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News from Hudsonia

Volume 31, Number 1 Spring 2017

Cover photo: Yellow iris *(Iris pseudacorus*), a European species that was presumably planted for ornament in the 1800s and has spread widely in the Hudson River tidal wetlands and along tributary streams. It rarely forms dense stands in our region.
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News from Hudsonia

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Volume 31, Number 1 Spring 2017

Dear Friends of Hudsonia,

We have many great projects this year, spanning a range of topics related to our mission of conservation science research and education: habitat mapping, natural resource inventories, site-specific biological assessments, biodiversity education for community leaders, research on turtles and other vulnerable wildlife, and studies of invasive species and their management. Projects such as these are our raison d'ètre, *but they do not come with all the financial support needed to keep the organization afloat.*

We hope that all News from Hudsonia *readers and everyone who benefits from Hudsonia's scientific work will contribute generously this spring.*

We scarcely need to mention that federal support for scientific inquiry and evidence-based conservation initiatives are under threat, and that federal funding for scientific agencies and organizations may soon dry up. In these times, local efforts are more important than ever and are essential to the important research and conservation work that so many of you value.

This is a pivotal time for the future of environmental protection and for Hudsonia.

Please donate generously to help us meet these challenges!

All our best,

Philippa Dunne
Chair

Erik Kiviat
Executive Director

* Nothing is provided in exchange for your donation except the sense that you are helping biodiversity survive. Hudsonia only uses funds for the organization's nonprofit purposes. Our most recent nonprofit tax return (Form 990) is available from the Hudsonia office or the NYS Office of Charities Registration.

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BACKYARD MANAGEMENT OF INVASIVE PLANTS: A biology-based, practical, low-impact approach

By Kristen Bell Travis*

Have you ever noticed a nonnative, invasive plant growing on your property and wondered how much to worry about it, whether it would be worth controlling, and how? Hudsonia has recently created a guide that may help, written for landowners and gardeners to aid in decisions about managing invasive plants and to provide concrete guidance for methods that work and are environmentally safe. "Best Management Practices for Priority Invasive Plants in the Lower Hudson Valley"[1] is available on the Lower Hudson PRISM (Partnership for Regional Invasive Species Management) website, and includes fact sheets for 15 species now common in the northeastern US (see sidebar next page); many of the described methods can also be used successfully for other species.

WHEN SHOULD INVASIVE PLANTS BE MANAGED?

Ecologically, the simplest answer is: when invasive plants threaten native species, and their removal would reverse those threats. In some cases, invasives directly threaten native plants through competition

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* Kristen Bell Travis is a Hudsonia Research Associate.

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for space or resources; or they threaten native plants and animals indirectly by changing soil chemistry, soil microbiota, nutrient cycling, vegetation structure, or plant community composition of a natural habitat.

In other cases, however, the invaded area is highly disturbed—such as a roadside ditch or pile of fill— and the invasive plant may fill a useful niche by growing where many native plants cannot and providing shelter or resources to native animals, or valuable ecosystem services such as soil stabilization, water quality maintenance, or carbon sequestration. A highly altered environment may be unable to support native species unless significant changes are made, for example, to soil structure, soil microbial or fungal communities, water or nutrient availability, or canopy closure. The closer a habitat or community resembles a native, undisturbed example, the better chance of a successful outcome for invasive species removal.

Control of invasives may be unsuccessful if the underlying conditions remain unchanged.

Complicating this picture is the fact that many of our forests, wetlands, and other natural communities that are protected from obvious disturbances such as logging or filling are nevertheless suffering from many less obvious ones. These include grazing and browsing from overabundant white-tailed deer, insect pests that do widespread damage to forest trees, inputs of a variety of pollutants (including atmospheric deposition of nitrogen), invasions of non-native earthworms, and a shifting climate. For example, strong, positive relationships have been found between the abundances of non-native earthworms, white-tailed deer, and garlic-mustard, stiltgrass, and Japanese barberry.[2] It is also becoming clear that past disturbance—such as plowing or other agricultural activity tens, hundreds, or even thousands of years ago—has continuing effects on soil properties, nutrient cycling, and plant community composition.[3] The presence or abundance of non-native plants is often predicted by one or more of these factors, and—just as with the more obviously disturbed land—removal of the non-natives is unlikely to change the conditions that facilitated their growth.[4]

Nevertheless, there is strong evidence that many invasive plants, just by their presence or abundance, dramatically shift soil nutrient composition, microbiota, nutrient cycling rates, and other processes, making their immediate environment friendlier to themselves and often to other invasive plants.[5] In some cases their removal reverses these ef-

Black swallowwort (*Cynanchum louiseae*) is related to and resembles native milkweeds, but when monarch butterflies lay their eggs on swallowwort, the larvae seldom survive. Erik Kiviat © 2017

Hudsonia's BMP fact sheets are available on the Lower Hudson PRISM website for these non-native invasive plant species.

Norway maple (*Acer platanoides*)
Tree-of-heaven (*Ailanthus altissima*)
Garlic-mustard (*Alliaria petiolata*)
Japanese barberry (*Berberis thunbergii*)
Oriental bittersweet (*Celastrus orbiculatus*)
Black swallowwort (*Cynanchum louiseae*)
Glossy buckthorn (*Frangula alnus*)
Bell's honeysuckle (*Lonicera × bella*)
Purple loosestrife (*Lythrum salicaria*)
Stiltgrass (*Microstegium vimineum*)
Mile-a-minute (*Persicaria perfoliata*)
Common reed (*Phragmites australis*)
Knotweed (*Polygonum cuspidatum and P. × bohemica*)
Multiflora rose (*Rosa multiflora*)
Water-chestnut (*Trapa natans*)

fects, although such changes can take many years.[6] Moreover, some of the disturbance factors contributing to the success of invasive plants (and the decline of natural communities) can be addressed: nutrient and chemical inputs from lawn and garden fertilizers, home septic systems, pest control, and livestock can be reduced; deer can be deterred from some areas; and landowners can determine where and how often mowing, tree harvesting, and other disturbances will happen. Planting native woody or herbaceous plants in invaded areas can also help by providing competitors for the invasive plants, aiding forest regeneration, and possibly restoring soil properties and plant and animal communities. In conjunction with measures such as these, removal of invasive species may benefit native habitats and species.

In some cases a population of a rare plant or animal is known to be threatened by the encroachment of an invasive plant, but the opposite case can also be true, where an invasive species provides critical habitat for a species of conservation concern. The vast majority of cases are less clear-cut, with invasive plants at low to moderate densities, or in discrete patches, and providing some value to other organisms in the form of cover or food, but perhaps reducing habitat quality for an unknown number of other organisms.

Invasive plants are sometimes beneficial for wildlife, soil stabilization, water quality, or carbon storage.

For example, invasive shrubs such as Japanese barberry, multiflora rose, and Bell's honeysuckle can be important components of shrublands and young forests that support the rare New England cottontail;[7] in these habitats they can also provide nesting habitat and food resources during migration for some birds of conservation concern,[8] suggesting that their removal without replacement by native shrubs could be detrimental to some species. However, compared to native shrubs, these invasive shrubs provide lower-quality fruits[9] and sometimes (but not always) reduce the nesting success of birds.[10] In one study in Connecticut, dense thickets of barberry in the forest understory were found to change the microclimate of the forest floor, and were associated with nine times more Lyme disease-infected black-legged ticks than areas without barberry; where barberry was removed, the numbers of infected ticks were reduced by nearly 60%.[11] But veeries (and perhaps other forest understory nesting birds) preferentially nest in dense thickets of Japanese barberry and other invasive shrubs, without reductions in nest success compared to nests in native vegetation.[12] Unfortunately, many of our decisions about whether or not to manage an invasion can only be based on imperfect knowledge and available resources.

WHY FOCUS ON NON-CHEMICAL CONTROL?

In invasive species management, as in agricultural weed management, chemical control has long been the dominant method. It is almost always more labor-efficient (hence cost-efficient) than manual or mechanical control, and often more successful, at least in the short term. Despite these obvious benefits, the environmental costs of herbicide use are considerable. Glyphosate-based herbicides (such as Roundup®) are the most commonly used types in the US and globally.[13] Although glyphosate is widely reported to break down quickly in the environment, its half-life in soil can vary from a few days to over a year depending on soil type; its equally toxic breakdown product AMPA takes even longer to dissipate.[14,15] Glyphosate and/or AMPA were found in over half of thousands of soil and

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ARE RARE BIOTA, HABITATS, AND FLOOD PROTECTION COMPATIBLE? Creation Science for the 21st Century

By Erik Kiviat*

Engineered banks of the River Lez at Montpellier, France. Erik Kiviat © 2017

Coasts and estuaries, including the large estuarine delta system centered on the mouth of the Hudson River, have provided locales for the development of many of the world's largest cities and the natural resources and trade routes that support them. Coasts and estuaries are, by nature, exposed to accelerating sea level rise, storm waves, and surges intensified by climate change. All over the world we have long been building berms, wetlands, dunes, forests, breakwaters, seawalls, reefs, dikes, and other engineered features to protect coastal communities from storms. Several of these proposed or under construction in the New York City area are a reef and dune system along the south shore of Staten Island, a moveable surge barrier in Newtown Creek (Queens and Brooklyn), a seawall along the East River in lower Manhattan, and dikes in the New Jersey Meadowlands.

The residential, commercial, and industrial areas that we are trying to protect from storm damage are, or were, habitat for many wild native organisms that are now of conservation concern. Estuaries and low-lying coastal lands support this component of biodiversity in greater proportion than the acres involved, and the expansion of urban areas and their environmental footprints threaten this diversity. Biological resources are important because, among other reasons, they are critical to ecosystem services – the work that nature does for human society including the maintenance of air, water, and soil quality, protection against rising sea level, and the aesthetic and cultural roles played by wild species.

Vast areas of coastal wetlands, forests, and other habitats have been filled or converted to uses that are adverse to their native biota. These alterations to the coastal landscapes have resulted in habitat loss and fragmentation, pollution, spread of invasive species, and other stressors that have worked to the detriment of the plants, fungi, and animals that persist or formerly occurred there. New storm defenses will result in additional habitat conversion. Even the restoration of beaches, dunes, and marshes often degrades or replaces the habitats of rare plants and animals, and sometimes incorporates the use of herbicides, chemically

* Erik Kiviat is Hudsonia's executive director.

treated lumber, or erosion control netting that can poison or trap wild organisms.

Storm defenses commonly are sited on lands where there is little information about extant biodiversity, and the impacts of these systems on biology are rarely studied well. Some sites, even on wetland fill or in common reed marshes, already support plants or animals of conservation concern that need to be surveyed and considered in planning. Most storm defenses are designed for strength, aesthetics, and low cost, and the designs do not incorporate the protection, restoration, or creation of the habitats required to maintain rare elements of biodiversity that could, or did, exist there. A few projects are designed to, for example, attract diverse marine organisms to created oyster reefs, or provide plant resources for the declining monarch butterfly. More often, biodiversity is given lip service with phrases such as, "stabilized dune habitat for wildlife" or "Atlantic white cedar ponds," with no analysis of the habitat affinities of particular species of wildlife, or the changed environmental conditions that would almost certainly prevent re-establishment of certain habitats in urbanized areas.

Building storm defenses properly is costly, but the loss of ecosystem services from coastal ecosystems may be even more so. I believe that creation and maintenance of biological communities and rare native species can be designed into many of these projects at marginal or no added expense. These will probably not be intact, all-native species assemblages such as existed centuries ago, because urban areas usually cannot support such communities without intensive and perpetual maintenance.

First, the biological surveys that should precede project design must be accurate and thorough. Most such work does not meet these simple criteria, and misses many of the important habitats and species. If only fishes, birds, and a few plants are surveyed, many organisms of conservation concern will be missed. Second, the species to be restored or communities to be created must be selected carefully and their ecologies well understood before attempting to establish the appropriate soil, vegetation, water, and other aspects of habitat. Many habitat restoration projects fail because too little is known about the animal's behavior, because some aspect of their habitat is impossible to recreate, or because the climate and the assemblage of predators, competitors, mutualists, parasites, and pathogens have changed.

Third, the culture of storm defenses is often strong on engineering and aesthetics but weak on ecology. Good habitats are not always pretty; for example, the forbs, shrubs, and small trees, half of them nonnative species, that often grow on old wetland fill may be offensive to some human eyes but of good quality for brown thrashers, monarchs, or Needham's skimmer dragonflies. Fourth, created habitats on storm defense features should be compared to "natural" reference habitats as part of an analysis of success in habitat creation. Often multiple reference sites are needed for statistical purposes, in part because suitable habitats for, e.g., a piping plover or seabeach amaranth, may be quite variable within a range of suitability. Planners, developers, and regulatory agencies, however, are often reluctant to study anything away from the immediate construction site.

Because space is limited in urban areas, many constructed storm defenses will destroy important habitat such as tidal wetland or shrubland. Creating habitat for biological communities and rare species on and around the storm defense features may help mitigate this loss, but only if the constructed habitats function well for the target organisms. Created habitats can also provide non-habitat ecosystem services such as stormwater absorption and soil stabilization.

Storm defenses and biodiversity are too important in this age when cities are sprawling into the habitats of endangered species, and dollars for environmental infrastructure are in short supply. It will take more experience and thought to protect urban biodiversity, and traditional approaches to flood protection are not enough. Careful experimentation and scientific study are as important as costs and completion. Finally, in some cases, habitat goals and passive recreation (e.g., walking, picnicking, wildlife viewing) can be combined on dikes or by means of boardwalks crossing dunes or wetlands. However, some birds and other organisms that may be targets of habitat creation are sensitive to human presence and need to be shielded from even low intensity activities.

Coastal areas will be best defended wherever marshes, swamps, dunes, and forests are maintained intact or re-established so that they can absorb the storm energy as they have always done. This can be accomplished by 1) prohibiting new development in coastal areas within predicted storm surge zones; 2) incrementally dismantling existing structures within those zones, and moving buildings and infrastructure to safer inland areas; and 3) restoring high-functioning habitats that will serve both to protect the developed landscape and support characteristic coastal species.

CONSERVATION ACHIEVEMENT AWARD

In recognition of decades of ecological research and conservation education, Hudsonia received a Conservation Achievement Award for the Hudson River and Harbor Estuary at the 30th anniversary celebration of the New York-New Jersey Harbor & Estuary Program, a collaborative effort of the NYSDEC, U.S. Environmental Protection Agency, Hudson River Foundation, and other entities to improve the health of the estuary and the harbor.

HUDSONIA PROJECT UPDATES, 2017

Binnen Kill

Hudsonia's habitat, plant, fish, amphibian and reptile studies of the Binnen Kill area in **Albany County** continue in partnership with Louis Berger U.S., the Hudson River National Estuarine Research Reserve, and Scenic Hudson. The results will help guide planning for restoration and management of wetlands and other habitats as sea level rises. (Funded by the New York State Department of Environmental Conservation through the New England Interstate Water Pollution Control Commission.)

Biodiversity Education

Short Course. In September Hudsonia will hold a three-day short course on *Habitat and Water Resource Assessment and Conservation* for Land Use Planning in **Albany County**, designed especially for representatives of municipal planning boards, conservation advisory councils, and town boards, county planning agencies, and staff of land trusts. The course includes indoor lectures, hands-on exercises, and field trips that will prepare participants to incorporate biodiversity conservation principles into their routine land-use planning and decision-making. **Field workshop**. We will offer a half-day outdoor workshop to municipal officials to increase their ability to recognize and assess major habitat types in the field, including forests, wetlands, stream corridors, floodplains, and meadows. The workshop will include use of a few key maps/air photos as reference while in the field, recognition of habitat characteristics and quality indicators, and conservation considerations. **Small stream & wetland series.** We are developing a series of evening classes on the ecology, identification, and conservation of small streams and small wetlands for a selected audience of land use decision-makers. The course (to be held in 2018) will explain the importance of those habitats to local ecosystems, and how to use the State Environmental Quality Review (SEQR) process, local legislation, volunteer efforts of landowners, and other means to protect these neglected resources. **Technical assistance.** Hudsonia continues to provide technical assistance to local land-use planning and decision-making agencies and organizations that have participated in Hudsonia and Estuary Program courses and workshops, as well as municipalities that have a Hudsonia habitat map. The assistance is intended to build capacity and support local plans, policies, and practices that achieve strong conservation outcomes. (All of the above will be carried out in collaboration with Cornell University staff, with funding from the NYS Environmental Protection Fund through the NYSDEC Hudson River Estuary Program.)

Conservation Education

In collaboration with the Cragsmoor Conservancy, we will develop and implement a conservation education program for the **Cragsmoor** community in the Shawangunk hills (Ulster County). The program will provide information and guidance on land management to protect Cragsmoor habitats, plants, wildlife, and water resources. (The project is funded by a grant to the Cragsmoor Conservancy from the Land Trust Alliance.)

Habitat Mapping

We are completing the habitat mapping for the **Town of Dover** (Dutchess County), and starting similar projects for the **City of Poughkeepsie** (Dutchess County) and the **Town of Pound Ridge** (Westchester County). The habitat maps and reports issuing from these projects will provide information about habitats, plants, and animals of conservation concern, and are intended to help landowners, municipal agencies, and others better understand how to effectively protect biodiversity, water resources, and the natural systems that support the human community. (Completion of the Dover project is funded by an anonymous donor through the Dutchess Land Conservancy; the Poughkeepsie and Pound Ridge projects are funded by the NYS Environmental Protection Fund through grants to the municipalities from the NYSDEC Hudson River Estuary Program.)

Natural Resource Inventories

This year we are completing the Natural Resources Conservation Plan for the **Town of New Lebanon** (Columbia County) in collaboration with the New Lebanon Conservation Advisory Council; preparing a Natural Resources Inventory for the **Town of Dover** (Dutchess County) as part of their larger Climate Smart Community initiative; and preparing a Natural Resources Inventory for **Columbia County** in collaboration with the Columbia County Environmental Management Council and the Columbia Land Conservancy. These documents will illustrate and describe many of the natural resources of those areas (e.g., minerals, water, plants, animals, habitats, scenic areas, recreational resources), explain their importance to local ecosystems and the human community, and how to identify the priorities for conservation. (All three projects are funded by the NYS Environmental Protection Fund—the New Lebanon project through a grant to the town from the NYSDEC Hudson River Estuary Program, the Columbia County project through a grant to the Columbia Land Conservancy from the Estuary Program, and the Dover project through a Climate Smart Communities grant from NYSDEC,)

Turtle Studies

We have begun a third year of radio-tracking painted turtles in **Tivoli North Bay** (Dutchess County). As yet, there is no published research on this common species in tidal marsh habitat. The North Bay turtles seem to have large home ranges and a high frequency of scars from predation attempts, suggesting that the tidal marsh is not good habitat for this species. We are also analyzing data from our field work on the endan-

Painted turtle with attached radio transmitter (top), and intern Ali Maliha radio-tracking turtles in Tivoli North Bay (bottom).
Erik Kiviat © 2017.

gered **bog turtle** and the threatened **Blanding's turtle** (Dutchess County). (Supported by the Lillian Goldman Charitable Trust.)

Saw Kill

Hudsonia is part of a Bard College team studying areas above and below two old dams on the lower Saw Kill (Dutchess County). We are in the midst of bird, reptile, amphibian, eel, and moss studies. Later this year recommendations will be made about turbine installation for microhydropower, or dam removal. The project will provide guidance for other assessments of small dams throughout New York. (Funded by NYSERDA and NYSDEC).

Other Technical Assistance

Hudsonia is assisting a landowner in **planning land preservation** in Dutchess County, assessing opportunities for management of a wetland in Ulster County, conducting a field assessment of an undeveloped **parkland site** in **Bergen County** (New Jersey), and reviewing the ecological relationships of the mute swan. We have also discussed with conservationists the **ecology of shrubland** and the pros and cons of the **Young Forest Initiative** in **New York** and **New Jersey**.

Other Work

Recently Hudsonia has provided information from our projects to the New York Natural Heritage Program for their assessments of the status of **rare plants**, to the NYSDEC and US Fish and Wildlife Service for **management of bog turtles**, and to the Nature Conservancy for Hudson River **restoration planning**. We presented papers on **urban flora and vegetation** in the Meadowlands at the Northeast Natural History Conference, and on the habitat functions and other **ecosystem services** provided by nonnative **common reed** (*Phragmites*) at the New York State Wetland Forum – Society of Wetland Scientists Mid-Atlantic conference (the latter with reed researcher Judy Weis of Rutgers University). Hudsonia has assisted undergraduate and graduate students studying **urban ecology**; the relationships among **shrubs, insects, and birds; snapping turtles, diamondback terrapins, and benthic invertebrates; predation on ticks by salamanders**; and the development of pigmentation in **American eels**.

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water samples taken across the US,[13] and both are also found in crops, processed foods, and livestock feed.[15]

Herbicides are often effective in the short-term, but have large environmental costs.

Glyphosate exposure at environmentally relevant concentrations causes liver and kidney damage in rats; is predicted to alter hormonal systems (including sexual development), gene expression patterns, and embryonic development in vertebrates; and is probably carcinogenic to humans. Its antibiotic effects may harm the intestinal flora of vertebrates, and promote the development of new strains of antibiotic-resistant bacteria.[15] "Inert" ingredients in herbicide formulations, such as the surfactant mix including POEA in Roundup®, can prove much more toxic to amphibians, fish, and aquatic invertebrates than the herbicide itself.[16] Herbicides can easily reach non-target habitats and organisms due to drift, runoff, and mistakes in application. Techniques of application such as "clip and drip" and injection reduce but do not eliminate the risk of nontarget effects.[17]

Belief in the efficacy of herbicides may lead users to be less likely to perform follow-up treatment or monitoring, although in most cases successful eradication of a patch takes several years with herbicides, just as with mechanical methods. Overuse of herbicides demonstrably leads to the evolution of herbicide-resistant weeds.[15] Also, herbicides are predicted to decline in efficacy with increasing atmospheric carbon dioxide and/or temperature.[18] For these reasons Hudsonia has focused on non-chemical management practices, which are ultimately more sustainable for human health, environmental health, and biodiversity protection.

Cut stems of glossy buckthorn (*Frangula alnus*) sprout prolifically. Smothering or flame treatment or repeated cutting over several years may kill the plant.
Erik Kiviat © 2017

SETTING MANAGEMENT GOALS AND MAKING A PLAN

A good first step is to determine the habitats most worthy of management—from a biodiversity perspective—on your property, including any large, high quality, rare, or uncommon habitats. Next, assess the locations, extent, and density of each invasive species of concern; which habitats each may threaten; and whether each is a problem now or may become one if left unchecked. If a diverse mixture of native plants coexists and persists within the invasion, perhaps active management is not needed. In forests, pay particular attention to woody plant regeneration. Generally, actions such as limiting access to white-tailed deer, replanting native woody plants, or limiting soil and canopy disturbance will do more to enhance habitat for native species and discourage invasive plants than direct removal of the offending plants. For example, forested stream buffers help prevent establishment of mile-a-minute and knotweed. The native wildflower bloodroot (*Sanguinaria canadensis*) planted at a density of at least 5/m^2 (0.4/ft^2) can suppress growth of garlic-mustard.[19]

Once you know the problem areas and species, set realistic goals. These should take into account the time, labor, and budget at your disposal, with the expectation that management will need to happen for several or many years. They should also reflect the chance of success of restoring a native habitat. In most cases, total removal of an invasive is not reasonable with any method. Some reasonable goals include monitoring disturbed areas to remove the first individuals of newly colonizing species; completely removing a small patch; keeping a large patch from spreading; preventing seed production; or reducing density of the invasive. Oldfields, where invasive plants often proliferate after active management ends, are cases where goal-setting can be especially helpful. Such areas could be managed as grassland, shrubland, or (succession to) forest habitat—all habitats with value for biodiversity—and depending on the desired habitat, different goals for each invasive plant might make sense.

Next, identify the best timing for management actions, and set up a schedule across years, integrated with other lawn, garden, and farm management tasks. Timing can be crucial for eliminating annual seed production, reducing plant vigor, or increasing the mortality rate. Most importantly, include restoration (if necessary) and monitoring as part of the plan, to avoid the recovery of the targeted species or the invasion of other weeds.

Sometimes the right tool can make a nonchemical control project feasible. We discuss methods using some less common but efficacious

tools such as the propane weed torch, scythe, black plastic (for smothering), drawknife (for girdling), and pulling tools like "Puller Bear®" or "Uprooter®," as well as common hand tools such as the garden fork, pruning saw, and weed eater. (Much better than black plastic is rubber roofing, which remains intact and effective for many years without disintegrating. Discarded remnants can sometimes be obtained at building supply retailers or roofing contractors.)

SOME EXAMPLE APPROACHES AND METHODS

Avoid worsening the problem. For tree-of-heaven, for example, do not cut stems without further treatment: this results in abundant resprouting and is worse than doing nothing.[20] For Japanese barberry and Oriental bittersweet, winter cutting leads to more vigorous resprouting than summer cutting. Mowing stiltgrass multiple times in a season may stimulate seed production. Study the ecology and behavior of the target species before undertaking your control project.

Timing can be crucial for eliminating annual seed production, reducing plant vigor, or increasing the mortality rate.

Limiting disturbance of the canopy and soils will often do more to discourage invasive plants than direct removal of the offending plants.

Limit resprouting of cut shrubs or trees. "Partial girdling" has been used for tree-of-heaven and might work for other vigorous resprouters: In winter or early spring, carefully use a drawknife to remove a 12-inch-wide (30 cm) band of bark (but not the cambium underneath), around the whole circumference of the trunk or stem.[21] A two-step "cut and flame" treatment has been used for Japanese barberry and would probably work for other shrubs: In early spring, cut the stems near ground level with a brush cutter. After stems resprout, use directed flame treatment (when forest floor is damp or wet, use a 400K BTU propane torch to apply a direct flame for 3-40 seconds, until individual stems become carbonized and begin to glow).[22]

Timely annual removal, based on the plant's reproductive biology, can prevent seed production or eliminate a patch. For multiflora rose, mile-a-minute, Japanese barberry, and some other perennials, an annual cutting in summer will minimize or eliminate fruit production. For the biennial garlic-mustard, twice per year removal is the most efficient: hand-pull first-year rosettes in the fall and flowering plants in the spring.[23] For the annual stiltgrass, hand-pull plants once a year in the fall before seed set (hand-pulling allows native plant regeneration).[24,25,26] For larger areas, mow (or scythe, weed-whack, or pasture sheep) once a year any time after June.[26,27] To allow native plant recovery, mow annually for 3-4 years then take a year off.[27]

Oriental bittersweet (*Celastrus orbiculatus*) is widely dispersed by wildlife that consume the fruit. It grows rapidly and, if cut, reproduces readily from root fragments. Erik Kiviat © 2017

Improve habitat value of patches too large and dense to remove. For common reed, a large patch can be turned into better wetland habitat through a combination of measures such as planting trees and shrubs, manipulating water levels, dredging shallow ponds, grazing livestock, or creating sites to encourage muskrat lodge construction.[28] Biocontrol agents, when available, often do not eliminate an invasive plant, but in some situations they can reduce height, density, and/or reproduction to levels that promote coexistence with native flora and fauna; this has been demonstrated with *Galerucella* beetles on purple loosestrife[29,30] and a *Rhinoncomimus* weevil on mile-a-minute.[31] Check the New York Invasive Species Research Institute website (http://www.nyisri.org/resources/biocontrol/) for availability of biocontrol agents approved in New York. Livestock grazing can be used to manage common reed and purple loosestrife in pastures, wet meadows, fens, and other open, dry-end wetlands.[32,33] Multiflora rose, which commonly invades pastures, can be almost eliminated within four years by grazing goats or a combination of goats and cattle.[34]

For more detail on these and other methods of control, see our "Best Management Practices."[1] Compared to most other fact sheets on invasive plants, ours present a more research-supported summary

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of the negative or positive effects of each plant, its reproduction and spread, and some of the best nonchemical management options, with assessments of their effectiveness when experimental results are available. Hudsonia is grateful to the Lower Hudson PRISM for funding this project. ■

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Bob Boyle's many accomplishments as a writer, fisher, and environmentalist have been given just attention in national media. Bob's 1969 book *The Hudson River: A Natural and Unnatural History* illuminated Erik Kiviat's early interests in the estuary and all its human and nonhuman denizens. Bob was a member of Hudsonia's Advisory Board from 2002 until his death in 2017.

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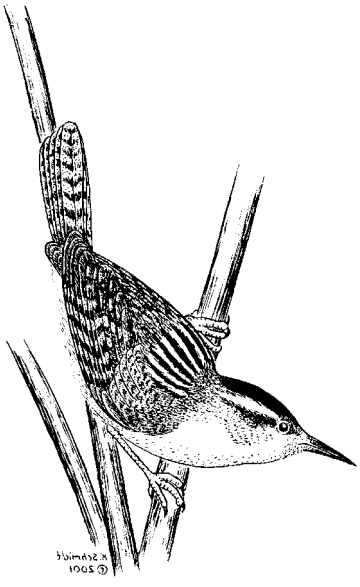

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