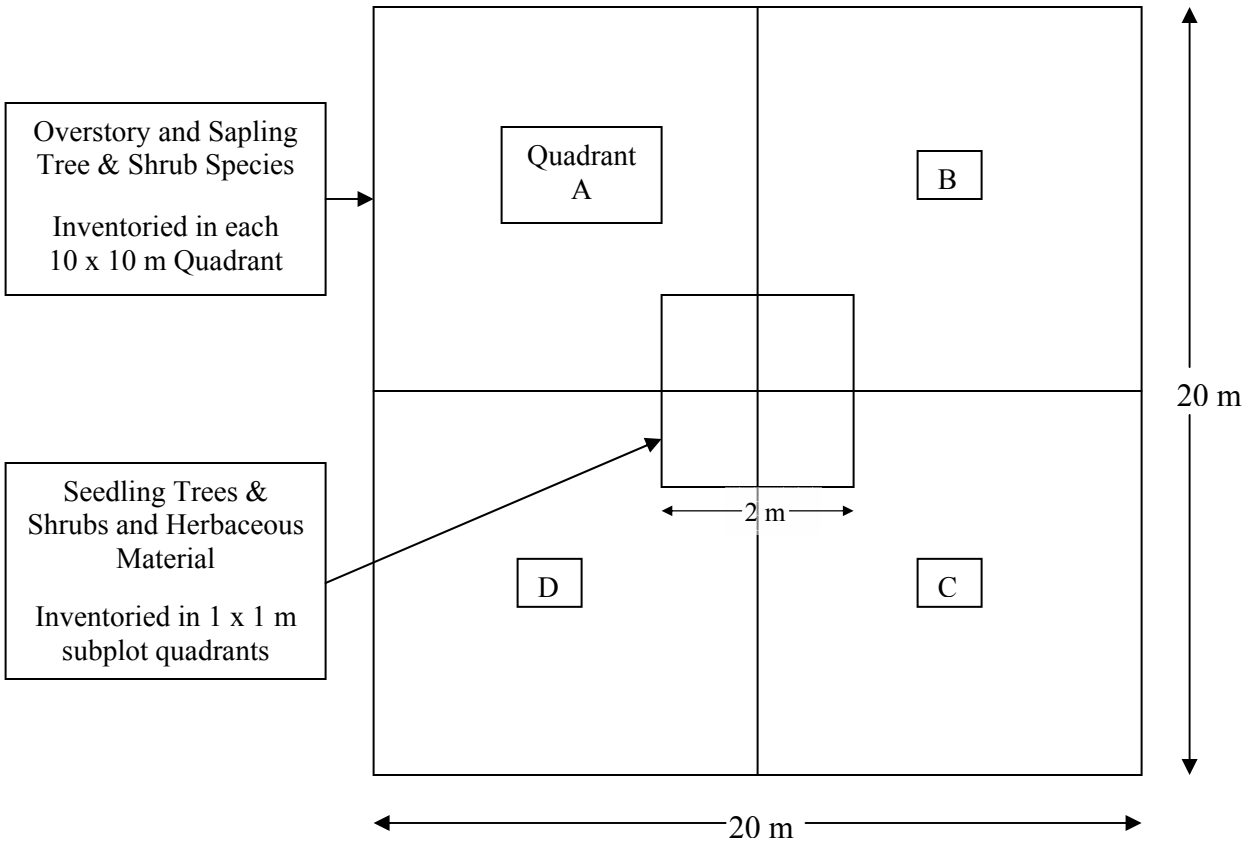
Appendix B. Diagrams of the three types of monitoring plots in Gettysburg National Military Park

Diagram B1. Demonstration Plot design



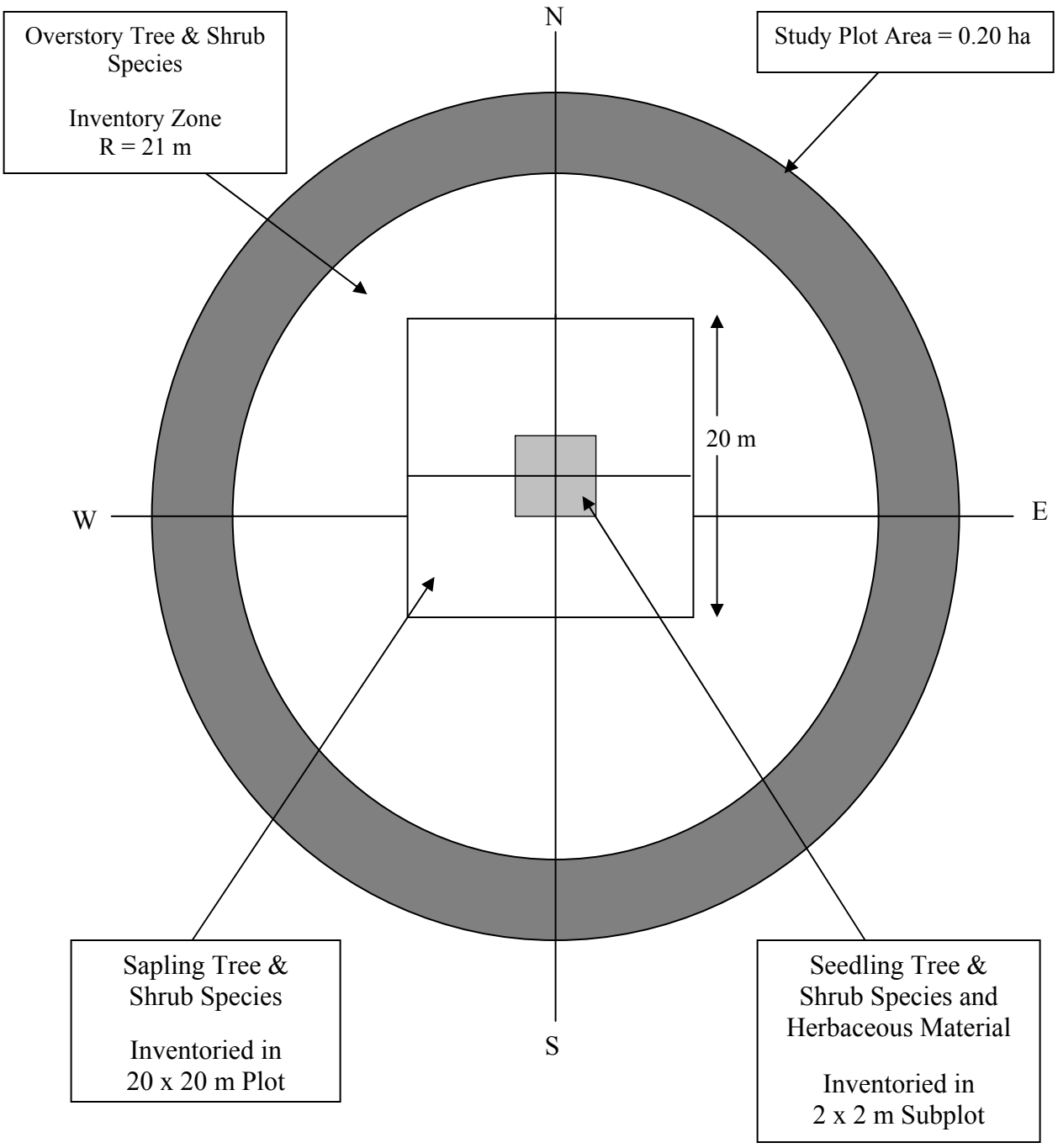
Appendix B. Diagrams of the three types of monitoring plots in Gettysburg National Military Park (continued).

Diagram B2. Long-term Monitoring Plot design



Appendix B. Diagrams of the three types of monitoring plots in Gettysburg National Military Park (continued).

Diagram B3. Canopy Treatment Plot design.



Appendix C. Scientific and common names of tree and shrub species in the Demonstration Plots in 2002.

Tree	
Aceraceae	*Acer platanoides* L. – Norway maple
Aceraceae	*Acer rubrum* L. – red maple
Cupressaceae	*Juniperus virginiana* L. – eastern redcedar
Fabaceae	*Robinia pseudoacacia* L. – black locust
Fagaceae	*Quercus alba* L. – white oak
Fagaceae	*Quercus prinus* L. – chestnut oak
Fagaceae	*Quercus rubra* L. – northern red oak
Fagaceae	*Quercus velutina* Lam. – black oak
Juglandaceae	*Carya glabra* (P. Mill.) Sweet – pignut hickory
Juglandaceae	*Carya ovata* (P. Mill.) K. Koch – shagbark hickory
Juglandaceae	*Carya tomentosa* (Lam. ex Poir.) Nutt. – mockernut hickory
Magnoliaceae	*Liriodendron tulipifera* L. – yellow poplar
Nyssaceae	*Nyssa sylvatica* Marshall – Blackgum
Oleaceae	*Fraxinus* species – ash species
Rosaceae	*Prunus avium* (L.) L. – sweet cherry
Rosaceae	*Prunus serotina* Ehrh. – black cherry
Simaroubaceae	*Ailanthus altissima* (P. Mill.) Swingle – tree-of-heaven
Ulmaceae	*Ulmus* species – elm species
Shrub	
Berberidaceae	*Berberis thunbergii* DC. – Japanese barberry
Caesalpiniaceae	*Cercis canadensis* L. – eastern redbud
Caprifoliaceae	*Lonicera tatarica* L. – Tartarian honeysuckle
Caprifoliaceae	*Viburnum prunifolium* L. – smooth blackhaw
Cornaceae	*Cornus florida* L. – flowering dogwood
Lauraceae	*Lindera benzoin* (L.) Blume – spicebush
Lauraceae	*Sassafras albidum* (Nutt.) Nees – sassafras
Rosaceae	*Amelanchier arborea* (Michx.f.) Fern. – serviceberry
Rosaceae	*Rosa* species – mainly multiflora rose
Rosaceae	*Rubus* species – blackberry, dewberry or black raspberry
Smilacaceae	*Smilax rotundifolia* L. – greenbriar
Vitaceae	*Vitis* species – grape species

Appendix D. List of herbaceous and vine species inventoried in the line transects or the 1 x 1m quadrants in which the line transects were completed. The list is alphabetized by common names used in text and tables. Scientific name and family for each is indicated. Taxonomy follows that of Rhoads and Klein (1993).

Common Names	Scientific Names	Family Name
Agrimony	*Agrimonia gryposepala* Wallr.	Rosaceae
American pennyroyal	*Hedeoma pulegioides* (L.) Pers.	Lamiaceae
Arrow-leaved violet	*Viola sagittata* Ait.	Violaceae
Bellwort	*Uvularia sessifolia* L.	Liliaceae
Black sanicle	*Sanicula marlandica* L.	Apiaceae
Black raspberry	*Rubus occidentalis* L.	Rosaceae
Blackberry	*Rubus* spp.	Rosaceae
Bluets	*Hedyotis caerulea* (L.) Hook.	Rubiaceae
Bottlebrush grass	*Elymus hystrix* L.	Poaceae
Bush honeysuckle	*Lonicera* spp.	Caprifoliaceae
Canada mayflower	*Maianthemum canadense* Desf.	Liliaceae
Carrion-flower	*Smilax herbacea* L.	Smilacaceae
Cinquefoil	*Potentilla canadensis* L.	Rosaceae
Clearweed	*Pilea pumila* (L.) A. Gray	Urticaceae
Cleavers	*Galium aparine* L.	Rubiaceae
Club-rush	*Trichophorum planifolium* (Sprengel) Palla	Cyperaceae
Common blue violet	*Viola sororia* Willd.	Violaceae
Common smartweed	*Polygonum hydropiper* L.	Polygonaceae
Common dittany	*Cunila origanoides* (L.) Britt.	Lamiaceae
Common yellow wood-sorrel	*Oxalis stricta* L.	Oxalidaceae
Cut-leaved grape fern	*Botrychium dissectum* Spreng.	Ophioglossaceae
Cut-leaved toothwort	*Cardamine concatenata* (Michx.) O. E. Schulz	Brassicaceae
Dandelion	*Taraxacum officinale* Weber	Asteraceae
Early blue violet	*Viola palmata* L.	Violaceae
Enchanter's-nightshade	*Circaea lutetiana* L.	Onagraceae
False nettle	*Boehmeria cylindrica* (L.) Swartz	Urticaceae
False solomon's-seal	*Simlacina racemosa* (L.) Desf.	Liliaceae
Field pussytoes	*Antennaria neglecta* Greene	Asteraceae
Forked chickweed	*Paronychia canadensis* (L.) Wood	Caryophyllaceae
Garlic-mustard	*Alliaria petiolata* (Bieb.) Cavara & Grande	Brassicaceae
Giant ragweed	*Ambrosia trifida* L.	Asteraceae
Goldenrod spp.	*Solidago* spp.	Asteraceae
Grass spp.		Poaceae
Greenbrier	*Smilax rotundifolia* L.	Smilacaceae
Ground-cherry	*Physalis subglabrata* Mackenzie & Bush	Solanaceae
Hog-peanut	*Amphicarpa bracteata* (L.) Fern.	Fabaceae
Horse balm	*Collinsonia canadensis* L.	Lamiaceae
Horse nettle	*Solanum carolinense* L.	Solanaceae
Indian hemp	*Apocynum cannabinum* L.	Apocynaceae
Jack-in-the-pulpit	*Arisaema triphyllum* (L.) Schott ssp. *triphyllum*	Araceae
Japanese barberry	*Berberis thunbergii* DC.	Berberidaceae
Japanese honeysuckle	*Lonicera japonica* Thunb.	Caprifoliaceae

Appendix D. List of herbaceous and vine species inventoried in the line transects or the 1 x 1m quadrants in which the line transects were completed. The list is alphabetized by common names used in text and tables. Scientific name and family for each is indicated. Taxonomy follows that of Rhoads and Klein (1993) (continued).

Common Names	Scientific Names	Family Name
Jewelweed	*Impatiens capensis* Meerb.	Balsaminaceae
Joe-pye-weed	*Eupatorium purpureum* L.	Asteraceae
Jumpseed	*Polygonum virginianum* L.	Polygonaceae
Lady's-thumb	*Polygonum persicaria* L.	Polygonaceae
Lion's-foot	*Prenanthes serpentaria* Pursh.	Asteraceae
Liverleaf	*Hepatica nobilis* P. Mill.	Ranunculaceae
Lopseed	*Phryma leptostachya* L.	Verbenaceae
Mayapple	*Podophyllum peltatum* L.	Berberidaceae
Mint	*Mentha* spp.	Lamiaceae
Moneywort	*Lysimachia nummularia* L.	Primulaceae
Moss	*Polytrichum* spp.	Polytrichaceae
Mountain-mint	*Pycnanthemum tenuifolium* Schrad.	Lamiaceae
Multiflora rose	*Rosa multiflora* Thunb.	Rosaceae
Naked-flowered tick-seed	*Desmodium nudiflorum* (L.) DC.	Fabaceae
Old field cinquefoil	*Potentilla simplex* Michx.	Rosaceae
Panic-grass	*Panicum boscii* Poir.	Poaceae
Pennsylvania bitter cress	*Cardamine pensylvanica* Muhl. ex Willd.	Brassicaceae
Poison-ivy	*Toxicodendron radicans* (L.) Kuntz	Anacardiaceae
Pokeweed	*Phytolacca americana* L.	Phytolaccaceae
Rattlesnake-weed	*Hieracium venosum* L.	Asteraceae
Rough bedstraw	*Galium asprellum* Michx.	Rubiaceae
Rue-anemone	*Thalictrum thalictroides* (L.) Eames & B. Boivin	Ranunculaceae
Sedge spp.	*Carex* spp.	Cyperaceae
Sedge	*Carex laxiflora* Lam.	Cyperaceae
Sheep sorrel	*Rumex arcetosella* L.	Polygonaceae
Skullcap	*Scutellaria* spp.	Lamiaceae
Small-flowered crowfoot	*Ranunculus abortivus* L.	Ranunculaceae
Solomon's-seal	*Polygonatum biflorum* (Walt.) Ell.	Liliaceae
Spring-beauty	*Claytonia virginica* L.	Portulacaceae
Stickseed	*Hackelia virginiana* (L.) I. M. Johnston	Boraginaceae
Stiltgrass	*Microstegium vimineum* (Trin.) A. Camus	Poaceae
Summer grape	*Vitis aestivalis* Michx.	Vitaceae
Sweet-cicely	*Osmorhiza claytonii* (Michx.) C.B. Clarke	Apiaceae
Sweet-scented bedstraw	*Galium triflorum* Michx.	Rubiaceae
Three-seeded mercury	*Acalypha rhomboidea* Raf.	Euphorbiaceae
Venus's-looking-glass	*Triodanis perfoliata* (L.) Nieuwl.	Campanulaceae
Violet wood-sorrel	*Oxalis violacea* L.	Oxalidaceae
Virginia snakeroot	*Aristolochia serpentaria* L.	Aristolochiaceae
Virginia-creeper	*Parthenocissus quinquefolia* (L.) Planch.	Vitaceae
White-avens	*Geum canadense* Jacq.	Rosaceae
White-snakeroot	*Eupatorium rugosum* L.	Asteraceae
Wild onion	*Allium canadense* L.	Liliaceae

Appendix D. List of herbaceous and vine species inventoried in the line transects or the 1 x 1m quadrants in which the line transects were completed. The list is alphabetized by common names used in text and tables. Scientific name and family for each is indicated. Taxonomy follows that of Rhoads and Klein (1993) (continued).

Common Names	Scientific Names	Family Name
Wild licorice	*Galium circaezans* Michx.	Rubiaceae
Wild black currant	*Ribes* spp.	Grossulariaceae
Wild-comfrey	*Cynoglossum virginianum* L.	Boraginaceae
Wood geranium	*Geranium maculatum* L.	Geraniaceae

Appendix E. Scientific and common names of tree and shrub species in the Long-term Monitoring Plots in 2002.

Tree	
Aceraceae	*Acer platanoides* L. – Norway maple
Aceraceae	*Acer rubrum* L. – red maple
Cupressaceae	*Juniperus virginiana* L. – eastern redcedar
Fagaceae	*Quercus alba* L. – white oak
Fagaceae	*Quercus coccinea* Muenchh. – scarlet oak
Fagaceae	*Quercus prinus* L. – chestnut oak
Fagaceae	*Quercus rubra* L. – northern red oak
Fagaceae	*Quercus velutina* Lam. – black oak
Juglandaceae	*Carya glabra* (P. Mill.) Sweet – pignut hickory
Juglandaceae	*Carya ovata* (P. Mill.) K. Koch – shagbark hickory
Juglandaceae	*Carya tomentosa* (Lam. ex Poir.) Nutt. – mockernut hickory
Juglandaceae	*Juglans nigra* L. – black walnut
Moraceae	*Morus* species – mulberry species
Nyssaceae	*Nyssa sylvatica* Marshall – Blackgum
Oleaceae	*Fraxinus* species – ash species
Pinaceae	*Pinus strobes* L. – eastern white pine
Pinaceae	*Pinus virginiana* P. Mill. – Virginia pine
Platanaceae	*Platanus occidentalis* L. – American sycamore
Rosaceae	*Prunus avium* (L.) L. – sweet cherry
Rosaceae	*Prunus serotina* Ehrh. – wild black cherry
Ulmaceae	*Celtis occidentalis* L. var. *occidentalis* – hackberry
Ulmaceae	*Ulmus rubra* Muhl. – slippery elm
Shrub	
Berberidaceae	*Berberis thunbergii* DC. – Japanese barberry
Caesalpiniaceae	*Cercis canadensis* L. – eastern redbud
Caprifoliaceae	*Viburnum prunifolium* L. – smooth blackhaw
Cornaceae	*Cornus florida* L. – flowering dogwood
Lauraceae	*Lindera benzoin* (L.) Blume – spicebush
Lauraceae	*Sassafras albidum* (Nutt.) Nees – sassafras
Rosaceae	*Amelanchier arborea* (Michx.f.) Fern. – serviceberry
Rosaceae	*Crataegus* species – hawthorn species
Rosaceae	*Rosa* species – mainly multiflora rose
Rosaceae	*Rubus* species – blackberry, dewberry or black raspberry

Appendix F. A comparison of the Importance Values of the herbaceous species present during inventories in May-June and July, 1995, in five woodlots in Gettysburg National Military Park. Pitzer woodlot is not included since no data were collected in May-June, 1995.

Table F1. A comparison of the May-June and July, 1995, relative density (RD), relative coverage (RC), relative frequency (RF), and Importance Values (IV) of the ten herbaceous species with the greatest Importance Values in the fenced Long-term Monitoring subplots in Biesecker woodlot, Gettysburg National Military Park. The May-June Biesecker data were collected May 16-22, 1995. The July data were collected July 23-24, 1995.

Biesecker Fenced Subplots									
	May-June					July			
Species	IV	RD	RC	RF	Species	IV	RD	RC	RF
Japanese honeysuckle	86.4	27.6	36.7	22.0	Japanese honeysuckle	84.0	22.6	30.9	30.5
Spring-beauty	58.9	19.7	11.0	28.2	Grass spp.	67.8	38.8	10.0	19.0
Grass spp.	30.9	16.5	4.8	9.5	Enchanter's-nightshade	42.4	10.5	18.2	13.7
Jewelweed	28.7	8.5	10.5	9.7	Virginia-creeper	26.4	4.8	13.9	7.7
Enchanter's-nightshade	17.1	4.0	7.8	5.2	Jewelweed	15.1	3.8	5.3	6.0
Virginia-creeper	14.6	3.2	4.0	4.5	Wild licorice	14.2	5.2	3.4	5.6
Prenanthes spp.[a]	13.4	4.9	5.2	3.3	Sedge (*Carex* spp.)	12.4	6.0	1.5	4.9
Cut-leaved toothwort	8.4	2.6	2.7	3.1	White-snakeroot	10.7	1.6	6.6	2.5
Wild licorice	7.2	2.5	1.9	2.8	Cinquefoil	9.7	2.6	3.2	3.9
Sedge (*Carex* spp.)	6.0	2.5	1.2	2.4	White-avens	3.2	0.7	1.5	1.1

[a] *Prenanthes* spp. was labeled as *Compositae* spp. #1 in May-June survey report

Appendix F. A comparison of the Importance Values of the herbaceous species present during inventories in May-June and July, 1995, in five woodlots in Gettysburg National Military Park. Pitzer woodlot is not included since no data were collected in May-June, 1995 (continued).

Table F2. A comparison of the May-June and July, 1995, relative density (RD), relative coverage (RC), relative frequency (RF), and Importance Values (IV) of the ten herbaceous species with the greatest Importance Values in the unfenced Long-term Monitoring subplots in Biesecker woodlot, Gettysburg National Military Park. The May-June Biesecker data were collected May 16-22, 1995. The July data were collected July 23-24, 1995.

Biesecker Unfenced Subplots									
	May-June					July			
Species	IV	RD	RC	RF	Species	IV	RD	RC	RF
Spring-beauty	90.1	26.8	26.9	36.4	Grass spp.	162.9	70.8	42.3	49.7
Grass spp.	72.6	32.2	19.9	20.3	Cinquefoil	24.3	5.2	10.3	8.9
Enchanter's-nightshade	34.4	9.4	11.9	13.1	Common dittany	20.4	5.4	6.6	8.4
Sedge (*Carex* spp.)	26.9	13.6	7.1	6.2	Enchanter's-nightshade	17.9	2.4	10.8	4.7
Cinquefoil	14.4	3.0	6.5	4.9	Smartweed spp.	17.8	2.9	8.6	6.3
Prenanthes spp.[a]	9.4	1.9	4.6	3.0	Japanese honeysuckle	12.0	1.8	6.5	3.6
Violet wood-sorrel	9.3	2.8	3.8	2.6	Sedge (*Carex* spp.)	9.3	3.6	1.5	4.2
Wild licorice	9.1	2.6	4.0	2.6	Wild licorice	6.6	1.8	1.6	3.1
Japanese honeysuckle	9.1	1.8	5.0	2.3	Hog-peanut	5.8	0.7	3.6	1.6
Cut-leaved toothwort	7.8	2.0	2.5	3.3	Rough bedstraw	5.4	2.5	1.4	1.6

[a] *Prenanthes* spp. was labeled as *Compositae* spp. #1 in May-June survey report

Appendix F. A comparison of the Importance Values of the herbaceous species present during inventories in May-June and July, 1995, in five woodlots in Gettysburg National Military Park. Pitzer woodlot is not included since no data were collected in May-June, 1995 (continued).

Table F3. A comparison of the May-June and July, 1995 relative density (RD), relative coverage (RC), relative frequency (RF), and Importance Values (IV) of the ten herbaceous species with the greatest Importance Values in the unfenced-control subplots in Biesecker woodlot, Gettysburg National Military Park. The May-June Biesecker data were collected May 16-22, 1995. The July data were collected July 23-24, 1995.

Biesecker Unfenced-Control Subplots									
	May-June					July			
Species	IV	RD	RC	RF	Species	IV	RD	RC	RF
Spring-beauty	86.0	31.5	17.9	76.6	Smartweed spp.	78.4	26.7	30.5	21.1
Japanese honeysuckle	65.5	19.4	29.8	16.3	Japanese honeysuckle	71.6	20.6	26.8	24.1
Garlic-mustard	31.2	10.3	11.0	9.9	Grass spp.	39.6	21.7	4.9	13.1
Wild licorice	25.4	9.5	8.4	7.6	Wild licorice	34.9	12.7	8.4	13.8
Enchanter's-nightshade	25.2	6.4	11.4	7.4	Garlic-mustard	23.4	5.6	7.8	10.0
Smartweed spp.	16.7	5.7	5.4	5.5	Enchanter's-nightshade	19.7	4.8	7.3	7.7
Prenanthes spp.[a]	15.9	4.1	6.2	5.5	White-snakeroot	7.7	2.1	3.3	2.3
Grass spp.	14.8	7.2	2.6	5.1	Wild-comfrey	6.3	0.7	4.0	1.5
White-snakeroot	4.8	1.2	2.4	1.1	Virginia-creeper	5.2	1.1	2.6	1.5
Cut-leaved toothwort	3.8	1.2	1.0	1.6	Goldenrod spp.	3.5	1.1	1.0	1.5

[a] *Prenanthes* spp. was labeled as *Compositae* spp. #1 in May-June survey report

Appendix F. A comparison of the Importance Values of the herbaceous species present during inventories in May-June and July, 1995, in five woodlots in Gettysburg National Military Park. Pitzer woodlot is not included since no data were collected in May-June, 1995 (continued).

Table F4. A comparison of the May-June and July, 1995 relative density (RD), relative coverage (RC), relative frequency (RF), and Importance Values (IV) of the ten herbaceous species with the greatest Importance Values in the unfenced Long-term Monitoring subplots in Bushman Hill woodlot, Gettysburg National Military Park. The May-June Bushman Hill data were collected June 5 and 16, 1995. The July data were collected July 25-26,1995.

Bushman Hill Unfenced Subplots									
	May-June					July			
Species	IV	RD	RC	RF	Species	IV	RD	RC	RF
Grass spp.	49.1	26.8	12.1	10.1	Grass spp.	55.4	31.2	13.5	10.8
Rough bedstraw	42.7	18.7	8.6	18.7	Rough bedstraw	55.0	23.3	11.4	20.4
Japanese honeysuckle	40.5	11.9	14.6	14.1	Naked-flowered tick-trefoil	39.4	8.5	16.8	14.2
Naked-flowered tick-trefoil	22.5	6.1	8.7	7.7	Japanese honeysuckle	27.8	7.1	10.1	10.6
Enchanter's nightshade	22.0	6.0	7.5	6.2	Virginia-creeper	19.8	4.3	9.2	6.4
Virginia-creeper	17.6	3.8	7.6	6.2	Enchanter's nightshade	13.8	3.2	4.9	5.8
Wild-comfrey	17.5	2.5	9.5	5.5	Agrimony	12.2	3.0	4.8	4.4
Jack-in-the-pulpit	16.7	2.9	8.4	5.3	Cinquefoil	10.0	2.9	3.9	3.3
Agrimony	13.9	4.2	4.6	5.2	Wild licorice	8.9	2.6	2.3	4.0
Wild licorice	11.0	3.9	2.8	4.3	Smartweed spp.	8.2	2.4	3.1	2.7

Appendix F. A comparison of the Importance Values of the herbaceous species present during inventories in May-June and July, 1995, in five woodlots in Gettysburg National Military Park. Pitzer woodlot is not included since no data were collected in May-June, 1995 (continued).

Table F5. A comparison of the May-June, 1995 relative density (RD), relative coverage (RC), relative frequency (RF), and Importance Values (IV) of the ten herbaceous species with the greatest Importance Values in the unfenced Long-term Monitoring subplots in Herr Ridge woodlot, Gettysburg National Military Park. The May-June Herr Ridge data were collected May 24 and June 21, 1995. The July data were collected July 23-24, 1995.

Herr Ridge Unfenced Subplots									
	May-June					July			
Species	IV	RD	RC	RF	Species	IV	RD	RC	RF
Enchanter's-nightshade	79.8	24.9	27.6	27.3	Virginia-creeper	85.6	24.4	34.9	26.3
Jewelweed	62.4	19.6	22.1	20.7	Enchanter's-nightshade	76.6	23.1	27.9	25.6
Virginia-creeper	48.1	14.7	17.8	15.5	Wild licorice	42.1	18.1	9.6	14.4
Wild licorice	25.8	11.1	4.8	9.8	Sedge (*Carex* spp.)	18.7	10.4	2.0	6.3
Japanese honeysuckle	20.9	6.5	7.2	7.2	Poison-ivy	17.0	4.8	8.4	3.9
Sedge (*Carex* spp.)	15.7	9.4	1.7	4.6	Japanese honeysuckle	14.3	3.9	3.7	6.7
Mayapple	12.0	2.5	6.2	3.3	Cinquefoil	13.5	5.0	3.6	4.9
Poison-ivy	8.7	2.0	4.3	2.4	Summer grape	8.1	2.4	2.9	2.8
Cinquefoil	7.0	2.5	1.8	2.6	Rough bedstraw	5.6	2.7	1.1	1.8
Rough bedstraw	6.6	3.4	1.2	2.0	Jewelweed	5.6	1.4	1.8	2.5

Appendix F. A comparison of the Importance Values of the herbaceous species present during inventories in May-June and July, 1995, in five woodlots in Gettysburg National Military Park. Pitzer woodlot is not included since no data were collected in May-June, 1995 (continued).

Table F6. A comparison of the May-June and July, 1995 relative density (RD), relative coverage (RC), relative frequency (RF), and Importance Values (IV) of the ten herbaceous species with the greatest Importance Values in the unfenced Long-term Monitoring subplots in Powers Hill woodlot, Gettysburg National Military Park. The May-June Powers Hill data were collected May 22-23, 1995. The July data were collected July 24-25, 1995.

Powers Hill Unfenced Subplots									
	May-June					July			
Species	IV	RD	RC	RF	Species	IV	RD	RC	RF
Enchanter's-nightshade	35.0	10.3	12.2	12.5	Rough bedstraw	38.2	18.1	7.5	12.7
Japanese honeysuckle	30.4	9.1	11.0	10.4	White-snakeroot	37.1	7.9	19.2	10.0
Rough bedstraw	29.8	14.0	6.9	9.0	Grass spp.	26.0	12.2	5.2	8.6
Wild licorice	29.2	10.6	8.0	10.6	Wild licorice	22.4	8.4	4.6	9.5
Sedge (*Carex* spp.)	26.7	9.6	10.9	6.2	Japanese honeysuckle	21.2	5.9	6.2	9.1
White-snakeroot	22.9	4.9	10.9	7.1	Stiltgrass	10.3	1.2	5.9	3.2
Grass spp.	21.2	10.8	4.0	6.3	Clearweed	18.2	5.4	8.3	4.6
Jack-in-the-pulpit	15.8	2.7	8.7	4.4	Enchanter's-nightshade	17.7	4.6	6.7	6.4
Stiltgrass	12.3	6.0	2.8	3.5	Smartweed spp.	14.1	3.9	5.0	5.2
Cinquefoil	9.2	3.2	2.6	3.4	Sedge (*Carex* spp.)	13.8	5.8	2.0	6.1

Appendix G. Scientific and common names of tree and shrub species in the Canopy Treatment Plots in 2002.

Tree	
Aceraceae	*Acer platanoides* L. – Norway maple
Aceraceae	*Acer rubrum* L. – red maple
Cupressaceae	*Juniperus virginiana* L. – eastern redcedar
Fagaceae	*Quercus alba* L. – white oak
Fagaceae	*Quercus prinus* L. – chestnut oak
Fagaceae	*Quercus rubra* L. – northern red oak
Fagaceae	*Quercus velutina* Lam. – black oak
Juglandaceae	*Carya glabra* (P. Mill.) Sweet – pignut hickory
Juglandaceae	*Carya ovata* (P. Mill.) K. Koch – shagbark hickory
Juglandaceae	*Carya tomentosa* (Lam. ex Poir.) Nutt. – mockernut hickory
Juglandaceae	*Juglans nigra* L. – black walnut
Magnoliaceae	*Liriodendron tulipifera* L. – yellow poplar
Nyssaceae	*Nyssa sylvatica* Marshall – Blackgum
Oleaceae	*Fraxinus* species – ash species
Rosaceae	*Prunus avium* (L.) L. – sweet cherry
Rosaceae	*Prunus serotina* Ehrh. – black cherry
Ulmaceae	*Celtis occidentalis* L. var. *occidentalis* – hackberry
Ulmaceae	*Ulmus* species – elm species
Shrub	
Aceraceae	*Acer negundo* L. – boxelder
Anacardiaceae	*Rhus* species – sumac species
Berberidaceae	*Berberis thunbergii* DC. – Japanese barberry
Caesalpiniaceae	*Cercis canadensis* L. – eastern redbud
Caprifoliaceae	*Lonicera tatarica* L. – Tartarian honeysuckle
Caprifoliaceae	*Viburnum acerifolium* L. – mapleleaf viburnum
Caprifoliaceae	*Viburnum prunifolium* L. – smooth blackhaw
Cornaceae	*Cornus florida* L. – flowering dogwood
Elaeagnaceae	*Elaeagnus umbellate* Thunb. – autumn olive
Ericaceae	*Vaccinium* species – blueberry species
Hamamelidaceae	*Hamamelis virginiana* L. – witch hazel
Lauraceae	*Lindera benzoin* (L.) Blume – spicebush
Lauraceae	*Sassafras albidum* (Nutt.) Nees – sassafras
Rosaceae	*Amelanchier arborea* (Michx.f.) Fern. – serviceberry
Rosaceae	*Rosa multiflora* Thunb. ex Murr. – multiflora rose
Rosaceae	*Rubus* species – blackberry, dewberry or black raspberry
Smilacaceae	*Smilax rotundifolia* L. – greenbriar
Vitaceae	*Vitis* species – grape species

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NPS D-177 March 2006

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