

**TREE OF HEAVEN CONTROL PROJECT
at
FRIENDSHIP HILL NATIONAL HISTORIC SITE
and
MORROW'S HONEYSUCKLE CONTROL PROJECT
at
FORT NECESSITY NATIONAL BATTLEFIELD**

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ABSTRACT

In the Spring of 2007, USDA Forest Service personnel and USDI Park Service personnel established a tree of heaven (*Ailanthus altissima*) control project at Friendship Hill National Historic Site and a Morrow's honeysuckle (*Lonicera morrowii*) control project at Fort Necessity National Battlefield. The purpose of these projects was to significantly reduce the amount and negative impacts of these two invasive species and prevent their spread into uninfested areas.

At Friendship Hill National Historic Site, 21,177 tree of heaven were treated (9193 were treated mechanically and 11,984 were treated with herbicides) in 73 areas. At Fort Necessity National Battlefield, 3528 Morrow's honeysuckle were treated (50 were treated mechanically and 3478 were treated with herbicides) on approximately 5.5 acres. Both of these projects will continue in 2008.

INTRODUCTION

Friendship Hill National Historic Site (FRHI) is a 677 acre National Park Service site located on the banks of the Monongahela River approximately 3 miles north of Pt. Marion, PA (Figure 1). FRHI was established in 1978 and is the former estate of Albert Gallatin, who served as the Secretary of the Treasury under Thomas Jefferson and James Madison. In addition to Gallatin's 35 room mansion, FRHI is comprised by some maintenance buildings, roads, an extensive trail system, agricultural fields, abandoned fields, four small streams, a railroad track and forested areas. Most of the terrain is fairly flat to gently sloping, except the very steep slopes that face the Monongahela River.

Tree of heaven was introduced into the United States from China in 1784 as a garden species and then was used as a pollution tolerant urban tree in Philadelphia. It was available at tree nurseries by 1840. Tree of heaven has smooth light gray bark with thick branches that have pinnately compound leaves up to 3 feet in length with 11-41 leaflets per leaf. Tree of heaven is often found in disturbed habitats, along roadsides, fence rows, abandoned fields, forest edges, forest openings and urban areas. It often grows in dense stands that displace native plants and may grow up to 6 ½ feet in a growing season. Reproduction is by seed and vegetatively via root suckering. Tree of heaven is dioecious, as plants are either male or female. Females may produce as many as 300,000 seeds per year. Seeds are produced in a 180° two-winged samara which may remain on the tree throughout the entire winter. Crushed tree of heaven leaves and stems give off a rancid peanut butter smell. Unlike most invasive plant species which foliate before most native plants, tree of heaven is one of the last plant species to foliate in the Spring. Another oddity of tree of heaven compared to other invasive plants is the length of time the seeds remain viable in the seedbank. Most invasive species produce seeds that stay viable several years up to two or three decades while tree of heaven seeds remain viable for only a year or two.

Although tree of heaven is not the most widely distributed invasive plant species at FRHI, it was selected because it is not only found in the understory but also in mid-story and the overstory. Another reason tree of heaven was selected is that it has the ability to rapidly colonize areas and poses a significant threat when established. An inventory conducted by the Western Pennsylvania Conservancy at FRHI in 2005 revealed that tree of heaven exceeded 20% cover in half of the areas where it was found and in some areas it is a substantial part of the canopy. It was recommended in this inventory report that tree of heaven should be a target of control and that eradication may be possible, with a diligent effort, in some areas.

Figure 1. -- General location map of Friendship Hill and Fort Neccessity.



Fort Necessity National Battlefield (FONE) is a 903 acre National Park Service site located approximately 10 miles southeast of Uniontown, PA, on US Route 40 (Figure 1). The National Park Service acquired most of the land for FONE in 1931. In addition to the main park unit where the actual Fort Necessity is located, FONE has two more smaller units under its jurisdiction. Junonville Glen unit is 26 acres and is located 7 miles west of the main unit on Chestnut Ridge and Braddock's Grave unit which is 24 acres and is located 1 mile west of the main unit. Terrain at FONE varies from fairly flat to moderately sloping. The two most visible sites at FONE are the reconstructed Fort Necessity and the state of the art Visitor Center. The opening battle of the French and Indian War was fought at Fort Necessity. On July 3, 1754, French and Indian troops attacked a fort constructed by the British who were led by George Washington. This battle was the first major event in his military career and was the only time he surrendered to an enemy.

Morrow's honeysuckle is one of the many bush honeysuckles that now inhabit the United States. Other exotic bush honeysuckles include amur (*Lonicera maackii*), Bell's (*L. x bella*), dwarf (*L. xylosteum*), fragrant (*L. fragrantissima*), Standish's (*L. standishii*) and tartarian (*L. tatarica*). Distinguishing individual species of bush honeysuckle can be difficult. Morrow's honeysuckle is native to Japan, Korea and Manchuria and was first introduced into North America in the late 1700's. It has been widely planted as an ornamental, for erosion control and for wildlife cover and food. Leaves are simple, oval to ovate, blue green above and paler pubescent below. Flowers appear in May and June, are white changing to yellow, 1/2 to 3/4 inches in length and are very fragrant. Juicy red berries 1/4 inch in diameter appear in June and July and may hang on for several months. Morrow's honeysuckle is relatively shade-intolerant and most often occurs in forest edges, abandoned fields, roadsides, open upland habitats as well as wet areas such as bogs and lakeshores. It is a multi-stemmed deciduous shrub that grows up to 15 feet tall and is spread rapidly due to birds and mammals dispersing their seeds. Morrow's honeysuckle along with other invasive honeysuckles are often the first shrubs to foliate in the spring and can form a dense understory which can restrict native plant growth and tree seedlings establishment. Although honeysuckle berries are readily eaten by some migratory birds, they don't have the high fat content needed for their long migratory flight.

Morrow's honeysuckle was the invasive plant species selected and targeted at FONE because it is having the largest impact of any invasive plant species. In the inventory conducted by the Western Pennsylvania Conservancy at FONE in 2005, it was present at over 80% of the plots surveyed in modified successional forests and was abundant (>20% cover) in almost half of the plots where it occurred. FONE would like to provide and enhance habitat for the American woodcock (*Scolopax minor*). This popular bird is usually found in fairly open wetlands and wet meadows where they mate, nest and feed on earthworms which are their primary food source. Morrow's honeysuckle is having several negative impacts on this bird. The most obvious is that Morrow's honeysuckle infestations reduce or eliminate these open areas. Two other impacts are that earthworms are found in much lower numbers underneath honeysuckle than natural vegetation and predation of their nests located in honeysuckle is greater than nests in natural vegetation (Love et al. 2006). In order to restore habitat for the bird, mechanical (brush hog) and chemical (broadcast herbicide) measures have already been implemented in a 15 acre abandoned field west of the Fort. These control measures were non-selective as all vegetation, including native plant species, were treated. This invasive species accounted for at least 90% of the cover and stems per acre in this area.

METHODS/ RESULTS FOR THE TREE OF HEAVEN CONTROL PROJECT AT FONE

Using an aerial photograph and a topographic map, 382 acres were delineated where tree of heaven was likely to occur (forest edges, abandoned fields, forest openings and disturbed areas). Transects were then walked through these areas (Figure 2). When tree of heaven was found, a plot was established and marked on a map. Directions to each plot were recorded. The plots varied in size, shape and number of tree of heaven based on its distribution and the geographic features of an area. Each plot was then designated with a number or a letter. For the most part, a plot was numbered if it had a tree of heaven large enough to have a number painted on it. Conversely a plot that had all small trees received a letter. The tree of heaven in each plot was then marked with paint primarily to keep track of them while tallying during the initial survey. The number of seedlings (dbh >1") was recorded for each plot as well as the number of stems in each 2" dbh size class.

During the initial survey to locate tree of heaven, 65 plots were established (plot #'s 1-54 and letters A-K). The plot locations are shown in Figure 3. The total number of tree of heaven tallied was close to 10,000, with well over half of the stems being seedlings. The total obtained during this survey vastly under estimated the actual number of tree of heaven. In order to reduce the amount of herbicide used, a decision was made to mechanically remove (hand pull) as many of the seedlings as possible. In late March and early April, a total of 9193 seedlings were pulled by hand. The number of seedlings pulled for each plot is listed in the first column of Table 1, located in Appendix A. A seedling was not counted as being pulled unless all or the vast majority of its root system was also pulled.

The first round of herbicide work for the tree of heaven control project was conducted during the last week of May and the first day of June. Foliage expansion was 100% on tree of heaven by this time. Garlan 3A® (44% triclopr triethylamine salt) and Razor Pro® (41% glyphosate) were used during this process. A foliar application of Razor Pro was made to all tree of heaven seedlings less than 7 feet tall using a low pressure back pack sprayer and or hand held garden type sprayer. The Razor Pro was in a solution at 7.5% mixed with water at 92.5%. The Garlan 3A was applied undiluted using the "hack and squirt" technique to all tree of heaven in the 2" dbh class and greater and seedlings taller than 7 feet. Shallow, downward cuts were made using a hatchet around the stem of each tree of heaven, spaced to allow approximately ½ inch of intact bark between each cut. Using a one quart spray bottle, each cut was treated with Garlan 3A. The amount of herbicide for the "hack and squirt" operation for each tree used was based on the DBH of the tree. Since the larger trees have a much larger root system, more herbicide is needed to kill them. The application rate of the Garlan 3A for each size class follows in the table below.

Application rate of Garlan 3A by DBH size class

DBH	Garlan 3A	DBH	Garlan 3A
Seedling (>1")	.5ml	12"	18 ml
2"	1 ml	14"	21 ml
4"	4 ml	16"	32 ml
6"	6 ml	18"	35 ml
8"	8 ml	20"	40 ml
10"	15 ml	22"	44 ml

Figure 2. -- Tree of heaven survey areas at Friendship Hill National Historic Site, 2007.

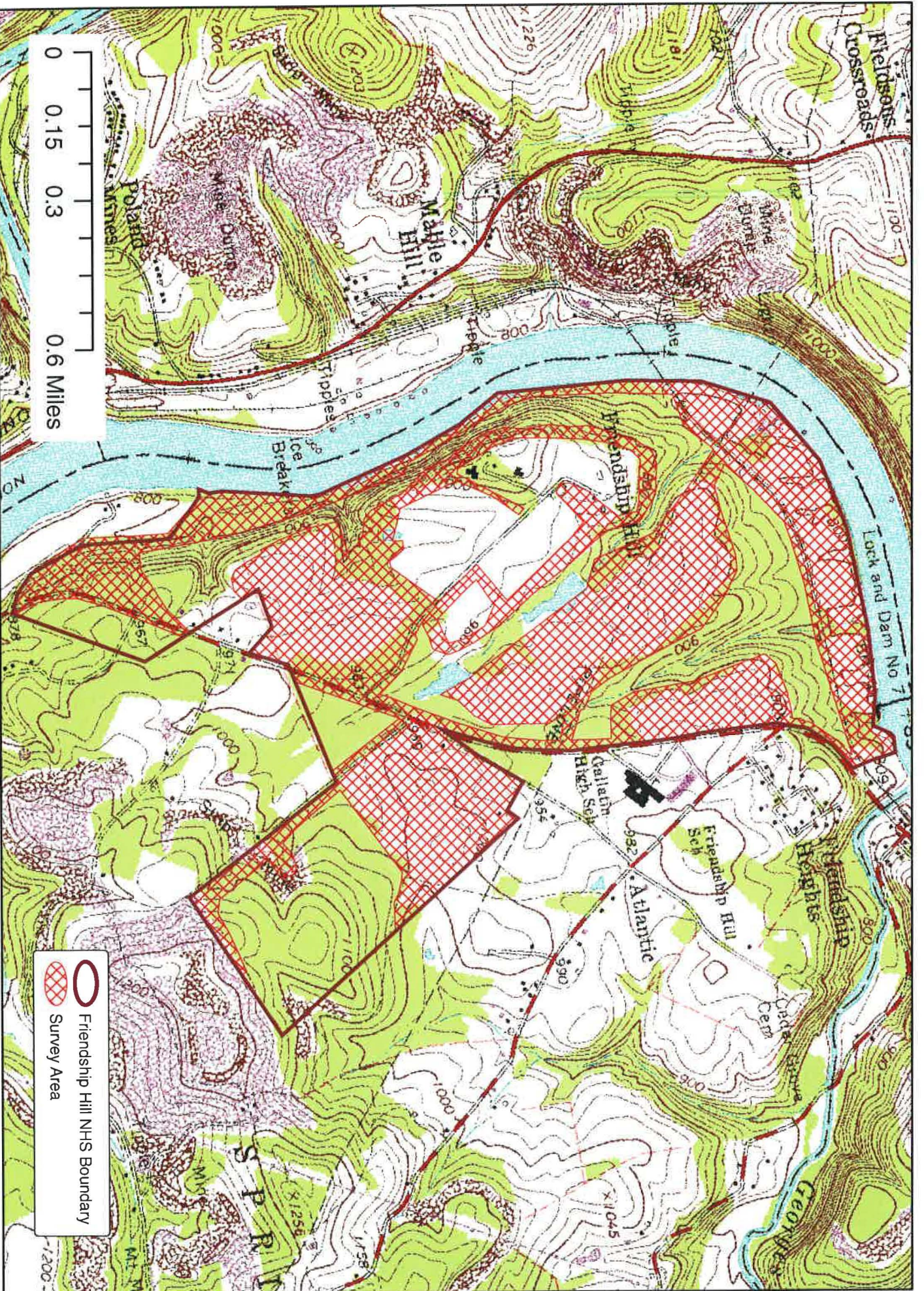


Figure 3. -- Location of the tree of heaven survey plots at Friendship Hill National Historic Site, 2007.



During the initial round of herbicide treatments, 5 additional plots were established (plot #'s 95-99). Four of these plots were relatively small and were either comprised mainly by tree of heaven 2" dbh and less or only a few trees. The only exception was plot # 96 where 237 tree of heaven were detected and treated. This plot is actually located on private property on the industrial site immediately south of FRHI. This area of tree of heaven had already been detected during the initial survey. Since most of the tree of heaven in the plot were located less than 50 feet from the Park Service boundary, it was decided to treat them (with permission from the industrial site) to eliminate a potential seed source. Permission was granted so the plot was established and treatment was conducted.

Herbicide was applied in a total of 70 plots during the initial round of treatments with the number of tree of heaven treated in a plot ranging from 1 to 497. A total of 3392 seedlings were treated with a foliar application of Razor Pro while 2077 stems were treated with Garlan 3A. The table below presents the number of stems by size class for the first round of Garlan 3A hack and squirt application.

Number of stems treated by DBH size class for the Garlan 3A hack and squirt application.

DBH	>1" (seedlings)	2"	4"	6"	8"	10"	12"	14	≥ 16"	All size classes
# of stems treated	546	598	343	184	189	90	42	37	48	2077

Individual plot data for the first round of herbicide application is presented in Table 1 located in Appendix A.

A second round of herbicide application was conducted during July and followed the same procedure as the first application. Tree of heaven that were treated during the first application were not treated during this second round. Only trees that were missed during the first round or had sprouted since the first round were treated. An additional three plots were established (plot #'s 92-94) during this round of herbicide application. These three plots combined totaled only 21 tree of heaven. Treatment was conducted in 61 plots as there were 12 plots where all the tree of heaven had been previously treated. Treatment in individual plots ranged from 0 to 389 and totaled 6515 for this round of herbicide application. A total of 6221 seedlings were treated with a foliar application of Razor Pro while 294 stems were treated with Garlan 3A. The table below presents the number of stems by size class for the second round of Garlan 3A hack and squirt application.

Number of stems treated by DBH size class for the Garlan 3A hack and squirt application

DBH	>1" (seedlings)	2"	4"	6"	8"	10"	12"	14	≥ 16"	All size classes
# of stems treated	132	87	25	27	14	4	2	0	3	294

Individual plot data for the second round of herbicide application is presented in Table 2 located in Appendix A.

A total of 21,177 tree of heaven were treated at FONE for this control project in 2007. Of this total, 9193 were treated mechanically, 9703 were treated with a foliar application of Razor Pro

and 2371 were treated with a hack and squirt application of Garlan 3A. Seedlings comprised 19,484 (92%) of the tree of heaven treated.

In early September, fourteen of the tree of heaven plots were visited to evaluate the efficacy of the Garlan 3A hack and squirt treatment. These plots were selected because they were easily accessible. All the tree of heaven that received a hack and squirt application of Garlan 3A in plot #'s 1, 2, 3, 4, 5, 6, 7, 8, 9, 93, 94, and 95 were evaluated while a portion of the treated trees in plot #15 and #17 were evaluated. Of the 174 trees that were evaluated, 144 (82.8%) were dead. Most of the living trees had crown dieback that ranged from 75-99 percent. The summarized results of this evaluation are presented by size class in the table that follows.

Evaluation of Garlan 3A treated trees by DBH size class

DBH	>1" (seedlings)	2"	4"	6"	8"	10"	12"	14"	≥ 16"	All size classes
# evaluated	47	53	26	19	20	8	1	2	2	174
# dead	46	37	22	18	15	8	1	1	0	144

The 30 tree of heaven that were alive during this evaluation were then herbicided with Garlan 3A with the hack and squirt technique using the previously described protocols.

A total of 310 ounces (2.42 gallons) of Garlan 3A and 320 ounces (2.5 gallons) of Razor Pro were used during this tree of heaven herbicide work. All the herbicide work was done by or under the direct supervision of Public Pesticide Applicators certified by the Pennsylvania Department of Agriculture.

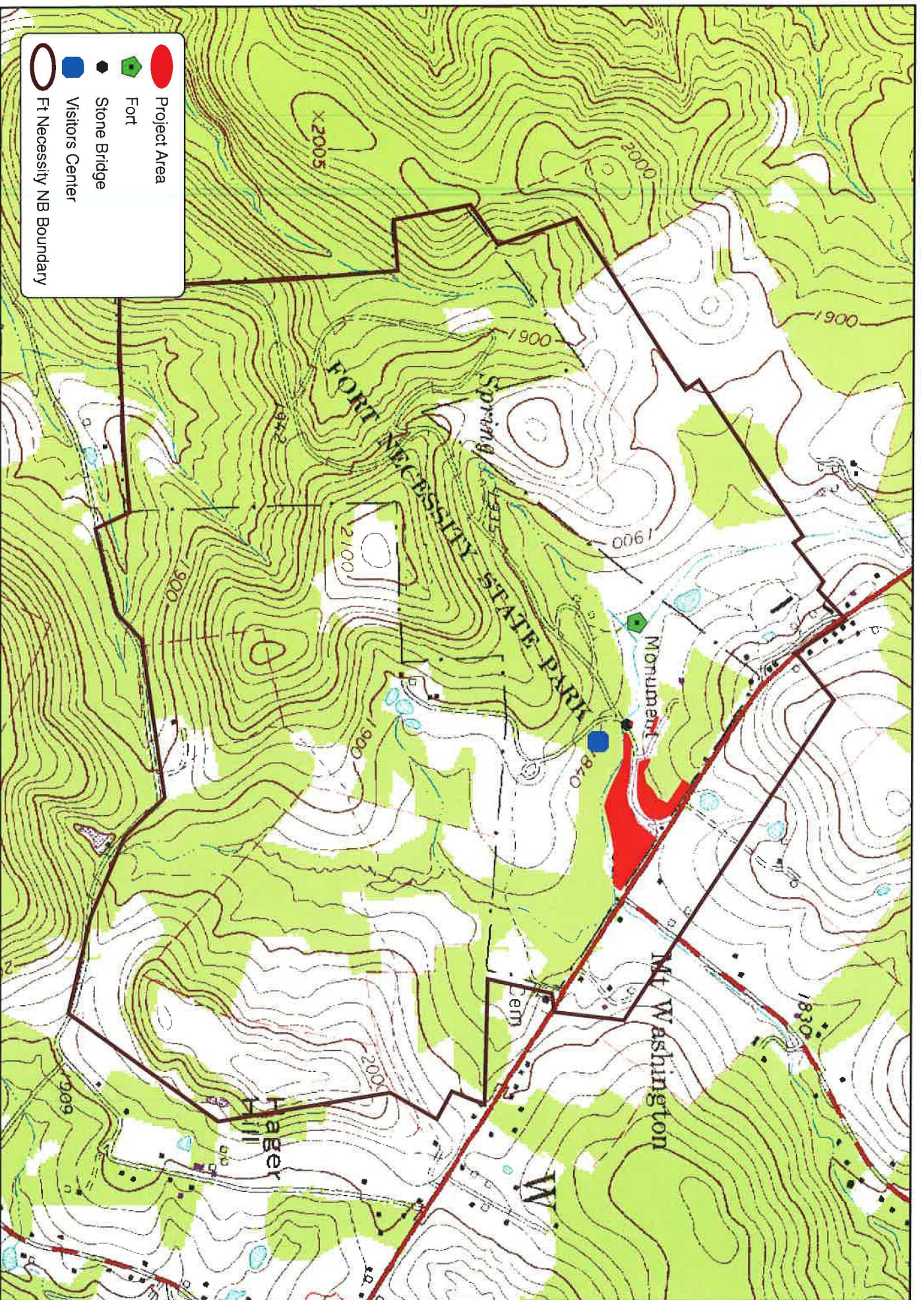
METHODS/ RESULTS FOR THE MORROW'S HONEYSUCKLE CONTROL PROJECT AT FONE

The Natural Resource Manager at FONE identified areas where the removal of Morrow's honeysuckle was a priority (Figure 4). All of these areas were infested with Morrow's honeysuckle and were located between the National Pike (US Route 40) and the Visitor's Center. The two primary areas covered approximately 5.4 acres and were the abandoned fields located on both sides of the main entrance road. The heaviest concentration of Morrow's honeysuckle was located near Great Meadow Run. The honeysuckle control project was also conducted in two smaller areas, encompassing approximately .1 acre, located east of the Fort.

The Morrow's honeysuckle control project was a "cut stump" herbicide operation. The honeysuckle was cut with a chainsaw and then the stump was immediately sprayed with a solution of equal parts Razor Pro, water and vegetable oil using a low pressure garden type sprayer. The height of the tallest stem of each cut honeysuckle was recorded into the nearest one foot size class.

The control project started on the left side (southeast) of the entrance road in early April and was completed in 3.5 days. A total of 1587 honeysuckle bushes were cut and herbicided. The control project then focused on the right side (northwest) of the entrance road with a total of 675 honeysuckle bushes cut and herbicided in 2 days. The cut stump treatments continued in the two secondary areas. One of these areas (Lower Great Meadows) was completed with the cutting and herbiciding of 73 honeysuckle bushes. Time permitted the cutting and herbiciding of only 3 honeysuckle bushes west of the stone bridge over Great Meadow Run. A total of 2338

Figure 4. -- Morrow's honeysuckle control project areas at Fort Necessity National Battlefield, 2007.



Morrow's honeysuckle bushes had been cut and herbicided in 5.5 days in April. Table 3 located in Appendix A presents the Morrow's honeysuckle cut stump treatment data by height class for each of the areas and operation periods and is summarized for all areas for the first operational period in the table below.

Number of Morrow's honeysuckle bushes treated by height class during April 2007

Height class	1'	2'	3'	4'	5'	6'	7'	8'	9'	≤ 10'	All height classes
# of bushes treated	60	146	211	274	285	325	238	285	215	435	2338

Of the 2338 bushes treated, a sub-sample of 159 were examined to determine an average number of stems per bush. The number of stems per bush ranged from 1 to 31 and averaged 5. Three was the most common stem count, occurring 17.7% of the time while 10 or more stems occurred on 7.5% of the bushes.

Approximately 20 Japanese barberry (*Berberis thunbergii*) were also cut and herbicided during this control project. All 20 were located southeast of the entrance road. Also during this time, 50 small honeysuckle seedlings (>2" tall) were hand pulled.

In early September, the control project continued in the two larger areas along the entrance road as Morrow's honeysuckle that were missed during April were cut and treated. A total of 119 honeysuckle bushes were cut and herbicided southeast of the entrance road while 17 were cut and herbicided northwest of the entrance road. The distribution of honeysuckle by height class treated during this operational period is presented in columns 6 and 7 of Table 3.

A total of 2474 Morrow's honeysuckle bushes received a cut stump treatment in the four areas in 2007. With an average of 5 stems per bush, a total of approximately 12,370 stems were treated. The average height of the tallest stem in a bush was approximately 7 feet.

All height classes exceeded 200 bushes except the one foot height class with only 60 and the 2 foot height class with 146. The 10 foot and greater height class had the largest number with 435, which is 18.6 % of the total number of bushes treated.

Also in September, a foliar application of Razor Pro was applied to 1004 small honeysuckle (most less than 2 feet tall). The herbicide mixture consisted of Razor Pro at 7.5% and water at 92.5% and was applied using a garden type sprayer. These small honeysuckles were treated with a foliar application instead of the cut stump treatment for a couple of reasons. The stem diameter of most these small honeysuckle is the size of a pencil or less. These stems are very limber and are fairly difficult and dangerous to cut. Also once the stems are cut, they offer a very small target for a stump treatment. It is difficult to supply a small amount of herbicide on a very small target. It is also much quicker to apply a foliar application of herbicide on these small stems than to use cut stump treatments.

A total of 400 ounces (3.125 gallons) of Razor Pro was used treating Morrow's honeysuckle at FONE in 2007. All of the applications were made by or under the supervision of Public Pesticide Applicators.

DISCUSSION/ PLANS FOR TREE OF HEAVEN CONTROL PROJECT AT FRIENDSHIP HILL NATIONAL HISTORIC SITE

The large amount of tree of heaven at FRHI did not originate over the last couple years and like most invasive species, it can not be controlled in a single year. It is unrealistic to think that it can be completely eradicated from the site given the amount of tree of heaven located within close proximity. A realistic goal at the project is to eradicate this species from the mid-story and overstory at FRHI.

All 73 plots established in 2007 will be re-visited 3 times in 2008. Mechanical removal of seedlings followed by two rounds of herbicide application (both foliar and hack and squirt) will be conducted. The mechanical removal of seedlings significantly reduced the amount of herbicide used on this project and also reduces non-target impacts of herbicide on native vegetation. This extra visit also decreases the number of "missed" seedlings in any year. Pulled seedlings are not counted unless the bulk of the root system is also pulled. This helps prevent double counting seedlings as being pulled and then later as being herbicided. Seedlings that were treated with a foliar application of Razor Pro during the first round of herbicide application and were living during the second application were not treated. One reason for this is that the number of seedlings treated would be inflated because some seedlings would be treated twice. A change in protocol will be made in 2008. Seedlings that are treated during the first application and are still alive during the second application will be treated but will not be counted during the second application.

Another reason that the seedlings weren't re-treated during the second round of herbicide application was that obtaining a mortality rate for the foliar application of Razor Pro would be inaccurate since some seedlings would be treated more than once. Even though seedlings were not re-treated in 2007, it is very difficult to get an accurate mortality rate for several reasons such as the small size of some of the seedlings, large size of some of the plots, rapid degradation of dead seedlings and other competing vegetation. Also some of the seedlings that existed during the second round of herbicide application sprouted after the first round. The mortality rate dilemma is illustrated in this example. If 50 seedlings are sprayed during the first round of herbiciding in a plot and 48 were killed, the mortality rate would be 96%. However, if 6 seedlings were missed during the first round and 32 germinated between rounds of herbiciding there were 40 living seedlings during the second round of herbiciding. Based only on the number of living seedlings (50 vs.40), it appears that the mortality rate was only 20% when it actually was 96%. The tracking of individual seedlings could be done on a limited number of seedlings but a large scale tracking operation would be very tedious and very time consuming.

It is much easier to obtain a mortality rate for the hack and squirt application based on the size of the tree of heaven treated (seedlings 7' and taller and trees in the 2" dbh class and larger) and the visibility of the hatchet hacks on the stems. Based on the approximate 83% mortality rate of the 174 hack and squirt tree of heaven sampled in September of 2007, there should be a lot less trees for the Garlan 3A application in 2008. A mortality rate will be calculated for all 2371 tree of heaven that received the hack and squirt application of Garlan 3A in 2007 during the first round of herbicide treatment in 2008. The 30 tree of heaven that were re-treated with Garlan 3A in September will also be evaluated. The mortality rate from these trees may prove that already stressed trees will succumb readily and quickly with a second application in the same year. The faster the death of the herbicided trees the better because it allows less time to reproduce either by seed (females) or by root suckers (both male and female).

It may take another year or two for the total number of seedlings to decrease drastically in the already established plots. By that time the overstory and mid-story tree of heaven will likely be dead and won't be producing root suckers and most of the seed bank will be depleted.

Detection surveys will be conducted in order to locate other pockets of tree of heaven. In areas that already have been surveyed, these tree of heaven pockets are likely to be small. In new areas, the tree of heaven may be more extensive. One area that was not surveyed in 2007 that will be surveyed this year is area from plot # 54 northeast to the property corner then northwest to plot # 34.

Tree of heaven located on private property in close proximity to Park Service property should also be treated (with consent of the property owner) in 2008. Reducing the seed source in these areas will be beneficial in the efforts to eliminate tree of heaven from FRHI.

Similar to the tree of heaven at FRHI, the Morrow's honeysuckle at FONE will not be controlled in a single year. Due to the large seed bank, control measures will have to be implemented over a long time. A realistic goal of the project is to prevent Morrow's honeysuckle from reaching reproductive maturity in any of the areas where the project has been implemented.

For 2008, small honeysuckle seedlings should be hand pulled or herbicided with a foliar application of Razor Pro on both sides of the entrance road and in the Lower Great Meadows area. The volunteer group that will be working on invasive plants for Project Weed Wack will provide a good work force for the hand pulling. Any larger honeysuckle that was missed in 2007 should receive a cut stump treatment in 2008. The foliar application of Razor Pro should be applied after the honeysuckle foliates in the Spring but before the native plants foliate. This will minimize the impacts of the herbicide on nearby non-target plants.

Work should continue in the Stone Bridge area and other high priority sites that are infested with honeysuckle. Other invasive species such as Japanese barberry, multiflora rose (*Rosa multiflora*) and winged burning bush (*Euonymus alatus*) should also be treated in these areas with either a foliar application of herbicide or a cut stump treatment. The removal of the honeysuckle will increase the amount of sunlight and moisture available for other vegetation, including other invasive species. Without treatment, growth of other invasive species will be stimulated.

The efficacy of the 2007 cut stump treatments will be evaluated in Spring of 2008. On living stumps, the number of sprouts will be quantified and will be treated with a foliar application of Razor Pro.

CONCLUSION

The tree of heaven at Friendship Hill and the Morrow's honeysuckle at Fort Necessity have become established over a large number of years. Control of these two invasive species will also take a number of years. Without control measures, these two invasive species, along with other invasive species, will continue to grow and spread into currently infested areas. Their negative impacts on birds, fauna and native plant species will also increase.

Control of tree of heaven and Morrow's honeysuckle in infested areas can be accomplished over time with diligent and hard work. Control over a large area such as a watershed can only be accomplished through bio-control or through the combined efforts of concerned citizens. In order to increase public knowledge about these invasive species projects both FONE and FRHI should create a display about these projects. Increasing public knowledge and support is critical in the wide-spread control of these invasive species.

REFERENCES

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APPENDIX A

Table 1 – Number of tree of heaven by treatment type and size class for each plot from March to June 1, 2007, at Friendship Hill National Historic Site

Plot #	Seedlings (>1")			DBH								Total
	Pulled	Foliar	H + S	2"	4"	6"	8"	10"	12"	14"	≤ 16"	
1	15	6	4	3	3	4	2	2	1	0	0	40
2	10	1	3	3	1	3	0	0	0	0	0	21
3	69	4	0	1	3	4	5	2	0	0	0	88
4	45	1	3	1	0	1	1	0	0	0	0	52
5	22	2	0	0	1	3	2	0	0	0	0	30
6	0	0	0	0	0	0	0	0	0	1	0	1
7	1	1	0	0	1	0	0	0	0	0	0	3
8	21	2	5	2	0	1	0	1	0	0	0	32
9	0	0	0	0	0	0	1	0	0	0	0	1
10	370	90	6	5	16	24	33	15	3	1	2	565
11	475	133	18	8	6	7	10	7	1	0	4	669
12	8	0	0	0	1	0	3	1	0	0	0	13
13	0	0	2	3	3	0	1	1	0	0	0	10
14	7	5	1	0	0	0	5	0	0	0	0	18
15	409	141	16	32	12	2	7	2	2	1	1	625
16	12	9	13	18	11	3	0	1	0	0	0	67
17	0	0	0	4	2	1	0	0	0	1	1	9
18	5	3	17	14	17	5	2	0	1	0	2	66
19	27	12	23	24	41	18	3	1	0	0	0	149
20	7	0	0	1	0	0	1	0	0	0	0	9
21	56	7	1	0	1	0	2	2	0	0	0	69
22	67	21	23	3	2	2	1	0	0	1	0	120
23	0	0	0	0	2	1	0	0	1	0	0	4
24	581	165	4	6	4	5	3	2	0	0	0	770
25	598	228	53	43	11	8	5	5	4	5	4	964
26	517	124	5	12	3	0	1	0	0	2	2	666
27	1142	277	25	51	30	9	10	13	5	2	10	1574
28	0	4	0	10	1	1	0	0	0	1	1	18
29	301	165	15	12	7	1	0	1	0	0	1	503
30	6	33	0	1	6	2	1	1	0	0	0	50
31	1	1	0	0	1	0	0	0	0	0	0	3
32	0	0	0	0	0	1	3	0	0	0	0	4
33	0	0	0	0	0	0	1	0	0	0	0	1
34	134	62	16	15	7	5	1	1	0	1	0	242
35	152	27	42	39	15	5	6	1	2	2	2	293
36	0	1	0	3	3	0	0	1	0	0	0	8
37	0	0	0	0	0	0	1	0	0	0	0	1
38	11	63	10	4	2	2	0	0	0	0	0	92
39	166	31	5	0	1	0	0	0	0	0	0	203
40	156	96	3	2	4	1	2	0	0	0	0	264
41	0	22	0	2	4	2	1	0	0	0	0	31

Table1 (continued) – Number of tree of heaven by treatment type and size class for each plot from March to June 1, 2007, at Friendship Hill National Historic Site

Plot #	Seedlings (>1")			DBH								Total
	Pulled	Foliar	H + S	2"	4"	6"	8"	10"	12"	14"	≥ 16"	
42	8	15	0	3	1	0	1	0	0	0	0	28
43	146	34	0	2	4	2	1	0	0	0	0	189
44	83	37	0	2	7	3	6	0	0	0	0	138
45	295	105	7	11	12	10	4	4	2	2	1	453
46	0	0	1	0	2	4	4	3	1	1	0	16
47	0	1	0	1	1	0	0	0	0	0	0	3
48	0	0	19	5	2	0	5	6	0	3	1	41
49	0	0	1	2	6	0	0	0	0	0	0	9
50	24	9	0	5	2	2	4	2	0	0	0	48
51	255	207	16	19	4	1	0	0	1	1	3	507
52	13	2	0	0	0	1	0	0	0	0	0	16
53	517	137	6	12	6	4	7	1	3	1	2	696
54	231	229	45	44	45	11	15	6	8	6	5	645
95	0	1	22	12	4	0	1	0	0	0	0	40
96	0	143	16	38	14	8	10	4	0	2	2	237
97	0	1	0	0	0	3	0	0	0	0	0	4
98	0	9	9	18	3	1	1	0	0	0	0	41
99	0	0	3	2	0	0	2	0	0	0	0	7
A	45	45	0	2	0	0	0	0	0	0	0	92
B	28	15	0	1	0	0	0	0	0	0	0	44
C	6	0	0	2	0	0	0	0	0	0	0	8
D	54	1	0	0	0	0	0	0	0	0	0	55
E	1376	443	19	18	4	3	7	2	1	0	0	1873
F	594	58	4	15	1	4	1	2	4	0	1	684
G	4	31	11	14	1	1	0	0	0	1	1	64
H	52	8	1	0	0	0	0	0	0	0	0	61
I	1	0	0	0	0	0	0	0	0	0	0	1
J	0	0	0	1	0	0	0	0	0	0	0	1
K	70	124	53	47	2	5	6	0	2	2	2	313
Total	9193	3392	546	598	343	184	189	90	42	37	48	14662

Note – plot #s 92, 93 and 94 were established after the first round of application herbicide application

Foliar = foliar application of Razor Pro (41% glyphosate) at 7.5% mixed with water at 92.5%

H+S = hack and squirt with Garlan 3A. Application rate based on DBH

Table 2 – Number of tree of heaven by treatment type and size class for the second round of herbicide application at Friendship Hill National Historic Site, July 2007.

Plot #	Seedlings (>1")		DBH								Total
	Foliar	H+S	2"	4"	6"	8"	10"	12"	14"	≤ 16"	
1	14	0	0	0	0	0	0	0	0	0	14
2	12	0	0	0	0	0	0	0	0	0	12
3	21	0	0	0	0	0	0	0	0	0	21
4	9	0	0	0	0	0	0	0	0	0	9
5	1	0	0	0	0	0	0	0	0	0	1
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	1	0	0	0	0	0	0	0	1
8	66	0	0	0	0	0	0	0	0	0	66
9	28	0	0	0	0	0	0	0	0	0	28
10	114	0	3	2	4	1	2	1	0	0	127
11	253	6	0	4	4	1	0	1	0	0	269
12	0	0	0	0	0	0	0	0	0	0	0
13	1	1	0	0	0	0	0	0	0	0	2
14	8	0	1	1	0	0	0	0	0	0	10
15	219	7	0	0	0	0	0	0	0	0	226
16	236	3	1	3	0	0	0	0	0	0	243
17	0	0	0	0	0	0	0	0	0	0	0
18	10	0	0	0	0	0	0	0	0	0	10
19	5	6	4	0	1	3	0	0	0	0	19
20	20	0	0	0	0	0	0	0	0	0	20
21	11	0	0	0	0	0	0	0	0	0	11
22	5	1	1	0	0	1	0	0	0	0	8
23	0	0	0	0	0	0	0	0	0	0	0
24	271	0	0	0	0	1	0	0	0	0	272
25	454	4	2	0	0	0	0	0	0	0	460
26	387	9	2	0	0	0	0	0	0	0	398
27	988	10	14	3	7	3	1	0	0	2	1028
28	5	0	0	0	0	0	0	0	0	0	5
29	79	4	0	0	0	0	0	0	0	0	83
30	95	0	0	0	0	0	0	0	0	0	95
31	0	0	0	0	0	0	0	0	0	0	0
32	21	0	0	0	0	0	0	0	0	0	21
33	5	0	0	0	0	0	0	0	0	0	5
34	103	0	0	0	1	2	0	0	0	0	106
35	61	0	2	0	0	0	0	0	0	0	63
36	1	1	0	0	0	0	0	0	0	0	2
37	6	0	0	0	0	0	0	0	0	0	6
38	33	0	1	1	0	0	0	0	0	0	35
39	58	0	2	0	0	0	0	0	0	0	60
40	28	0	2	0	0	0	0	0	0	0	30
41	0	0	0	0	0	0	0	0	0	0	0

Table 2 (continued) Number of tree of heaven by treatment type and size class for the second round of herbicide application at Friendship Hill National Historic Site, July 2007.

Plot #	Seedlings (>1")		DBH								Total
	Foliar	H+S	2"	4"	6"	8"	10"	12"	14"	≤ 16"	
42	22	0	0	0	0	0	0	0	0	0	22
43	6	0	0	0	0	0	0	0	0	0	6
44	228	3	2	0	0	0	1	0	0	0	234
45	141	0	0	1	2	1	0	0	0	0	145
46	14	0	0	0	0	0	0	0	0	0	14
47	0	0	0	0	0	0	0	0	0	0	0
48	75	0	0	1	1	0	0	0	0	0	77
49	0	0	0	0	0	0	0	0	0	0	0
50	62	0	0	0	0	0	0	0	0	0	62
51	157	0	2	0	0	0	0	0	0	0	159
52	44	0	0	0	0	0	0	0	0	0	44
53	199	16	9	0	2	0	0	0	0	0	226
54	229	23	23	4	4	0	0	0	0	0	283
92	0	0	0	1	0	0	0	0	0	0	1
93	4	3	2	4	0	0	0	0	0	1	14
94	0	5	0	0	0	1	0	0	0	0	6
95	11	2	0	0	0	0	0	0	0	0	13
96	251	0	0	0	0	0	0	0	0	0	251
97	18	0	0	0	0	0	0	0	0	0	18
98	9	4	2	0	1	0	0	0	0	0	16
99	0	0	0	0	0	0	0	0	0	0	0
A	8	0	0	0	0	0	0	0	0	0	8
B	3	0	0	0	0	0	0	0	0	0	3
C	3	0	0	0	0	0	0	0	0	0	3
D	21	0	0	0	0	0	0	0	0	0	21
E	370	4	0	0	0	0	0	0	0	0	374
F	145	0	0	0	0	0	0	0	0	0	145
G	389	0	0	0	0	0	0	0	0	0	389
H	0	0	0	0	0	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0	0	0	0	0
K	184	20	11	0	0	0	0	0	0	0	215
Total	6221	132	87	25	27	14	4	2	0	3	6515

Foliar = foliar application of Razor Pro (41% glyphosate) at 7.5% mixed with water at 92.5%.
H + S = hack and squirt with Garlan 3A. Application rate based on DBH.

Table 3 – Number of cut stump treated Morrow's honeysuckle bushes by height class for each area and operational period.

Height class	Area and operational period						
	Southeast Entrance Road 4/07	Northwest Entrance Road 4/07	Lower Great Meadows 4/07	Stone Bridge 4/07	Southeast Entrance Road 9/07	Northeast Entrance Road 9/07	All areas 4/07 and 9/07
1'	57	3	0	0	0	0	60
2'	92	35	7	0	10	2	146
3'	129	48	7	0	21	6	211
4'	177	66	10	0	18	3	274
5'	184	65	13	0	21	2	285
6'	212	78	17	0	16	2	325
7'	168	60	1	0	8	1	238
8'	195	77	5	0	7	1	285
9'	146	61	0	1	7	0	215
≤ 10'	227	182	13	2	11	0	435
All height classes	1587	675	73	3	119	17	2474

APPENDIX B



A portion of plot #26 prior to treatment. The tree of heaven is marked with orange and yellow paint.



A pile of pulled tree of heaven seedlings.



Foliage on a tree of heaven 3 days after treatment with Garlon 3A.



Foliage on a tree of heaven 7 days after treatment with Garlon 3A.



Foliage on tree of heaven 21 days after treatment with Garlon 3A.

Aerial view of plot #s 10, 11 and 12 twenty-one days after treatment with Garlon 3A
The declining trees are treated tree of heaven. The scattered trees with the yellow crowns (most are located in the middle of the photo) are treated trees.



Two large tree of heaven 6 weeks after treatment with Garlon 3A (cover photo).



Two tree of heaven 9 months after treatment with Garlon 3A. The boles of these trees have already snapped off.





Several dead tree of heaven 9 months after treatment with Garlon 3A. The bark has already sloughed off most of their boles.

A large multi-stemmed Morrow's honeysuckle being cut in the "cut stump" treatment (cover photo).





The stumps of two multi-stemmed Morrow's honeysuckle bushes.



The remains of a Morrow's honeysuckle infested area. All honeysuckles in the photo have been cut and the stumps have been treated.