

Invasive Plant Species and Habitat Management Plan for Saratoga National Historical Park

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Executive Summary

This management plan:

- 1) describes the process to prioritize habitat management zones and invasive species treatments in Saratoga National Historical Park,
- 2) determines park-specific priorities for invasive species management, and
- 3) provides detailed recommendations for the implementation of invasive species management in the park.

Invasive Plant Species and Habitat Management Plan for Saratoga National Historical Park

Invasive species significantly impact the natural and cultural resources of Saratoga National Historical Park. These harmful invasive species reduce native biodiversity, alter forest structure, suppress tree regeneration, degrade wildlife habitat, and pose significant threats to the long-term condition of parks' natural and cultural resources. A recent analysis by NPS scientists of 12 years' worth of data collected from over 1,400 forest plots in 39 eastern national parks indicate that invasive plants are a large and, literally, growing problem for many national parks (Miller et al. 2021).

Recent forest health monitoring (2007-2018, Miller et al. 2021) in SARA showed relatively high invasive abundance throughout the years and invasive shrubs continue to increase by 2.2% cover over each 4-year cycle. The most frequent observations in SARA were shrubs, such as multiflora rose (*Rosa multiflora*), bush honeysuckle (*Lonicera* spp.), and common buckthorn (*Rhamnus cathartica*). In 2022, Japanese stiltgrass (*Microstegium vimineum*) was also detected for the first time in the park. Considerable effort has been made by the park to suppress herbaceous plants such as knapweed (*Centaurea* spp.) within the fields of the park. However, effective management of these species is challenging, as invasive plants are inherently difficult to control once established.

This plan recommends a three-pronged approach to managing invasive species in SARA:

1. early detection and rapid response;
2. release of approved biological controls;
3. strategically treating invasive species to protect the park's special places.

Early Detection and Rapid Response

The most cost-effective and ecologically viable method to control invasive species is to stop invasive species from becoming established and widespread in a park. The Northeast Temperate Inventory and Monitoring Network (NETN) maintains a target list of invasive species for early detection and rapid response. The list for SARA has been adapted and updated for this project from the EDRR list by Wheeler and Miller 2014 (Table 1). These species may be present at very low levels or are not yet established in the park and are likely to invade given their regional distribution. The park's resource management staff treats invasives and keeps track of any early detection species observed during their work. Natural resource staff at SARA are currently responding to the discovery of some of these early detection species in the park including common reed (*Phragmites australis*) and Japanese knotweed (*Fallopia japonica*; Figure 1-3 – Early Detection Zones). There are also plans to begin treating the Japanese stiltgrass (*Microstegium vimineum*) that was found in 2022 by the NETN forest monitoring team. Prescription treatments for these species are included in Appendix A.

For more information about species detection or an updated target list, contact Kate Miller, NETN Quantitative Ecologist (Kathryn_Miller@nps.gov).

We encourage park staff to refer to this table and to update it as needed based on updated early detection species for New York. It is important to revisit the areas that have been treated to determine whether the species are still under control and to document any emerging species occurring throughout the park. Maintaining updated spatial data (through ArcGIS, iNaturalist or EDDMaps) on invasive presence will be beneficial for updating this plan in the future.

Table 1. Working target early detection and rapid response (EDRR) species list for Saratoga National Historical Park.

Pest Type	Scientific Name	Common Name
Herb	<i>Fallopia</i> spp.	knotweeds
Herb	<i>Heracleum mantegazzianum</i>	giant hogweed
Herb	<i>Lepidium latifolium</i>	pepperweed
Herb	<i>Microstegium vimineum</i>	Japanese stiltgrass
Herb	<i>Miscanthus sinense</i>	Chinese silver grass
Herb	<i>Oplismenus hirtellus</i> ssp. <i>undulatifolius</i>	wavyleaf basketgrass
Herb	<i>Phragmites australis</i>	common reed
Herb	<i>Ranunculus ficaria</i>	fig buttercup
Shrub	<i>Alnus glutinosa</i>	European black alder
Shrub	<i>Euonymus alatus</i>	burningbush
Shrub	<i>Frangula alnus</i>	glossy buckthorn
Shrub	<i>Rhodotypos scandens</i>	black jetbead
Shrub	<i>Spiraea japonica</i>	Japanese spiraea
Shrub	<i>Rubus phoenicolasius</i>	wine raspberry
Tree	<i>Ailanthus altissima</i>	Tree of heaven
Vine – Non-woody	<i>Dioscorea oppositifolia</i>	Chinese yam
Vine – Non-woody	<i>Persicaria perfoliata</i>	mile-a-minute weed
Vine – Non-woody	<i>Vincetoxicum nigrum/Vincetoxicum rossicum</i>	swallowworts
Vine – Non-woody	<i>Ampelopsis brevipedunculata</i>	porcelainberry
Vine - Woody	<i>Lonicera japonica</i>	Japanese honeysuckle
Pests	<i>Adelges tsugae</i>	hemlock woolly adelgid
Pests	<i>Amyntas agrestis</i>	crazy snakeworm
Pests	<i>Anoplophora glabripennis</i>	Asian longhorned beetle
Pests	<i>Dendroctonus frontalis</i>	southern pine beetle
Pests	<i>Lycorma delicatula</i>	spotted lanternfly
Pests	<i>Sirex noctilio</i>	sirex woodwasp
Pests (fungal)	<i>Bretziella fagacearum</i>	oak wilt

Biological Controls

For invasive plants that are widespread, biological controls (also known as biocontrols) are often the only realistic management options for species that are highly invasive and well-established. Biocontrols are host-specific insects or pathogens that feed only on a particular invasive plant species. The biocontrols weaken the target invasive plant, limiting its spread and its ability to displace nearby native plants. The use of biocontrols is strictly regulated and guided by federal and state laws, an International Code of Best Practices, and specific protocols that are all designed to ensure the safety and effectiveness of biocontrol programs.

The biological control of purple loosestrife (*Lythrum salicaria*) illustrates how biocontrols can successfully reduce the abundance of highly invasive species to a tolerable level at which they coexist with native plant communities and may be beneficial for the control of loosestrife populations at SARA. From the mid-1990s until the mid-2010s, the Massachusetts Division of Ecological

Restoration (DER), Massachusetts Audubon, and partner organizations in the Sudbury-Assabet-Concord Cooperative Invasive Species Management Area released two loosestrife beetles. Similar efforts have occurred in Connecticut and the state of Connecticut currently has approved the release of four insects as biological controls for the species: *Hylobius transversovittatus*, *Galerucella californiensis*, *Galerucella pusilla*, and *Nanophyes marmoratus*. There are established populations of the *Galerucella* beetles across the state of New York and sites where releases have occurred are shown to have higher herbivory levels on Loosestrife. For the most effective control, the Lower Hudson Partnership for Regional Invasive Species Management (PRISM) recommends releasing the beetles at infestation sites. Beetles can be purchased, collected from existing sites, or reared on pots in a lab.

Additionally, there are other promising biocontrols for several species of concern in the Northeast region, which occur or could become more established in SARA. The Pennsylvania Department of Conservation and Natural Resources (PA DCNR) has released weevils, *Cyphocleonus achates* and *Larinus obtusus*, to combat knapweed species. The weevil, *Rhinoncomimus latipes*, feeds specifically on mile-a-minute (*Persicaria perfoliata*), an EDRR species at SARA and is being used to help control populations throughout Connecticut. An insect that is currently being reared at Philip Alampi Beneficial Insect Rearing Laboratory in New Jersey is the moth *Hyponomeuta opulenta*, that feeds on leaves, flowers, and seed pods of swallowwort, *Vincetoxicum nigrum*, another EDRR species at SARA. Lastly, *Laricobius nigrinus* beetles, a predator to Hemlock Woolly Adelgid, are being reared at Cornell University in partnership with the New York State Hemlock Initiative. The initiative has released these beetles to combat Hemlock Woolly Adelgid at 21 sites across New York since 2008.

Invasive Management through Prescribed Fire

Prescribed fire has been used in SARA as a landscape management tool and to maintain open grasslands. To maintain these grasslands, the objectives are to reduce woody vegetation and to reduce invasive species. When the timing of the burns occurs before knapweed (*Centaurea* spp.) plants go to seed, prescribed fire may also help encourage growth of native species and reduce abundance of knapweed (Gibbons 2022). However, woody species have also increased in abundance for several of the fields managed with fire (Gibbons 2022). Prescribed fire therefore may be an effective way to reduce knapweed in grasslands but may also require traditional invasive plant removal methods (i.e., chemical, and mechanical removal) where invasive shrubs are expanding.

Strategically Manage SARA's Special Places

Managing invasive plant species can seem like an endless and insurmountable challenge, so focusing limited time and resources where they can be most effective is key to successfully tackling the invasives problem. By strategically focusing treatments on their special places, parks can efficiently treat invasive plants in areas that are most important to preserve.

This management plan provides that strategic focus by identifying the places and invasive species within SARA that are highest priority for invasive species treatment. This plan was created using the Invasive Plant Species and Habitat Management Planning Process developed by Art Gover at Penn State's Wildland Weed Management Unit (Gover, 2016). This planning process is based on several important principles:

- Parks have finite resources that can only be directed to a small portion of potential natural resource needs.

- We can use park-specific data to make informed strategic decisions with limited resources. Strategic management is effective by protecting natural resources without wasted effort.
- Protecting the best sites within a park maximizes the benefit to park natural resources per person-hour expended on invasive species management.

While there has been considerable effort at SARA to manage invasive plant species over the last two decades, not all areas of the park have received the same level of attention and inaction in some areas can have negative impacts. This process considered all areas of the park, including levels of infestation and importance of the resource to the park, to prioritize the most important areas and species for management.

The Invasive Plant Species and Habitat Management Planning Process involves three steps: 1) defining habitat management zones, 2) prioritization, and 3) prescription.

Define Habitat Management Zones

To determine which areas of the park are highest priority, we assembled a team knowledgeable about SARA's invasive species. This team included the park's biological science technician, superintendent, the regional Invasive Plant Management Team (IPMT) Lead, two vegetation monitoring specialists from NETN and an invasive species specialist from the Schoodic Institute. This team met virtually to delineate Habitat Management Zones (HMZ) within SARA (Figure 1-3). Habitat Management Zones are discrete areas of the park that are ecologically or culturally valuable and where invasive species management is operationally feasible.

The Habitat Management Zones were delineated based on four criteria:

- 1) Areas containing high priority invasive species, including shrub honeysuckle (*Lonicera* spp.), multiflora rose (*Rosa multiflora*), knapweed (*Centaurea* spp.) and many others;
- 2) Ecologically and/or culturally significant areas;
- 3) Wetlands and riparian areas;
- 4) Use existing management boundaries where possible to align with other management efforts.

Through this process, we identified 59 habitat management zones, ranging in size from 0.22 to 98.9 acres. These were then pared down into zones that would be run through the tool (36 zones) and lower priority zones (23 zones) that will be treated later (Figures 1-3, Priority 3). Stewardship Index based on the ecological value of the zone's resources, and an Outreach Index that captured the value of the zone to the park's interpretation and outreach goals were assigned to each HMZ (for further details see Gover 2016).

Prioritization

After defining the Habitat Management Zones (HMZs), we then used a prioritization tool (Gover 2016) housed in a Microsoft Excel workbook to prioritize which Habitat Management Zones and which invasive species should be managed to maximize the benefit to park natural resources. First, data on invasive species were collected from:

- Invasive species locations identified by SARA Resource Management staff (2009 – 2023)
- Publicly available data from iNaturalist and EDDMaps (2011 – 2022)
- Invasive species data from Fire Effects Monitoring (2013 – 2022)



Figure 1. Habitat Management Zones in the northern section of the Battlefield unit for the treatment of invasive plants at Saratoga National Historical Park. Priority 1 indicates species that were run through the Invasive Species Management Planning tool (Gover 2016) and prescribed treatment.

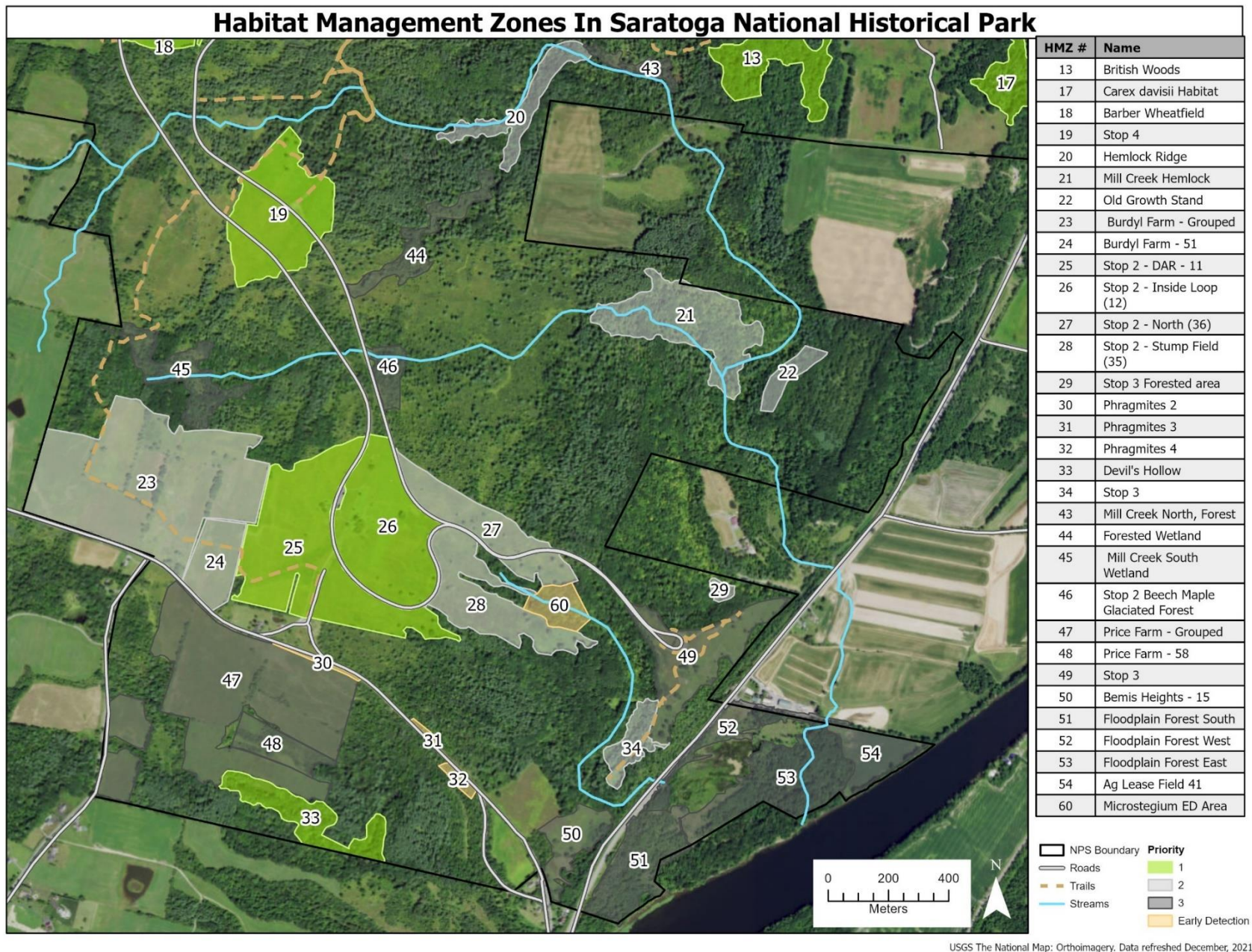


Figure 2. Habitat Management Zones in the southern section of the Battlefield unit for the treatment of invasive plants at Saratoga National Historical Park. Priority 1 indicates species that were run through the Invasive Species Management Planning tool (Gover 2016) and prescribed treatments.

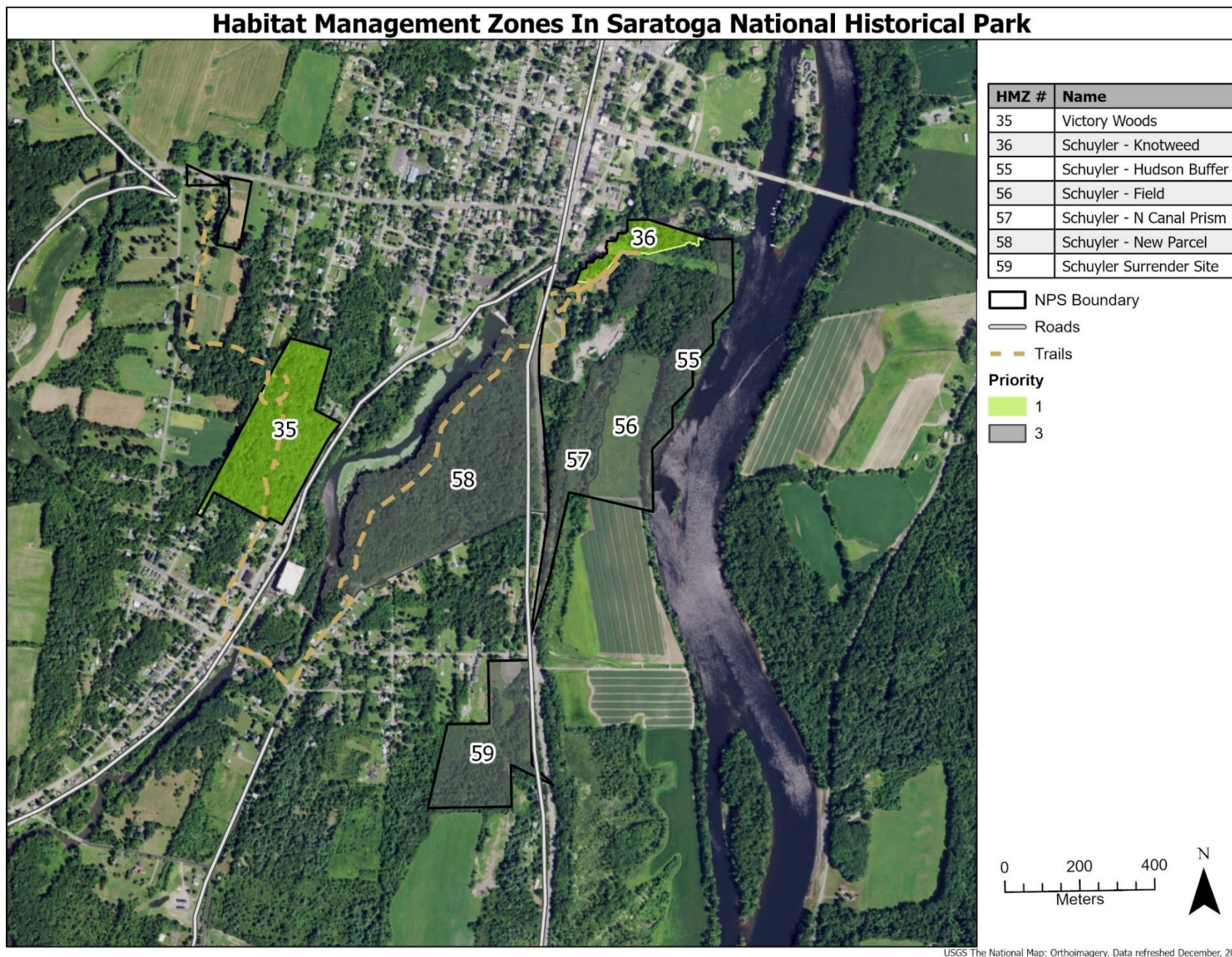


Figure 3. Habitat Management Zones in Victory Woods and Schuylerville Estate units for the treatment of invasive plants at Saratoga National Historical Park. Priority 1 indicates species that were run through the Invasive Species Management Planning tool (Gover 2016) and prescribed treatments

- Treatment and Survey data collected by NE IPMT (2016 – 2022)
- NETN forest monitoring plot data (2018 – 2022)

The list of all the invasive or non-native plant species occurring in SARA can be found in Appendix A, Table 1. From those data, we identified the invasive species known to occur in or within 10 m of the habitat management zones, then categorized the species into three groups:

1. Weedy non-native species that can act invasively (e.g., ground-ivy (*Glechoma hederacea*)) but do not cause as much ecological harm, relative to other invasive species which are known to be problematic in the park. These species were excluded from the prioritization tool.
2. “Most harmful” invasive species cause significantly greater negative impact to park resources (e.g., shrub honeysuckle (*Lonicera* spp.), multiflora rose (*Rosa multiflora*), and others). These species were given higher priority by the tool (Appendix A, Table 2).
3. The remaining invasive species known to occur in the Habitat Management Zones were included in the prioritization tool as “regular” invasive species (see Gover 2016 for more details) but were weighted lower than the “most harmful” species (Appendix A, Table 2).

Because some of the HMZs are not frequented by visitors or staff; invasive species data in these locations may be lacking. For these areas, we used generalized groups (invasive shrub, perennial, tree, etc.) of the most harmful and regular species into groupings with similar treatment prescriptions. For instance, most shrubs share similar treatment prescriptions and tend to co-occur; therefore, all shrubs with the same treatment prescriptions were grouped under “invasive shrubs”. That way, if these HMZs are surveyed and any invasive shrub, vine, tree, or herb is found, treatment prescriptions are available.

Next, we quantified the level of infestation of each invasive plant species per zone, the potential impacts of those invasive species on the habitats, the difficulty of managing those invasives, and the restoration effort required in each habitat. The prioritization tool ranks and weights all these inputs and creates a prioritization matrix (Table 2) that provides strategic direction for managers to protect the best sites within the park. Of the 36 habitat management zones run through the tool, 15 zones were identified as being operationally manageable in a 5-year time and of highest priority to manage. Species identified within these zones as high priority for management are highlighted in red, orange, and yellow in Table 2, and treatment prescriptions for these zones and species are included in Appendix B.

The remaining 21 zones were lower priority (Figure 1-3, Priority 2) and were not included in the prescription phase of the planning tool. However, the species found in these lower priority habitat zones are also present in at least one of the higher priority habitat zones, and their prescriptions can be easily applied to lower priority zones.

Table 2. Priority habitat management zones (darker green indicates higher priority) and priority invasive species (high number indicates higher priority) for Saratoga National Historical Park. See Appendix A Table 2 for list of species included in groups at end of table.

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Prescription

Last, we described how strategic invasive species management will be implemented in the park. The prescription specifies: **who** will be doing the work, **how** the invasives will be managed, and **when** the management should be conducted for only the habitat management zones that were identified as the two highest priorities (i.e., the 20 zones labeled Priority 1 in Figure 1) and for only those invasive species that were identified as priorities in Table 2. Habitat Management Zones should be treated in order by priority (i.e., treat all HMZ in Priority 1 before treating HMZ in Priority 2).

Other invasive species not specified by this plan may be treated while crews are in the Habitat Management Zones targeting priority species. Thus, species with lower ranks (e.g., 4, 5, 6) in Table 2 can also be treated when operationally efficient. For example, all invasive shrubs should be treated at the same time within a priority zone, even if the various shrub species received different priority rankings.

Appendix B contains the invasive species management prescriptions for the high priority zones and species. There are many opportunities for volunteers and park partners to play an important role in invasive species management in SARA. Also, many invasive management prescriptions require a Certified Applicator, someone who has completed the required trainings to use herbicides. Certified Applicators can be park staff, NPS Invasive Plant Team members, contractors or volunteers who have undergone training and licensing.

Restoration

Planting native plants in areas where invasive species have been removed will help restore habitats dominated by native species. The Local Information sections for each Vegetation Association detected during the SARA vegetation inventory are a useful reference for native species that are common components of a given habitat and that are likely to do well in that environment if introduced (see Appendix F in Edinger et al. 2014). A site visit may also be needed to determine species composition and for seed collection for potential revegetation efforts.

Strategic Management Protects Park Resources

Invasive species management is crucial to protecting Saratoga National Historical Park's important natural and cultural resources. Inaction will result in continued declines in the park's forests and other habitats, overall biodiversity, and the integrity of key cultural landscape features. The strategic prescriptions presented in this report direct scarce resources to the areas of the park where invasive species management will most benefit the park's cultural and natural resources.

This plan can be updated every 4 – 5 years, to determine progress on containing priority species in habitat management zones and re-evaluate park priorities considering staffing and funding levels. The latest monitoring data and new observations from the Invasive Species Early Detection / Rapid Response Program can also be incorporated into the updated plan. However, the Microsoft Excel workbook prioritization tool can be updated at any time (e.g., new invasive species found, land parcel newly acquired by the park, etc.), to evaluate evolving management priorities.

Literature Cited

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APPENDIX A Invasive Species Tables

Table 1. Non-native species documented at Saratoga National Historical Park through the 2022 IPM planning process. This list is not inclusive of all the non-native species at SARA.

Scientific Name	Common Name	Scientific Name	Common Name
<i>Acer platanoides</i>	Norway maple	<i>Lotus corniculatus</i>	bird's-foot trefoil
<i>Achillea millifolium</i>	yarrow	<i>Lysimachia nummularia</i>	creeping Jenny
<i>Agrostis capillaris</i>	browntop	<i>Lythrum salicaria</i>	purple loosestrife
<i>Agrostis gigantea</i>	redtop	<i>Malus</i> spp.	apple
<i>Ailanthus altissima</i>	tree-of-heaven	<i>Melilotus officinalis</i>	Yellow Sweetclover
<i>Alliaria petiolata</i>	garlic mustard	<i>Microstegium vimineum</i>	Japanese stiltgrass
<i>Anthoxanthum odoratum</i>	sweet vernal grass	<i>Morus alba</i>	white mulberry
<i>Barbarea vulgaris</i>	wintercress	<i>Penstemon digitalis</i>	foxglove beardtongue
<i>Berberis thunbergii</i>	Japanese barberry	<i>Persicaria longiseta</i>	low smartweed
<i>Bromus inermis</i>	smooth brome	<i>Persicaria maculosa</i>	lady's thumb
<i>Campanula trachelium</i>	nettle-leaved bellflower	<i>Phalaris arundinacea</i>	reed canary grass
<i>Cardamine impatiens</i>	narrowleaf bittercress	<i>Phleum pratense</i>	Timothy grass
<i>Celastrus orbiculatus</i>	oriental bittersweet	<i>Phragmites australis</i>	common reed
<i>Centaurea stoebe/Centaurea jacea</i>	knapweeds	<i>Pilosella aurantiaca</i>	orange hawkweed
<i>Cerastium fontanum</i>	mouse-ear chickweed	<i>Pilosella caespitosa</i>	meadow hawkweed
<i>Cirsium arvense</i>	Canada thistle	<i>Pinus nigra</i>	black pine
<i>Cirsium vulgare</i>	bull thistle	<i>Poa compressa</i>	Canada bluegrass
<i>Clinopodium vulgare</i>	wild basil	<i>Poa pratensis</i>	Kentucky bluegrass
<i>Convolvulus arvensis</i>	field bindweed	<i>Poa trivialis</i>	rough bluegrass
<i>Coreopsis tinctoria</i>	plains coreopsis	<i>Potentilla indica</i>	mock strawberry
<i>Dactylis glomerata</i>	orchard grass	<i>Potentilla recta</i>	sulphur cinquefoil
<i>Daucus carota</i>	Queen Anne's lace	<i>Prunella vulgaris</i>	self-heal
<i>Desmodium</i> spp.	tick trefoil	<i>Ranunculus acris</i>	meadow buttercup
<i>Dianthus armeria</i>	Deptford pink	<i>Rhamnus cathartica</i>	common buckthorn
<i>Echinacea purpurea</i>	purple coneflower	<i>Robinia pseudoacacia</i>	black locust
<i>Elaeagnus umbellata</i>	autumn olive	<i>Rosa multiflora</i>	multiflora rose
<i>Elymus repens</i>	couch grass	<i>Rudbeckia hirta</i>	black-eyed Susan
<i>Epipactis helleborine</i>	broad-leaved helleborine	<i>Rumex acetosella</i>	common sheep sorrel
<i>Euonymus</i> spp.	Euonymus	<i>Rumex crispus</i>	curly dock
<i>Fallopia japonica</i>	Japanese knotweed	<i>Schedonorus pratensis</i>	meadow rye grass
<i>Galium</i> spp.	bedstraw	<i>Securigaria varia</i>	crownvetch
<i>Geranium sanguineum</i>	Bloody Crane's-bill	<i>Silene latifolia</i>	white campion
<i>Glechoma hederacea</i>	ground-ivy	<i>Solanum dulcamara</i>	bittersweet nightshade
<i>Hemerocallis fulva</i>	orange daylily	<i>Sonchus oleraceus</i>	Common Sow-thistle
<i>Humulus lupulus</i>	common hops	<i>Stellaria graminea</i>	lesser stitchwort
<i>Hypericum perforatum</i>	common St. Johnswort	<i>Stellaria media</i>	chickweed
<i>Inula helenium</i>	elecampane	<i>Taraxacum officinale</i>	dandelion
<i>Iris pseudacorus</i>	yellow iris	<i>Taxus baccata</i>	common yew
<i>Leucanthemum vulgare</i>	oxeye daisy	<i>Tragopogon pratensis</i>	meadow salsify
<i>Ligustrum</i> spp.	privet	<i>Trifolium</i> spp.	clover species
<i>Linaria vulgaris</i>	common toadflax	<i>Tussilago farfara</i>	coltsfoot
<i>Lolium pratense</i>	tall fescue	<i>Urtica dioica</i>	stinging nettle
<i>Lonicera japonica</i>	Japanese honeysuckle	<i>Valeriana officinalis</i>	valerian
<i>Lonicera</i> spp.	shrub honeysuckle	<i>Verbascum thapsus</i>	common mullein
		<i>Veronica officinalis</i>	common speedwell
		<i>Viburnum lantana</i>	wayfaring tree
		<i>Vicia</i> spp.	vetch
		<i>Vinca minor</i>	lesser periwinkle

Table 2. Priority invasive species present at Saratoga National Historical Park

Species Guild	Scientific Name	Common Name
Tree	<i>Acer platanoides</i> <i>Ailanthus altissima</i> <i>Robinia pseudoacacia</i>	Norway maple tree-of-heaven black locust
Shrubs	<i>Berberis thunbergii</i> <i>Celastrus orbiculatus</i> <i>Elaeagnus umbellata</i> <i>Euonymus</i> spp. <i>Ligustrum</i> spp. <i>Lonicera japonica</i> <i>Lonicera</i> spp. <i>Rhamnus cathartica</i> <i>Rosa multiflora</i> <i>Viburnum lantana</i>	Japanese barberry oriental bittersweet autumn olive burningbush privet Japanese honeysuckle shrub honeysuckle common buckthorn multiflora rose wayfaring tree
Herbs	<i>Alliaria petiolata</i> <i>Cardamine impatiens</i> <i>Centaurea stoebe</i> / <i>Centaurea jacea</i> <i>Cirsium arvense</i> <i>Cirsium vulgare</i> <i>Fallopia japonica</i> <i>Iris pseudacorus</i> <i>Lythrum salicaria</i> <i>Microstegium vimineum</i> <i>Persicaria longiseta</i> <i>Phalaris arundinacea</i> <i>Phragmites australis</i>	garlic mustard narrowleaf bittercress knapweeds Canada thistle bull thistle knotweed yellow iris purple loosestrife Japanese stiltgrass low smartweed reed canarygrass common reed

APPENDIX B Invasive Species Treatment Prescriptions by Habitat Management Zones

Saratoga National Historic Park Invasive Priority Tool 2023 Notes:

General:

- I wrote these prescriptions as if to a small park with limited staff and invasive plant management experience, and not specifically to those who helped develop this plan. More experienced managers and contactors can modify the treatments to fit their operations.
- I labeled any staff or contractors with pesticide licenses as “Certified Applicators” rather than “Staff” or “Registered Technicians”. Any non-licensed staff can be lumped in with “Volunteers”.
- I didn’t include scenarios where volunteers or non-certified staff apply herbicides. If they are trusted and supervised by an applicator, then you can treat them as “Certified Applicators” as long as applicable state regulations are followed.
- I went heavy on manual and mechanical treatments for SARA and tried to include a couple non-chemical volunteer options for each species. Usually this was helping cut or hand-pulling species. Often the “cutting” option could be expanded to include mechanical treatments such as mowing, brush-hogging, or mastication.
- The treatment calendar generated is the tool’s suggested ideal time frame. Many of the treatments can be expanded beyond the given range. For example, all shrub species dictate foliar spraying starting mid-June, when many of these species are at full leaf-out a month earlier. I left the calendar as is since it covers the core season but be aware there is some flexibility.

Treatment Prescriptions:

Treatment methods I did not include but could be implemented:

- Methods like tarping, mulching, and similar. The tool doesn’t include these, but they can be utilized for small, developed sites.
- Revegetation options or monitoring. The first can be used when needed and the later should be done whenever possible. I didn’t want to clutter the document by adding this to every species in every zone.
- Hack and squirt and basal bark methods I limited to larger shrub and tree species. I left them off the shrubs and woody vines categories, but they could be used on any of these if they are large enough.
- Prescribed fire or biocontrol releases (except for purple loosestrife biocontrol I added).

Chemical Selections:

- Some treatments could be modified slightly from the prescription (for example, using a lower herbicide mix rate for certain species). I tried to provide a range of application rates so some adjustments could be made depending on the variety of different species being treated at the same time.
- I limited the number of different chemical options and didn’t include tank mixes to keep things simple. There are many other herbicide active ingredients that can be used. Some species in the lumped categories (such as “Invasive Perennial”) may have specialty rates or preferred herbicides beyond those listed.

- I included common chemical trade names to provide a reference to my mixing recommendations (not as a specific product recommendation). For example, I used Roundup Custom to represent all aquatic glyphosate concentrates having 5.4 lbs. active ingredient per gallon (53.8% active ingredient). There are many other brands that are equivalent, such as Rodeo. There are also lower strength glyphosate concentrates and ready to use products. These work fine, but you may need to adjust application rates according to the label.
- There was one species, Oriental lady's thumb (*Persicaria longisteta*) which I haven't work on before and there was little in the literature on it. I wrote the prescriptions based on other similar *Persicaria* and my own experience, but if treating it you may want to carefully monitor it to see what works best and adjust methods or chemical rates accordingly.

Contact the NE Invasive Plant Management Team (NE IPMT) to discuss these treatments or any other invasive plant or restoration needs:

NE IPMT

Delaware Water Gap NRA
1978 River Rd.
Bushkill, PA 18324
Office: 570-588-0534

Emily Booth
Liaison
Email: Emily_booth@nps.gov
Cell: 570-832-3743

Nicholas Stevenson
Team Lead
Email: nicholas_stevenson@nps.gov
Cell: 267-896-0135

Treatment Prescription Key (Adapted from Gover 2016)

Action	Description
Lead Worker	The available personnel determine what operations you can conduct.
Volunteer	As a <i>lead</i> worker, volunteers are limited to manual methods, and whatever equipment they are qualified/permitted to use. Volunteers may not apply pesticides unless a Certified Applicator is present.
Certified Applicator	A <i>certified applicator</i> is someone who has completed the required trainings to use herbicides. Certified Applicators licensed can be park staff, NPS Invasive Plant Team members, contractors or volunteers who have undergone training and licensing. A Registered Technician may apply autonomously and may also supervise other non-credentialed applicators as long they are on-site.
Treatment Method	
Pull	Remove plant from soil by pulling or digging it from the soil using manual equipment.
Cut	Remove top growth using hand-held or motorized tools. Typically directed towards woody plants, including vines.
Biological Control	Classical biological control is the release of an organism that impacts one specific host. This is most commonly accomplished with insects. In Pennsylvania, the purple loosestrife beetle and mile-a-minute weevil have been released to specifically suppress those weeds.
Foliar-Airstrike	An herbicide application to target plant foliage. 'Airstrike' is a label for <i>glyphosate</i> plus <i>triclopyr</i> , a non-selective mixture used for most spot treatments.
Foliar-Broadleaf	An herbicide application to target plant foliage. 'Broadleaf' is a label for <i>triclopyr</i> plus <i>2,4-D</i> is a selective mixture to control broadleaved weeds without injuring grasses.
Foliar-Specialized	An herbicide application to target plant foliage. 'Specialized' refers to any herbicide or mixture that is not 'Airstrike' or 'Broadleaf' and is used for a specific target species. Examples include <i>quizalofop-P</i> to treat Japanese stiltgrass, or <i>aminopyralid</i> or <i>aminocyclopyrachlor</i> to treat Canada thistle.
Stem-hack	Woody species can be stem-treated. Hack and squirt is a concentrated mixture applied to fresh, spaced cuts made in the bark.
Stem-basal	Woody species can be stem-treated. Basal bark is an oil-based mixture applied to the lower portion of intact stems.
Stump-aqueous	Non-suckering woody plants can be cut and stump-treated to prevent regrowth. Water-based mixtures can be applied to freshly cut stumps.
Stump-oil	Non-suckering woody plants can be cut and stump-treated to prevent regrowth. Oil-based mixtures can also be applied to previously cut stumps by treating the remaining bark as well
PRE	A preemergent herbicide can be applied to prevent annual species, such as Japanese stiltgrass or mile-a-minute, from germinating.
	Treatment period
	Preferred treatment period

Treatment Prescription for Victory Woods

[illegible]

[illegible]

Treatment Prescription for Stop 2 – Inside Loop

[illegible]

[illegible]

Treatment Prescription for Stop 2 - DAR

[illegible]

[illegible]

Treatment Prescription for British Woods

[illegible]

[illegible]

[illegible]

[illegible]

Treatment Prescription for Main Hemlock Area - 1

[illegible]

[illegible]

[illegible]

[illegible]

Treatment Prescription for Devil's Hollow

[illegible]

Treatment Prescription for Main Hemlock Area - 2

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Treatment Prescription for Microburst Area 5

[illegible]

Treatment Prescription for Barber Wheatfield

[illegible]

Treatment Prescription for Freeman Farm

[illegible]

[illegible]

Treatment Prescription for *Carex davisi* Habitat

[illegible]

Treatment Prescription for Schuyler - Knotweed

[illegible]

Treatment Prescription for Forested Wetland

[illegible]

[illegible]

[illegible]

Treatment Prescription for Stop 4

[illegible]

[illegible]

Treatment Prescription for Kroma Kill/Hemlock

[illegible]

[illegible]

[illegible]

[illegible]

Treatment Prescription for Early Detection Species

[illegible]