

Invasive Species Project: Denning's Point Park 2020



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**Report to the Lower Hudson Partnership in Regional Invasive Species
Management**

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Introduction

In 2020, Clarkson University, Beacon Institute for Rivers and Estuaries (CUIBIRE), in collaboration with Hudsonia, undertook a study of Denning's Point Park (Beacon, New York) on the Hudson River estuary. The project was contracted by the Lower Hudson Partnership for Regional Invasive Species Management (LHPRISM) with funds from the Environmental Protection Fund as administered by the New York State Department of Environmental Conservation.

The project addresses a common problem on parks and preserves: long-present, common invasive plants requiring strategic management to protect rare plants and important habitats, along with early detection – rapid response (EDRR) actions to forestall the establishment of newly arriving and potentially invasive non-native plants. Our project team conducted a repeat of a twelve-year-old survey of invasive non-native plants and rare native plants, trained interns and students to identify both, installed boot cleaning stations and signage, created educational videos, and drafted an invasive species management plan for the Denning's Point peninsula.

Denning's Point is a New York State Park that covers approximately 28 ha (69 ac). The point (or peninsula) was greatly disturbed historically by wetland fill to connect the former island to the mainland, the brick industry (clay and sand mining, waste dumping, infrastructure), estate plantings, farming, railroads, a manufacturing facility (Noesting Pin Ticket Company, and later Durisol), public recreation activities, and other uses (Heron 2006). The western shore was mined for sand, and approximately the northern half of the peninsula was mined for clay. A narrow fringe of large trees persisted along the western shoreline, and that area was the focus of public recreation in the form of swimming and boating. The center of the peninsula was the site of a large mansion, manicured estate grounds, a horse stable, and farm crops. The eastern trail was originally built as a rail bed, but the railroad was never completed. There was a cider mill on the eastern shoreline that processed apples grown on-site. The mansion, and presumably the associated agricultural activities, were abandoned ca. 1889, and the brickyard ceased operations in 1939. Much of the southern half of the peninsula has had about 130 years for forest development, whereas the northern half has had only 80 years.

The aim of our study was to identify invasive plants that could be managed effectively in a disturbed environment with the goal of fostering elements of native biodiversity, and to use this project as an opportunity to educate the public about the importance of invasive species and their strategic management.

Our project met three objectives: 1. Prepare a habitat map and conduct a survey of the vascular flora of the park to identify rare native species and non-native potentially invasive species; 2. Draft a management plan with a selective approach for non-chemical, efficient

management of particular species; and 3. Use the information about the park, its flora, and the management plan to educate school groups and the public concerning invasive species issues and solutions. Attached to this report is a full accounting of the status of deliverables included in the project proposal.

Denning's Point is in the Hudson River conservation target area of the LHPRISM. The entire estuarine shoreline and associated habitats are critical for rare plants and animals. Davis's sedge (S2, NYS-Threatened) and winged monkeyflower (S3, NYS-Rare) were priority concerns for our project. Estuary beggar-ticks (S3, NYS-Rare) also occurs onsite, as documented by the New York Natural Heritage Program. Although there are several documented occurrences of these species in the Hudson Valley, there has been little recent survey to determine how the species are faring in the region. Despite historic sand mining, the existing sandy-gravelly-rocky estuarine shoreline that borders the western side and southern tip of the point is an uncommon habitat on the Hudson River because most of the shorelines have been altered or do not share this surficial geology.

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Methods

Habitat Map and Flora Survey

Hudsonia conducted a biological study of Denning's Point in 2008 (Hartwig et al. 2009), producing a plant list, report, and habitat map, among other products. In 2020, we updated the 2009 habitat map remotely from newer (2013, 2016) orthophoto imagery using ArcGIS 10.8 (Environmental Systems Research Institute 2019). We then used this preliminary habitat map during field work to verify and correct habitat delimitations and describe vegetation, while concurrently surveying the flora of each habitat type.

The flora survey covered the entire property, with a closer focus on habitats of particular interest and locations where we found noteworthy rare native or non-native invasive plants in 2008. Graham spent seven days in the field, from June through October, refining the habitat map, mapping rare and invasive plant species, and conducting a flora survey. Kiviat spent two days on flora survey in May and July; they were joined by Rew and other CU|BIRE staff and interns on portions of those days. The flora survey was conducted under a permit from the New York State Office of Parks, Recreation and Historic Preservation (OPRHP), which administers Denning's Point Park.

For the flora survey, we recorded all plant species observed and we estimated rank abundance for each species (i.e., rare, occasional, common, abundant). We identified most plants in the field; some were photographed or collected for laboratory identification or to document noteworthy occurrences. We used standard plant identification manuals for the northeastern states. Voucher specimens of selected species are in the Bard College Field Station – Hudsonia Herbarium. GPS coordinates were recorded for non-native species with invasive potential, and for rare species, for mapping and monitoring purposes. We compiled the flora data into an annotated species list (Appendix 1). The 2008 flora data are also shown in the appendix for comparison.

Management Planning

It would not be possible to remove all the non-native plants from Denning's Point, or even all the non-native invasive species. Yet Denning's is an ideal site for demonstrating appropriate planning and management for newly arrived invasives as well as long-present, common invasive plants that threaten rare plants and habitats.

Therefore, we focused the management plan on: 1. Early detection species known or likely to be invasive and deleterious to native biota, but which are scarce enough to remove with relatively little effort or harm to the native flora; 2. Invasive species that appear to be threatening rare plants or vulnerable fauna; 3. Invasive species that are colonizing the small supratidal swamp on the eastern edge of the peninsula; 4. Non-native knotweed or common (European) buckthorn should they occur close to the intermittent woodland pool (vernal pool) complex or the supratidal pooled swamp, because these species are known to emit emodin, which is reported to be toxic to amphibian larvae; and 5. Experimental, small-scale removal or reduction of water-chestnut to determine if native submergent flora can be encouraged. We also recommend monitoring certain rare or invasive species to discern major changes in population status. In order to be included in the management plan for treatment (removal, reduction, or containment), an invasive species had to be scarce enough that treatment would be practical and manageable by small-scale, non-chemical means. Moreover, the objectives in the management plan are scaled so that they can be accomplished using available effort from staff of CUJBIRE, New York State Office of Parks, Recreation, and Historic Preservation (OPRHP), and volunteers.

Results





Habitat Map

Of the study area's 69 ac, 63.4 ac, or 92%, are in ecologically significant habitats. The remainder is developed, comprising the CUIBIRE Water Ecology Center and OPRHP's Denning's Point Caretaker's Residence and surrounding lawns, the entry road, the remaining paper clip factory structure, the concrete pad east thereof, and a newer road/trail that runs southeast from the pad to a structure on the southern shore. We mapped fourteen habitat types, including nine upland types, three wetland types and two tidal habitats. We made several changes to the 2009 habitat map, including adding, eliminating, and consolidating habitats. For example, we combined the three estuarine shore habitats from 2009 into a single type, since in reality the shore comprised a small-scale mosaic of similar types. We eliminated calcareous woodland and wet spot, and added walnut-maple-basswood forest and upland meadow. Table 1 shows all of the habitat types from the present study as well as their relationship to the 2009 types.

Overall, 57 ac (83%) of the peninsula were in upland habitats, a scant 1.5 ac (2%) in (non-tidal) wetlands, and 5 ac (7%) in tidal habitats. Most of the peninsula was forested, with 52 ac, or 75%, of the study area in one of several forest types (Figure 1). Upland hardwood forest and lowland hardwood forest were by far the most extensive habitats, at 21 ac and 20 ac, respectively. Walnut-maple-basswood forest, at 5 ac, was the only other habitat of at least 5 ac.

Evidence of human disturbance in these forests was pervasive, and included large man-made pits, an herbaceous and shrub understory dominated by invasive species, escaped horticultural plants (bottlebrush buckeye, periwinkle, Japanese snowball [Tier 2]), and pronounced cut-and-fill topography. The pits varied in depth from one meter (3.3 ft) to over 3 m (10 ft) and in length from 1 m to 4.5 m (15 ft). Some retained water or moisture during parts of the year, but did not hold water long enough to function as intermittent woodland pools.

Ecologically Significant Habitats at Denning's Point















-  Railroad
-  Road
-  Trail
-  Study area

Aerial orthophotos (2013) shown in developed areas and outside study area

Figure 1



Habitats

-  erss: estuarine rocky-sandy shore
-  iwpl: intermittent woodland pool
-  lhf: lowland hardwood forest
-  ma: marsh
-  nmof: Norway maple-oak forest
-  ru: ruins
-  sff: supratidal floodplain forest
-  ss: supratidal swamp
-  tm: tidal marsh
-  uhf: upland hardwood forest
-  um: upland meadow
-  us: upland shrubland
-  wg: waste ground
-  wmbf: walnut-maple-basswood forest

Upland habitats

Lowland hardwood forest (lhf)

This 20-ac forest was very moist, with patches of saturated soil during parts of the year. It was probably the area of most intensive past land use. Much of the ground was littered with a thick layer of brick rubble and brick piles. Substrates were fill, and the topography was uneven, with many mounds and depressions.

The canopy was dominated by eastern cottonwood, with black locust as a co-dominant species.

Most cottonwood and black locust had diameter at breast height (dbh) \leq 16 in, though larger cottonwoods up to 24 in were not uncommon, and rare specimens reached 30-36+ in. American elm and ash-leaved maple (boxelder) were common, while Norway maple, white mulberry, northern catalpa, and sweet cherry were all occasional. American elm reflected most of the trees in this habitat, in that most were small (\leq 12 in dbh), but occasional specimens attained larger diameters of 13-24 in. Common buckthorn was locally abundant as a sapling and small tree; the area south of the

CUJBIRE building and lawn was dominated by buckthorn. Black walnut was common north of the main trail, with many large individuals between 16 and 24+ in dbh. Invasive species prevailed in lhf: Oriental bittersweet was abundant in all three strata and covered large parts of the canopy. Wineberry was abundant, multiflora rose common, and autumn-olive locally common in the understory. On the ground, garlic mustard and Japanese stiltgrass were abundant and narrow-leaved bittercress common. Walking in most of this stand was difficult because of tangled, thorny, and often impenetrable thickets of the above species.

Norway maple-oak forest (nmof)

This long, narrow forest was probably the least disturbed on the point. The land was generally flat but included a small hill and ridge at the north end and steep western slopes/bluffs down to the shore. Soils were dry and sun exposure higher than in any other forest at Denning's,

2020 habitat	2009 habitat
Upland	
lowland hardwood forest (lhf)	lowland forest (lf)
Norway maple-oak forest (nmof)	oak forest (of)
ruins (ru)	ruins (ru)
supratidal floodplain forest (sff)	supratidal floodplain forest (stf)
upland hardwood forest (uhf)	upland hardwood forest (uhf)
upland meadow (um)	lowland forest (lf)
upland shrubland (us)	upland shrubland (us)
walnut-maple-basswood forest (wmbf)	upland hardwood forest (uhf)
waste ground (wg)	waste ground (wg)
lowland hardwood forest (lhf)/ Norway maple-oak forest (nmof)	calcareous woodland (cw)
lowland hardwood forest (lhf)/ upland hardwood forest (uhf)	wet spot (ws)
Wetland	
intermittent woodland pool (iwp)	intermittent woodland pool (iwp)
marsh (ma)	constructed pond (cp)
supratidal swamp (ss)	supratidal swamp (sts)
Tidal	
estuarine rocky-sandy shore (erss)	brick waste shore (bws)
	estuarine rocky shore (ers)
	estuarine sandy shore (ess)
tidal marsh (tm)	tidal marsh (tm)

Table 1. Mapped habitats in the present study and the 2009 study. 2009 habitats that were omitted in 2020 are faded.

especially on the western side. Norway maple was dominant and abundant; most trees were 6-20 in dbh, but a few reached 24 in or even 30 in dbh. American basswood was locally common toward the south end with diameters mostly between 7 and 15 in, with a few reaching 20-24 in dbh. While oaks were not common, there were quite a few large oaks with sprawling canopies, and we include them in the community name to emphasize that this was their primary and most suitable habitat at the point. Chestnut oak between 9 and 30 in was locally common, with numerous trees between 20 and 30 in; and black oak between 11 and 24 in was occasional. Red oak (16 in, 28 in, 28 in) and scarlet oak were both rare. Black cherry (mostly 16-30 in, with one massive tree >48 in), hop hornbeam, and black locust (up to 30 in) were occasional. Two northern hackberries here were the largest we found in the study area, at roughly 20 in and 24 in dbh, and tulip poplar (one >36 in), black birch, American beech, sassafras, and red maple, all rare in the study area, grew here. The understory was fairly sparse and mostly non-native, including Japanese barberry, wineberry, and (on the lower slopes) false-indigo. The herbaceous layer was dominated by graminoids, including at least nine grass species and sixteen *Carex* sedge species, a remarkable number for such a small area. The most common graminoids were common hairgrass, bentgrass, common sedge, common woodland sedge, gray sedge, and Appalachian sedge. Japanese honeysuckle seedlings were abundant, white wood aster and garlic mustard common, and black swallowwort (especially on the western slopes) and silverrod locally common. We also found two sizeable patches of Himalayan blackberry.

Ruins (ru)

We mapped as ruins several old buildings in various states of decay scattered across the site. The largest was the ruins of the old mansion, located within the walnut-maple-basswood forest. Because ruins can serve as habitat for many species, including bats, snakes, and birds, we mapped them separately from the developed areas. Because the remains of the paper clip factory south of Denning's Avenue are being redeveloped, we mapped it as a developed area rather than ruins.

Supratidal floodplain forest (sff)

Supratidal floodplain forest is upland forest that floods to a variable degree during higher than average tides or storm surges. As such it contains a mixture of upland and wetland herbaceous species. Northern catalpa (up to 16 in) and Norway maple were common, and a stand of large black walnut (up to 18 in) was here. Eastern cottonwood (up to 18 in, exceptionally to 30 in) and silver maple (up to 20 in) were occasional, and common buckthorn locally common as a tree and sapling. A green ash of about 16 in dbh was still alive despite the widespread emerald ash borer infestation. In the understory, wineberry and false-indigo were occasional. Herbaceous plants were diverse: Japanese stiltgrass, jumpseed, mugwort, wood nettle, and willow-leaved aster were common or locally abundant, and many other species less common—among them Davis's sedge, Gray's sedge, wild ginger, and lizard's tail, all regionally rare or uncommon. Wild yam, a species that is most frequent (at least in our region) in wooded habitats along the Hudson River, also grew here.

Upland hardwood forest (uhf)

Upland hardwood forest was dryer and of slightly higher elevation than lhf, and with more varied topography of hills and depressions. Black locust of 12-30 in dbh dominated most of the 21-ac stand, with rare individuals from 36 to 48 in. Unlike in the lhf, eastern cottonwood was rare here. Norway maple was locally abundant on the hill just south of the largest intermittent woodland pool and at the southern end of the peninsula. Black cherry was common, mostly up to 15 in, but occasionally up to 30 in. Black walnut, tree-of-heaven, silver maple, northern hackberry, American elm, and slippery elm were occasional. Most hackberries were small (3-5 in dbh), but we found two at the southern tip of 12-13 in. Oriental bittersweet, occasional, was not as great a presence here as in the lhf. Multiflora rose and spicebush were both abundant over large areas, and wineberry common. At least one large stand and several scattered individuals of Japanese snowball were present. Japanese stiltgrass, garlic mustard, and jumpseed were abundant in the ground layer, and gray sedge common. Native woodland flowers were uncommon, but common blue violet, honewort, white avens, and enchanter's-nightshade were occasional.

Upland meadow (um)

Unlike the lawn around the water lab (mapped as developed), upland meadows are mowed infrequently (once or twice a year or less) and therefore have greater habitat value. Meadows were quite limited at Denning's. There was a small meadow east of the water lab and its lawn, and a small, open sedgy area where the western trail forks. We found Venus's looking glass (regionally rare) in the latter meadow.

Upland shrubland (us)

Denning's Point was dotted with small shrubland patches of up to about 1 ac. Most of these were thickets of multiple invasive shrubs, usually carpeted with some combination of Oriental bittersweet, porcelainberry, Japanese honeysuckle, and one or more species of grape. Most of these thickets were within the uhf habitat, evidencing much recent disturbance to this forest. Common shrub species were multiflora rose, wineberry, Bell's honeysuckle, and black raspberry. Small (10-15 cm [4-6 in] dbh) trees were also present, mostly tree-of-heaven and black locust. Herb cover was dense and was primarily Japanese stiltgrass, along with garlic mustard and pokeweed.

Walnut-maple-basswood forest (wmbf)

This area was included within the broader uhf in 2009, but we felt it distinct enough to warrant mapping as a separate community. The forest here was evidently older than most on the peninsula and harbored trees of exceptional size of numerous species. Many were likely landscape trees on the former estate surrounding the now vanished mansion, which this forest encompasses. Massive black walnut trees were abundant and dominant. Most were ≥ 20 in dbh, with at least five between ~ 36 in and ~ 48 in. Large silver maple (mostly 16-24 in, one tree > 40 in) and basswood (15-24 in, one of ~ 36 in) were common and co-dominant. A white oak

of at least 48 in dbh stood next to the trail south of the eastern promontory. Northern hackberry (mostly 3-5 in dbh) and canopy-level Oriental bittersweet were also common. Stately tulip poplars (14-26 in, one of ~48 in) were occasional, as were sugar maple (including one of 24 in), American elm (two of 26 in, 36 in), slippery elm (two of 30 in, 36 in), black cherry, black locust, and tree-of-heaven (up to 24 in). However, despite its grandeur, this stand was not exempt from the onslaught of invasives that characterized the peninsula: in addition to Oriental bittersweet, a mass of porcelainberry covered a substantial area; multiflora rose, garlic mustard, and Japanese stiltgrass were abundant; wineberry was common; and bottlebrush buckeye and Japanese snowball (Tier 2) formed large, monotypic copses. Along with spicebush, also abundant (but native), these invasives combined into a daunting thicket over much of this forest, leaving resources for few other herbaceous plants.

Waste ground (wg)

Waste ground is an ecologists' term for land that has been severely altered by previous or current human activity, but lacks pavement or structures. This category encompasses areas such as sand and gravel mines, mine tailings, organic waste piles, unvegetated wetland fill, sites of razed buildings, and construction sites. In 2009 a large concrete pad just east of the former paperclip factory, littered throughout with large piles of construction debris, was classified as waste ground. We were unable to see this area in 2020 because of construction on the adjacent paperclip factory, but from recent aerial images it is clear the piles of debris have been removed, and that young hardwood forest has grown up in the several large gaps in the concrete pad. We therefore mapped this forest as lhf, and the concrete pad, which does not support more than plants in cracks, as developed. The remaining small waste ground consists of soil/mulch piles.

Wetland habitats

Intermittent woodland pool (iwp)

An intermittent woodland pool is a small wetland partially or entirely surrounded by forest, usually with sparse or no vegetation within the pool itself. Typically these pools have no surface water inlet or outlet (or ephemeral ones) and contain standing water during fall, winter, and spring that dries up by mid- to late summer during a normal year. Seasonal drying and lack of a stream connection ensure that these pools do not support fish, which are major predators on amphibian eggs and larvae.

Intermittent woodland pools can provide critical breeding habitat for several obligate pool-breeding amphibians, including wood frog and spotted salamander. During the breeding season, birds may be more abundant and diverse around intermittent woodland pools than elsewhere in upland forest (McKinney and Paton 2009). The invertebrate communities of these pools can be rich, providing abundant food for songbirds such as yellow warbler, common yellowthroat, Louisiana waterthrush (SGCN), and northern waterthrush.

We mapped four intermittent woodland pools ranging from < 0.1 to 0.6 ac. From 2008: The northern two pools were larger and deeper. Maximum water depth in one was greater than 30 cm (12 in) in late April, and in the other 25 cm (10 in), but both were dry by early July. By September these pools contained up to 5 cm (2 in) of water in deeper spots. However, by 28 October the pools were again dry. Based on our observations of fluctuating water levels, and the high likelihood that the pools are situated on clay soils, we believe these pools are filled with perched water rather than groundwater.

Vegetation varied among pools. The southernmost pool had abundant Japanese stiltgrass and little else. The smallest pool was sparsely vegetated but had three species not found elsewhere in the study area: limestone meadow sedge, pointed broom sedge, and dark green/mosquito bulrush. The northernmost and largest two pools were well-vegetated. Black willow and elm were common and pin oak occasional. In the understory, elm and northern catalpa saplings as well as silky dogwood were occasional. Beggar-ticks, false nettle, and clearweed were abundant or locally abundant, and blunt broom sedge and purple loosestrife occasional.

Marsh (ma)

A small cattail and common reed marsh had filled in the constructed pond mapped in 2009 in the CUIBIRE building lawn.

Supratidal swamp (ss)

Supratidal swamps are similar to tidal swamps but inundated less frequently. There were two supratidal swamps in the study area. One was on a small projection of land east of the former paperclip factory; the second was on the eastern promontory. The first swamp was composed mostly of woody species, including eastern cottonwood, elm, false-indigo, white mulberry, and silver maple. Multiflora rose was very common. Herbs were rather sparse, but included beggarticks, clearweed, jewelweed, sedges, smartweeds, violet, wood nettle, and yellow iris.

The second swamp had few trees but was completely shaded by canopy from adjacent forest. There was an elm and several silver maples, including one at ~28 in dbh. A black walnut reclined into the swamp. Japanese stiltgrass was common, and a patch of autumn clematis sprawled into the swamp. Large clumps of Gray's sedge (regionally rare) and yellow iris filled the swamp, along with arrow arum (common), yellow avens (common), and patches of Canada germander, wood nettle, clearweed, moneywort, dotted smartweed, and lance-leaved aster. We were not able to re-locate the winged monkeyflower (S3, NYS-Rare) that had been recorded at this location in 2008.

Tidal habitats

Estuarine rocky-sandy shore (erss)

Most of the western shore was a mix of sandy and gravelly shore, with brick waste common toward the northern end. The east shoreline beach was primarily sand and silt, with some boulder-gravel shore (ers) just north of the southern point. The southern point was a picturesque outcrop of bedrock. Trees were common on the back edge of the shore and on the southwestern point but absent elsewhere. American basswood and Norway maple were common. Other trees included white ash, silver maple, sugar maple, ash-leaved maple, slippery elm, white willow, white mulberry, one-seeded hawthorn, and the only pignut hickory we found on the peninsula. False-indigo was fairly common but shrubs otherwise rare. Willow-leaved aster and dotted smartweed formed carpets toward the back edge of the shore. Other herbs included sneezeweed, mugwort, nodding beggar-ticks, greater duckweed, common duckweed, watermeal, Canada germander, wild yam, autumn clematis, American water horehound, climbing hempweed, tidewater hemp, and black swallowwort. We found small patches of two regionally rare plants around the southern tip: brookweed and prairie cordgrass.

Tidal marsh (tm)

There was a small tidal marsh on the north side of the eastern promontory, vegetated mostly with intertidal spatterdock (abundant) and water-chestnut (locally abundant). Eurasian watermilfoil (LHPRISM Tier 2) was occasional.

Flora Survey

We found (at least) 283 species of vascular plants during flora surveys of the peninsula. Adding in estuary beggar-ticks (*Bidens bidentoides*), found by the New York Natural Heritage Program (NYNHP) in 2014, gives a total of (at least) **284 species**. The most speciose families were Cyperaceae (sedge family), Poaceae (grass family), Asteraceae (composite family), and Rosaceae (rose family), with at least 31, 30, 26, and 17 species, respectively. Our 2020 tally compares favorably to the list from the 2009 study: we encountered at least 260 species, while the previous study reported 124 species, for a net gain of 136 species. In other words, we found at least 159 species that were not found in 2009, but failed to find 23 species that were discovered in 2008 (and reported in 2009). We attribute most of this increase to greater field time and taxonomic knowledge in the 2020 study, not to migration of new species onto the peninsula in the intervening 12 years, which, while possible, is unlikely outside of non-native species experiencing rapid range expansions. Of the 23 species not found in 2020, it is possible that one or a few no longer occur on Denning's Point; for example, *Mimulus ringens* and *Mimulus alatus* (S3, NYS-Rare) both had small populations in a very limited area (within the small supratidal swamp) in 2008, and we could find neither in 2020. A few, such as *Carex albicans* and *Arabidopsis lyrata*, were likely missed in 2020 because they had already senesced

and disappeared by the time the bulk of our field work began, on 10 June. Three species from 2008—*Echinochloa crus-galli*, *Setaria* sp., and *Verbascum thapsus*—were reported only from the large waste ground east of the old factory structure, which we were unable to access in 2020 because of construction. Most of the 23 species probably had very small and/or inconspicuous populations that were simply overlooked in 2020: no flora survey can be comprehensive, due to time constraints, human error, and the usually opportunistic nature of such surveys. Mysteriously, we were unable in 2020 to re-find *Ornithogalum nutans*, a showy species that had a healthy population centered on one of the established trails in 2008. This species could yet be present, and is of concern for its still undetermined invasive potential. One species recorded in 2008 was likely a misidentification of a species we encountered in the present study: *Echinocystis lobata* (*Sicyos angulatus* in 2020). While *Catalpa speciosa* was recorded in 2008, we were uncertain enough about the tree's identity (*C. speciosa* vs. *C. bigonioides*) to record it as simply *Catalpa* sp. in 2020.

Of the 284 total species, 190, or 67%, are native to New York state; 87 (31%) are exotic; and 7 (2%) are ambiguous, either because of difficulties in identification or because a species has both native and non-native lineages. Most of the non-natives hail from Eurasia, though a few are native to other parts of the contiguous U.S. *Amorpha fruticosa* and *Robinia pseudoacacia*, for example, are both native to Pennsylvania and other states south of New York, but not to New York; *Helianthus tuberosus* is native to the midwestern U.S.; and *Asimina triloba* is native to western New York but thought to be naturalized from cultivation in the Hudson Valley (Weldy et al. 2021).

Many of the exotic species are not known to be invasive in our region, and are unlikely to become so based on knowledge of their population biology to date. Table 2 lists species that are ranked in the most recent Lower Hudson Prism Categorization (<https://www.lhprism.org/system/files/documents/Species%20Categorization%20LHPRISM.pdf>; updated 3/30/2020), because they are known to be invasive or have a strong potential to be invasive in the region. It includes species from both the previous and current surveys.

The categorization of species in this report are defined by the LH PRISM Species Categorization tiered system. Species tiers were created to standardize and prioritize the management of invasive species.

Species are labeled as Tier 1, 2, 3, 4, or 5 indicating their potential to impact the Lower Hudson Valley native plants and habitats. Tier 1 - early detection - species are surveyed to detect new introduced plants. Tier 2 - eradication - species are in low abundance and often removed immediately. Tier 3 - containment - species are abundant and are slowed from spreading. Tier 4 - local control - species are widespread and well-established. Tier 5 - monitor - species have potential to be invasive.

The breakdown of the ranked species that we found is:

Tier 2 – 2 species;

Tier 3 – 9 species;

Tier 4 – 22 species; and

Tier 5 – 4 species.

One taxon, Bell’s honeysuckle, represents a hybrid swarm between the parent species ranked as Tier 4 and Tier 5 (see footnote to Table 2). Table 2 also includes several species not on the LH Prism list that we consider to have invasive potential, at least on Denning’s Point. We have not, as yet, found any Tier 1 species there. From this list, we selected multiple exotic species to target for future management (see below), either because they appear to be a current threat to a specific habitat or species, or because they are known elsewhere to be pestiferous and are just becoming established on Denning’s Point. Figure 2 shows the known distribution of key invasive exotic species at Denning’s Point.

Table 2. Select non-native species found on Denning’s Point. Common names adhere to regional usage as much as is feasible; we have substituted where a common name alludes to a geographic region of origin that is incorrectly restricted. None of the species commonly known as “European,” “Norway,” “Amur,” “Himalayan,” or “Japanese” is actually endemic to the named region.

Scientific name	Common name	Tier	2020 observations
<i>Acer platanoides</i>	“Norway” maple	4	Locally abundant
<i>Acorus calamus</i> ¹	Sweetflag	Unranked	2008 only
<i>Aesculus parviflora</i>	Bottlebrush buckeye	Unranked	Two sizeable colonies
<i>Ailanthus altissima</i>	Tree-of-heaven	4	Occasional
<i>Alliaria petiolata</i>	Garlic-mustard	4	Abundant
<i>Amorpha fruticosa</i>	False-indigo	5	Common on W shore
<i>Ampelopsis glandulosa</i>	Porcelainberry	3	Occasional large patches
<i>Artemisia vulgaris</i>	Mugwort	4	Common
<i>Berberis thunbergii</i>	“Japanese” barberry	4	Occasional
<i>Cardamine impatiens</i>	Narrow-leaved bittercress	3	Common
<i>Catalpa</i> sp.	Catalpa	Unranked	Locally common
<i>Celastrus orbiculatus</i>	Oriental bittersweet	4	Abundant
<i>Clematis terniflora</i>	Autumn clematis	3	At least two small patches
<i>Elaeagnus umbellata</i>	Autumn-olive	4	Locally common
<i>Euonymus alatus</i>	Winged euonymus	4	One sizeable patch; seedlings elsewhere
<i>Humulus japonicus</i>	“Japanese” hops	3	One spot
<i>Iris pseudacorus</i>	Yellow iris	4	Uncommon
<i>Ligustrum vulgare/obtusifolium</i> var.	“European”/border privet	5/3	Occasional
<i>Lonicera japonica</i>	“Japanese” honeysuckle	4	Common
<i>Lonicera maackii</i>	“Amur” honeysuckle	3	Occasional
<i>Lonicera</i> × <i>bella</i> ³	Bell’s honeysuckle	4/5	Common
<i>Lysimachia nummularia</i>	Moneywort	4	Rare in supratidal swamp
<i>Lythrum salicaria</i>	Purple loosestrife	4	Rare
<i>Microstegium vimineum</i>	“Japanese” stiltgrass	4	Abundant
<i>Morus alba</i>	White mulberry	4	Occasional

<i>Myosoton aquaticum</i>	Giant chickweed	Unranked	2008 only
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	2	Occasional in tidal marsh
<i>Ornithogalum nutans</i>	Star-of-Bethlehem	5	2008 only; along E trail
<i>Phragmites australis</i> ⁴	Common reed	4	Rare
<i>Prunus avium</i>	Sweet cherry	4	Occasional
<i>Reynoutria japonica s.l.</i> ⁵	Knotweed	4/5	Two patches on W shore, one patch along W trail
<i>Rhamnus cathartica</i>	Common buckthorn	4	Common
<i>Robinia pseudoacacia</i>	Black locust	4	Abundant
<i>Rosa multiflora</i>	Multiflora rose	4	Abundant
<i>Rubus bifrons</i> ⁶	"Himalayan" blackberry	Unranked	Occasional
<i>Rubus phoenicolasius</i>	Wineberry	4	Abundant
<i>Trapa natans</i>	Water-chestnut	3	Abundant in bay
<i>Ulmus pumila</i>	"Siberian" elm	3	Rare in uhf
<i>Viburnum plicatum</i>	"Japanese" snowball	2	Two large patches, numerous small clusters
<i>Vinca minor</i>	Periwinkle	5	Large patch S end; smaller patch near mansion ruins.
<i>Vincetoxicum nigrum</i>	Black swallowwort	3	Occasional

¹ There has been taxonomic confusion regarding *Acorus* in North America. Current opinions indicate a native species *A. americanus* and a non-native *A. calamus*.

² We found both species of *Ligustrum* at Denning's but did not consistently distinguish between the two.

³ The two parent species, *Lonicera tatarica* and *L. morrowi* have created this hybrid swarm. Taxonomic opinions vary; Kiviat considers all Hudson Valley material referable to the hybrid. We count the hybrid entity as Tier 4.

⁴ *Phragmites australis* in the Northeast consists of two subspecies, native *Phragmites australis* ssp. *americanus* (very rare in New York), and non-native *Phragmites australis* ssp. *australis* from the Old World. The small colonies at Denning's are almost certainly the non-native subspecies.

⁵ "Knotweed" here includes two parent species, "Japanese" knotweed *R. japonica* (Tier 4) and giant knotweed *R. sachalinense* (Tie 5), and their hybrids *R. × bohémica* (Tier 4), constituting a hybrid swarm. These taxa have also been placed in the genera *Fallopia* and *Polygonum*. We consider the combined "knotweed" to be Tier 4.

⁶ The identity of this blackberry is uncertain; some of it could be native *R. allegheniensis* or *R. pensilvanicus*. The non-native *R. bifrons* is also known as *R. armeniacus*, *R. discolor*, and *R. fruticosus* agg. More than one species could occur at Denning's.

Star-of-Bethlehem (*Ornithogalum nutans*), a non-native garden ornamental, was numerous along the southern portion of the eastern trail in 2008 (Hartwig et al. 2009). At the time we wondered if it would compete with Davis's sedge. Surprisingly, star-of-Bethlehem was not relocated in 2020. This may be a rare example of an apparently well-established non-native species declining. We don't know if star-of-Bethlehem was planted along the trail and declined from lack of care, or if it found its own way there and thrived for a while before declining (we suspect the latter). Another possibility is that the species "hid" below-ground in an unfavorable year as some orchids do. We were also a bit surprised to not find butterfly bush (*Buddleja davidii*), which we had expected because of its proximity to Denning's Point along the East Shore Railroad.

Our data on non-native species occurrences on Denning's Point are being submitted to iMapInvasives.

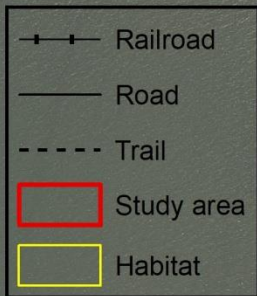
We also paid special attention to rare plants. In the 2008 survey, we found a small occurrence of winged monkeyflower (*Mimulus alatus*; S3, NYS-Rare) in the supratidal wetland of the promontory on the eastern shore. We were unable to relocate this species in 2020. In 2008 we found many clumps of Davis's sedge (*Carex davisii*, S2, NYS-Threatened), concentrated along the eastern trail. In 2020, Davis's sedge was again common along the eastern trail, and was also found along the western trail and scattered throughout the interior of the peninsula. Our mapped distribution comports well with the generalized distribution mapped by the NYNHP, aside from scattered small patches or individuals elsewhere. Figure 3 shows our records as well as those of NYNHP (from 2014). The Denning's Point population of Davis's sedge may be the largest Hudson River population of this species, and, in any case, is large enough to be considered a "responsibility" species and designated for special conservation attention. Although much of the population is arrayed along the trails, the species is also widespread away from trails and in a variety of habitats which should help protect it from the potentially adverse factors of human activities and estuarine dynamics.

NYNHP also mapped an occurrence of estuary beggar-ticks (*Bidens bidentoides*), S3, NYS-Rare, on the east side of Denning's Point Bay near the railroad tracks: specifically, 12 plants in "good to fair" habitat (2014). Heritage also indicated that abundant water-chestnut was a threat to the estuary beggar-ticks. We were unable to visit this occurrence during 2020 field work.

We mapped other rare species, including several that we consider to be regionally rare in the lower to mid Hudson Valley: Gray's sedge (*Carex grayi*), prairie cordgrass (*Spartina pectinata*), brookweed (*Samolus valerandi*), lizard's tail (*Saururus cernuus*), and Venus's looking glass (*Triodanis perfoliata*). A CU|BIRE adjunct team member, Brian Rubino, discovered several small seedlings of pawpaw (*Asimina triloba*) east of the mansion ruins (Figure 3). This species is ranked as S2, NYS-Threatened; however, it is thought to be native to only western New York, and to be naturalized from cultivation where it occurs in the Hudson Valley (Weldy et al. 2021). Therefore it is unclear whether this species on Denning's point represents a native population or an escapee from cultivation.

River birch was mapped as a rare species in the 2009 study, but has since been downgraded by NYNHP from S3 to S4 because so many of its occurrences are plantings. It is likely that trees mapped in waste ground at Denning's Point in 2009 were planted, as were a few individuals seen in 2020 on the lawn east of the water lab. Thus we do not include river birch here on our rare species map for the point (though we do retain it on our 2020 species list [Appendix 1]).

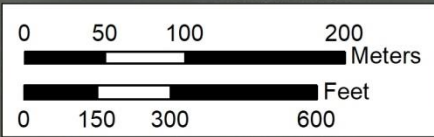
Selected Invasive Plants at Denning's Point



Aerial orthophotos (2013) shown in developed areas and outside study area

Figure 2

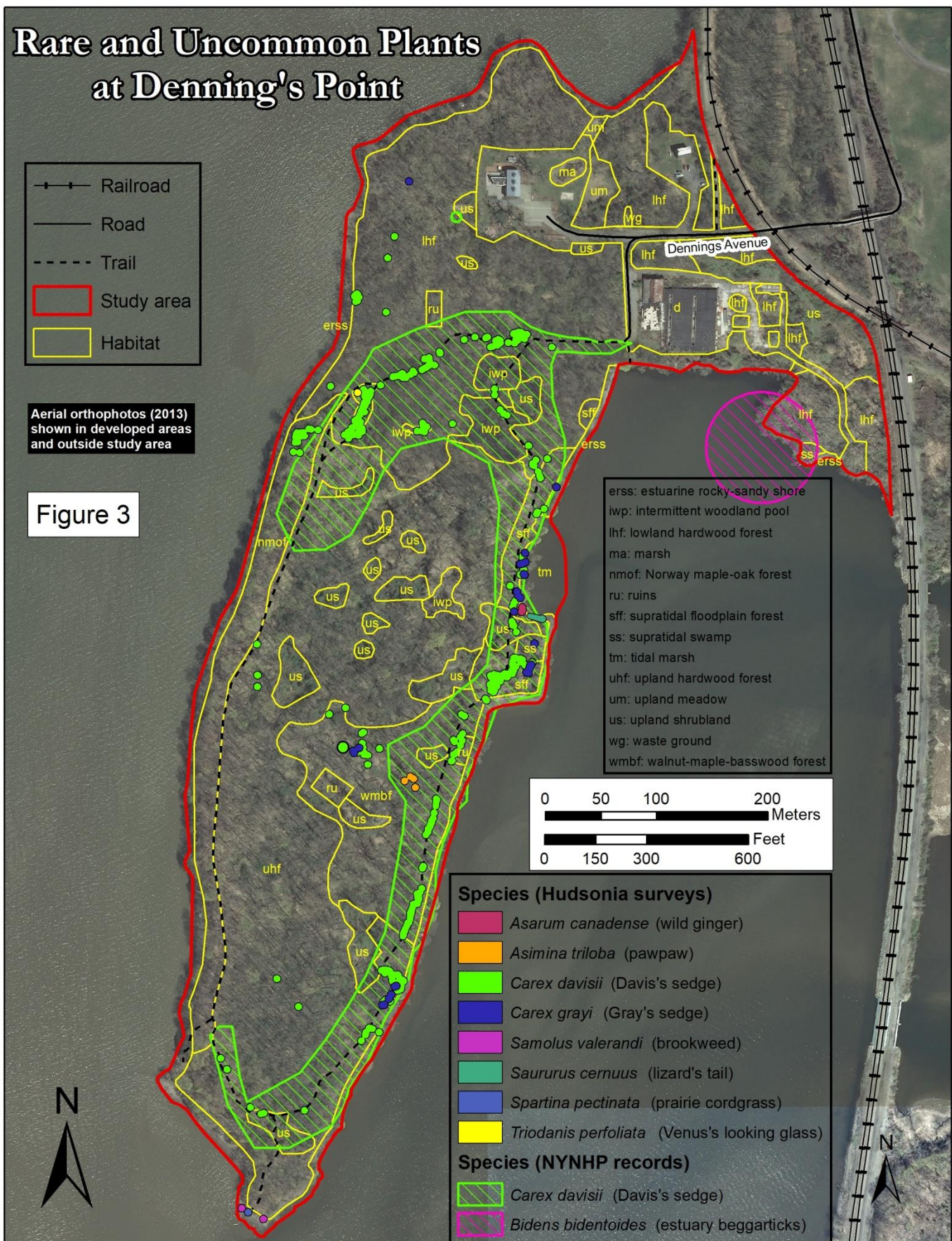
erss: estuarine rocky-sandy shore
 iwp: intermittent woodland pool
 lhf: lowland hardwood forest
 ma: marsh
 nmof: Norway maple-oak forest
 ru: ruins
 sff: supratidal floodplain forest
 ss: supratidal swamp
 tm: tidal marsh
 uhf: upland hardwood forest
 um: upland meadow
 us: upland shrubland
 wg: waste ground
 wmbf: walnut-maple-basswood forest



Species	
	<i>Aesculus parviflora</i> (bottlebrush buckeye) (unranked)
	<i>Ampelopsis glandulosa</i> (porcelain berry) (Tier 3)
	<i>Clematis terniflora</i> (Autumn clematis) (Tier 3)
	<i>Euonymus alatus</i> (winged euonymus) (Tier 4)
	<i>Humulus japonicus</i> (Japanese hops) (Tier 3)
	<i>Myriophyllum spicatum</i> (Eurasian watermilfoil) (Tier 2)
	<i>Phragmites australis</i> (common reed) (Tier 4)
	<i>Reynoutria japonica</i> s.l. (knotweed) (Tier 4/5)
	<i>Ulmus pumila</i> (Siberian elm) (Tier 3)
	<i>Viburnum plicatum</i> (Japanese snowball) (Tier 2)
	<i>Vincetoxicum nigrum</i> (black swallow-wort) (Tier 3)



Rare and Uncommon Plants at Denning's Point



Discussion

Management

The botany of Denning's Point is noteworthy because of the recovery from mining, agriculture, and horticulture; the number of large trees; the proliferation of non-native plants on disturbed soils; and the occurrence of rare plants, especially Davis's sedge. The Hudson River shores are crucial habitats for many uncommon and rare native plants and animals, and an environment that has been colonized (and continues to be colonized) by invasive plants. Denning's Point is a sentinel site for early detection, given potential pathways of dispersal to the area and the monitoring that CU|BIRE and collaborators can initiate and maintain. Though Denning's is not a candidate invasive species prevention zone (ISPZ), the 2008 and 2020 surveys confirmed the site does have ecosystems and species of interest worth protecting from large-scale competition with common invasive weeds such as tree-of-heaven and knotweed. Management and monitoring will be carried out by means of a collaboration of CU|BIRE in coordination with OPRHP and volunteers.

We understand that management of invasive plants must be strategic in an area where soils and vegetation were disturbed historically as much as is evident at Denning's Point. Some of the non-native weeds are so abundant and well-established that in practicality they cannot be controlled. Examples are Norway maple (*Acer platanoides*), multiflora rose (*Rosa multiflora*), and Japanese stiltgrass (*Microstegium vimineum*). Some of the non-native species are probably harmless to native biodiversity (e.g., wild garlic [*Allium vineale*], greater celandine [*Chelidonium majus*]). We selected several species for management either because they appear to be a threat to a specific habitat or species, or they are known elsewhere to be pestiferous and are just becoming established on Denning's Point.

1. Bottlebrush buckeye (*Aesculus parviflora*). There are two sizeable patches (colonies, see del Tredici 2000) of this densely growing, tall shrub in the interior near the mansion ruins. (One patch was recorded in 2008.) This species was very likely planted during the occupancy of the mansion and has persisted. Although not causing harm now, it has the potential to spread and form large colonies. Indeed, abundant seedling-size shoots (seedlings or ramets) around the fringes of the stands are evidence of propagation and slow expansion.

2. "Japanese" snowball (*Viburnum plicatum*). This tall shrub was not recorded in 2008. In 2020 we found two substantial patches and numerous small clusters and lone individuals in the interior of the peninsula. This species was probably planted near the mansion during its heyday, and may have been limited in extent, thus missed in the 2008 survey. *V. plicatum* is considered invasive in the Mid-Atlantic states (Coombs et al. 2020).

3. Knotweed (*Reynoutria japonica* s.l. = *Fallopia japonica* s.l. = *Polygonum cuspidatum* s.l.). This entity, in general, comprises two parent species (*R. japonica* and *R. sachalinense*) and their hybrids (*R. × bohemica*). It has been characterized as a hybrid swarm (Gammon et al. 2007; the term refers to hybrids that backcross with the parent species and form a complex with a spectrum of variation). Although *R. sachalinense* is larger and has leaves that are cordate at the base, compared to the smaller *R. japonica* with leaves truncate at the base (and there are other more subtle differences), many colonies seem intermediate, and for practical purposes it is not necessary to distinguish the parent species and hybrids. There is a large stand of knotweed on- and offsite near the railroads north of the entrance road and east of the caretaker's residence. This stand is beyond small-scale management; it will be interesting to see if the knotweed psyllid (*Aphalara itadori*, see Grevstad et al. 2018), as of 2020 being released in the New York for classical biological control of knotweed, has an effect on this large stand. However, at least three very small occurrences of knotweed elsewhere in the study area will be treated by frequent hand-pulling. This will help prevent knotweed from becoming invasive on the rest of the peninsula, which appears to be vulnerable due to historic soil disturbance and intensive visitor activity. In addition to its ability to form large colonies that are very difficult to eradicate, knotweed (like common buckthorn, see below) is a potential emodin emitter that could affect amphibian reproduction in the intermittent woodland pools or the supratidal swamp. One occurrence along the western trail and two along the western shoreline will be treated by hand-pulling at two-week intervals throughout the growing season. Pulled material will be carefully transported and disposed of within the large northeastern knotweed stand where it can do no additional harm should the material root. The eastern shore, which we did not see in its entirety, should be searched for additional stands. During the last two decades or so, knotweed has been spreading along the Hudson River shoreline, after colonizing in many places along tributary streams and highways.

4. Yellow iris (*Iris pseudacorus*). Yellow iris or yellow flag is very localized at Denning's Point, including in the supratidal swamp of the eastern promontory. Before attempting management, species identification of any iris clump should be confirmed in flower, because yellow iris and the native blue flag (*Iris versicolor*) are easily confused when vegetative. Yellow iris is widespread in the Mid-Hudson region, along the Hudson River and tributaries, and does not seem invasive (E. Kiviat, personal observation). However, inasmuch as there is very little of this species at Denning's and it occurs in an important habitat (supratidal pooled swamp), it seems prudent to consider it an EDRR (early detection, rapid response) species. The only large, consolidated stands of this species we have seen are in a large supratidal pool on Cruger Island in the Town of Red Hook (Kiviat, pers. obs.) and in a shrub swamp in the Town of Dover (Graham, pers. obs.).

4. Supratidal swamp and pool. This small area, about 300 m², occupies part of the promontory projecting into Denning's Point Bay a third of the way down the eastern shoreline of the

peninsula. Supratidal pools and supratidal swamps are rare habitats along the tidal Hudson River. This area supported winged monkeyflower in 2008 and has potential for other rare plants and animals. The habitat is being colonized by several non-native weeds, including common reed and yellow iris. All non-native plants will be cut or hand-pulled at frequent intervals (as often as biweekly) to inhibit growth and hopefully eventually kill them. Cut or pulled material will be carefully composted or dried on a non-soil surface to prevent rooting and establishment.

5. Common buckthorn (*Rhamnus cathartica*). Buckthorn is common in the study area and occurs in several habitats. We include management of this species because it is known to release a chemical called emodin that has been reported toxic to amphibian larvae (Sacerdote and King 2013), and buckthorn is also considered allelopathic (Warren et al. 2017). This would likely only be a threat to amphibians breeding in the intermittent woodland pool complex or the supratidal swamp pool, or to rare plants in the supratidal swamp pool. These pools will be monitored at three-year intervals. Common buckthorn growing within 5 m of the pools will be managed. Hand-pulling of seedlings and weed-wrenching of stems up to 7 cm dbh should effect control (Gale 2000).

6. Autumn clematis (*Clematis terniflora*). We found two patches of this plant and other scattered individuals. The species is as yet uncommon or rare in the Mid-Hudson region. It may be dispersing along the Hudson River East Shore Railroad or just blowing in the wind. Autumn clematis should be distinguished carefully from the native virgin's-bower (*Clematis virginiana*). Also, there is a case report of a chemical burn from topical medicinal use of autumn clematis leaves, so it should be handled with gloves and eye protection. We presume that hand-pulling, repeated as necessary, can control this species.

7. Water-chestnut (*Trapa natans*). Water-chestnut (Hummel and Kiviat 2004) dominates large areas of sheltered tidal shallows in the Hudson River estuary from Constitution Island Marsh north (with a few plants as far south as Iona Island Marsh). Denning's Point Bay was nearly all covered by water-chestnut in 2008 and 2020. The only other subtidal vascular plants in the bay are common coontail (*Ceratophyllum demersum*), a native species that grows in a narrow belt between the water-chestnut and the intertidal zone, and Eurasian watermilfoil (*Myriophyllum spicatum*; non-native, Tier 2). Water-chestnut is not amenable to simple management. However, if available effort permits, an experiment will be performed, by hand-pulling on plots (e.g., 10 x 10 m) annually, to see if spontaneous establishment of other native submergent species can be facilitated. Inasmuch as NYNHP expressed concern about water-chestnut impacts on estuary beggar-ticks, this situation will be assessed and if appropriate water-chestnut will be managed in a limited area at the beggar-ticks stand. Management of the watermilfoil is beyond the scope of this plan because of its abundance in the estuary and ability to propagate by fragmentation.

Additional EDRR species that will be considered for management, if labor and time permit, are winged euonymus (*Euonymus alata*), Japanese hops (*Humulus japonicus*), and black swallowwort (*Vincetoxicum nigrum*). These all have very limited occurrence on the peninsula, as far as we can tell (understanding that we were not able to survey and the construction site at the abandoned Noesting factory building and a few other small areas).

Monitoring

We recommend limited monitoring to help assess the potential harms of the spread of invasive plants on native flora. Monitoring must take place during the growing season (when there is mature foliage). The most important monitoring will be to check on the success of management described in items 1-7, above. Target species locations will be revisited at appropriate intervals to enable treatment of any regrowth or new colonization following initial treatment. Surveys will be annual initially, then less frequently when satisfactory control has been achieved.

Beyond these, we recommend the following monitoring tasks.

Davis's sedge. This species will be monitored at five-year intervals by mapping occurrences and counting "tufts" of this plant along the eastern trail and in the interior. Presence of potentially competing non-native species close to Davis's sedge plants will be recorded; star-of-Bethlehem and stiltgrass will be included in this attention.

Tree-of-heaven. In concert with the above surveys, tree-of-heaven (*Ailanthus altissima*) will be observed qualitatively along and near the eastern trail to discern if it is increasing substantially. We think this species will eventually decline due to the fungus that is killing it in the New York metro region (see Kasson et al. 2019).

False-indigo. False-indigo (*Amorpha fruticosa*), which is common along the Hudson River shorelines and present around the shoreline of Denning's Point, will be watched for potential inland spread, which is occurring to a limited extent in a few places (e.g., East Kingston and Barrytown). This shrub is considered invasive along the Connecticut River estuary but has not received much attention along the Hudson where it so far has not seemed to be a threat to rare species (Kiviat, pers. obs.).

Supratidal pooled swamp. The supratidal pooled swamp will be surveyed annually for winged monkeyflower as well as the efficacy of reduction of the invasive species (yellow iris, common reed, etc.).

Intermittent woodland pools. The intermittent woodland pools will be monitored, by walking around them, in alternate years, for colonization of knotweed or common buckthorn near the pools.

Water-chestnut. If a water-chestnut management experiment is undertaken, the experimental plots will be visited at low tide at least once during mid or late summer to survey for colonization by native subtidal flora such as common coontail, pondweeds (*Potamogeton* spp.), or wild-celery (*Vallisneria americana*) or by non-native species (principally Eurasian watermilfoil [*Myriophyllum spicatum*] and curly pondweed [*Potamogeton crispus*]).

Knotweed. The boundary of the large knotweed stand in the northeastern corner of the site will be marked with stakes and flagging where it extends onto the park property. This boundary will be inspected at two-year intervals to determine if the stand is expanding, stable, or contracting. If significant expansion is occurring over a period of a few years, containment treatments, such as frequent cutting or cutting followed by solarization, will be considered.

Multiflora rose. If time permits, multiflora rose will be monitored for potential decline due to rose rosette disease.

Flora survey. A general flora survey will be repeated in five to ten years. Increasing visitor use of the park makes it likely that new invasive species will be introduced and other floristic changes occur.

Spotted lanternfly. Spotted lanternfly, an invasive crop pest that is establishing in New York but has not yet been detected in the Hudson Valley, will be monitored for during appropriate seasons by checking tree-of-heaven along the eastern trail. This invasive plant is a preferred host and suitable sentinel host for the lanternfly.

The management and monitoring plan will be revised every five years. During the five-year period, individual management and monitoring tasks will be revised to benefit from field experience and new scientific information.

The finalization and implementation of this plan will be the purview of the State Office of Parks, Recreation and Historic Preservation and CU|BIRE.

Outreach and Engagement

Audience

Denning's Point is a Hudson River park with many nature-oriented visitors, constituting an important audience for invasive species education. The active interest and participation by

community members in programs and events offered by CUIBIRE offer a valuable opportunity to conduct invasive species public outreach and awareness activities. Clarkson's Beacon Institute and Hudsonia actively engaged a variety of demographics through educational outreach projects. This audience included grades P-12, and all ages for community volunteers who participated in scheduled events.

Public Education

Opportunities for outreach and engagement sought to engage a wide and diverse audience through means of virtual and in-person activities offered to the public. Early on in the project the CUIBIRE had limited access to in-person programming because of the COVID-19 restrictions implemented by gov't officials, Clarkson University, and other local authorities. Therefore, much of the outreach programming that was planned for the season shifted to either virtual interactions or were pushed back to the later months until some of the restrictions were lifted.

The CUIBIRE Invasive Species Project outreach staff consisted of Outreach Associate and PRISM Project Associate, Rebecca Rew, with assistance from Director of Environmental Programs, Asher Pacht, and Education Program Manager, Brigette Walsh. In addition, two part-time interns, Ashawna Abbott and Tony Shenderovich, were funded by the grant to assist with outreach and engagement activities. During July through October 2020 we developed informational resources including brochures, videos, and social media content. Our biggest effort was creation of invasive species videos and brochure/identification guide. Due to pandemic limitations, we placed more energy and emphasis on creating easily accessible and enjoyable informational videos as virtual resources for our community of students and plant and ecology enthusiasts. This can be an important resource and model for both CUIBIRE and the PRISM Partners going forward. The videos are expected to reach a wide range of ages and demographics via digital communication tools such as YouTube. After presenting our work at a Partners meeting, several have reached out to our team to explore collaboration on media creation and social media engagement.

The CUIBIRE team reached a wide audience through virtual and in-person means. Educational videos about non-native species were produced and posted to social media platforms such as Facebook to share invasive species related content. For in-person education, CUIBIRE offered socially distanced outdoor programming. The number of participants was limited for each event to ensure safety, and required all participants adhere to pandemic guidelines. As a result, our in-person reach was less than proposed; however, we adapted by shifting effort towards virtual education. We did succeed in proving out some engaging in-person event models, which we plan to deploy in future programming seasons.

Videos, Social Media, and Marketing Materials

In total, 25 non-native species videos (Table 3) were completed over the course of the project. Each video is approximately 1-2 minutes in length and will be available on our YouTube channel “Clarkson’s Beacon Institute” beginning in spring 2021. Our goal is to teach the general public some of the key identifying features of a variety of non-native plants that are found at Denning’s Point. Some videos include fun facts as well. Overall, the videos are expected to reach a wide audience by including both audio and visuals such as images, video, and text overlays. By utilizing the YouTube platform as our primary means for sharing, subtitles will be automatically generated for those hard-of-hearing or deaf. The text overlays provided in the videos without subtitles, however, generally cover the information needed for identification purposes. Videos will be launched based on the timing of bud burst, flowering, or other times that a plant is most conspicuous during the year. When the videos are uploaded to YouTube, the video description will include advanced information about each species and will provide additional references for interested viewers. All videos feature the Lower Hudson PRISM logo.

Table 3. Videos completed during the course of the project. An asterisk (*) indicates that the video does not include audio narrations. See taxonomic notes from Table 2.

Scientific Name	Common Name	LH PRISM Tier	Video	Flowering Period
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	2	no	June-July
<i>Viburnum plicatum</i>	Japanese snowball	2	no	April-May
<i>Ampelopsis glandulosa</i>	porcelainberry	3	no	Mid-late summer
<i>Cardamine impatiens</i>	narrowleaf bittercress	3	no	May-September
<i>Clematis terniflora</i>	autumn clematis	3	yes	Late summer- fall
<i>Humulus japonicus</i>	Japanese hops	3	no	July-August
<i>Lonicera maackii</i>	Amur honeysuckle	3	yes*	Late spring (May-June)
<i>Trapa natans</i>	water-chestnut	3	no	Mid to late July
<i>Vincetoxicum nigrum</i>	black swallowwort	3	yes*	Early summer
<i>Acer platanoides</i>	Norway maple	4	yes	May
<i>Ailanthus altissima</i>	tree-of-heaven	4	yes	Early summer
<i>Alliaria petiolata</i>	garlic mustard	4	yes*	Late April to May
<i>Artemisia vulgaris</i>	mugwort	4	yes	Late summer-early fall
<i>Berberis thunbergii</i>	Japanese barberry	4	yes	April-May
<i>Celastrus orbiculatus</i>	Oriental bittersweet	4	yes	May-June
<i>Elaeagnus umbellata</i>	autumn-olive	4	yes	Early summer: June and July
<i>Euonymus alatus</i>	winged euonymus	4	yes	June-July
<i>Iris pseudacorus</i>	yellow iris	4	yes	Late May into early July
<i>Lonicera japonica</i>	Japanese	4	yes*	May-frost
<i>Lonicera × bella</i>	Bell's honeysuckle	4/5	yes*	Mid to late spring
<i>Lythrum salicaria</i>	purple loosestrife	4	no	Mid-June
<i>Microstegium vimineum</i>	Japanese stiltgrass	4	yes	Late summer-early fall

<i>Morus alba</i>	white mulberry	4	no	Spring: May-June
<i>Phragmites australis</i>	common reed	4	no	Late July - August
<i>Prunus avium</i>	sweet cherry	4	yes	April-May
<i>Reynoutria japonica</i>	Japanese knotweed	4	yes*	August
<i>Rhamnus cathartica</i>	Common buckthorn	4	yes	Spring
<i>Robinia pseudoacacia</i>	black locust	4	yes	May to June
<i>Rosa multiflora</i>	multiflora rose	4	yes*	Late spring and early summer
<i>Rubus phoenicolasius</i>	wineberry	4	yes*	May
<i>Amorpha fruticosa</i>	false-indigo	5	yes	April - June
<i>Ligustrum vulgare/obtusifolium</i> var.	European/border privet	5/3	yes*	April - June
<i>Ornithogalum umbellatum</i>	star-of-Bethlehem	5	no	Spring-early summer
<i>Reynoutria sachalinensis</i>	giant knotweed	5	yes*	August
<i>Vinca minor</i>	Periwinkle	5	yes	March - April (sometimes again in fall)
<i>Acorus calamus</i>	Sweetflag	Unranked	no	Late spring - early summer
<i>Aesculus parviflora</i>	bottlebrush buckeye	Unranked	yes	June-July
<i>Catalpa bignonioides</i>	northern catalpa	Unranked	yes	May-July
<i>Chelidonium majus</i>	greater celandine	Unranked	yes	Mid-May - early October
<i>Crataegus monogyna</i>	common hawthorn	Unranked	no	March - June
<i>Myosoton aquaticum</i>	water chickweed	Unranked	no	Late spring - late summer
<i>Rubus bifrons</i>	Himalayan blackberry	Unranked	no	June - August

During the project, 20 Facebook posts were created about invasive species. In addition, Facebook was utilized for creating events for in-person public programs. When applicable, Clarkson's Beacon Institute recognized the Lower Hudson PRISM by tagging their Facebook page in posts relating to invasive species.

A press release to regional media will be published this winter by Clarkson's Media Relations department. The press release will credit LHPRISM and discuss the scope and findings of the project.

Promoting public awareness of invasive species was a major component of this project. One tactic to accomplish this was through support of the PlayCleanGo campaign. Clarkson's Beacon Institute purchased several PlayCleanGo products such as "STOP THE SPREAD" rack cards, PlayCleanGo face masks, and "WATCH OUT!" cards, and a boot brush cleaning station in effort to increase public awareness of and active engagement in preventing the spread of invasive plants. Installation of the boot brush cleaning station is expected in spring of 2021.

Spotted lanternfly awareness was a priority and it was emphasized as a focal species when interactions between the public took place. Multiple Facebook posts were created on this invasive insect.

Clarkson's Beacon Institute team developed an invasive species tri-fold brochure titled "Protect Our Lands and Waters," which will be available to the public in 2021. The content of the brochure aims to inform on how the LHPRISM tier ranking system yields strategic management of invasive species to protect our lands and waters. It also gives the audience advice on what they can do to help stop the spread of invasives. This brochure will be an educational resource to all park visitors and to the Lower Hudson PRISM. We expect the information presented in the brochure to remain relevant for approximately 5-10 years, but will be revised as needed. This brochure aims to educate the public on how the Tier categorization set forth by the LHPRISM can be used for strategic management. This information presented in the brochure is expected to be the focus for future nature walks with an emphasis of Tier 1, 2, and 5 species.

Within the brochure there is a mini plant identification challenge. At the bottom of this section is a QR code for an extended PDF version of 80 different native and non-native plant species for visitors to consult while at Denning's Point. This Plant ID Scavenger Hunt will be handed out to participants for guided nature walks.

In-Person Programs

Invasive species identification trainings were administered during the fall. In total, 3 public programs were delivered in-person. The invasive plant identification trainings from October 4, October 17, and November 15 reached a total of 30 participants. Due to the pandemic, registration for each event was limited to 10-12 participants. Spotted lanternfly awareness was emphasized at each program.

Beginning October 3rd, 2020 the Water Ecology Center (WEC), 199 Denning's Ave, Beacon, NY and gallery location, 199 Main Street, Beacon, were reopened for public visiting hours on Saturdays. Brochures on invasive species topics and awareness were made available to the public for pickup. In both locations, there are informational tables with a variety of brochures as well as a volunteer service agreement for those interested. Interactions with visitors involved conversations about upcoming events and information about the ongoing Invasive Species Denning's Point Project. No volunteers were brought onto the team this season, due to the late start of the project. Prior to Thanksgiving break, the WEC was closed to the public for the winter, however the gallery remains open to the public during the winter season.

Community Science

The CU|BIRE team was previously unfamiliar with the use of *Seek by iNaturalist* community science applications. Throughout the project, Clarkson's Beacon Institute team utilized *Seek by iNaturalist* to identify species throughout Denning's Point. We also advised visitors and program participants to use the applications. This increased our opportunities to engage with people despite the challenge of in-person programming during the pandemic.

P-12 Education

The *Mother Nature and Me* (MNM) Program was launched in 2020 in order to still reach smaller groups of students and families seeking outdoor learning opportunities. The MNM program allowed us to touch on invasive species topics such as a general overview of the impacts invasive species have on ecosystems. In one session, the group focused on the emerald ash borer invasion, and then later introduced the spotted lanternfly invasion. Students left with knowledge of how to reduce the spread of invasive insects and an increased awareness of invasive species in general.

CU|BIRE expects to continue incorporating invasive species activities into P-12 programming as our reach to students expands.

Looking Ahead

Public Education

Videos, Social Media, and Marketing Materials

Going forward, all invasive species non-personal interpretive materials created will be available to the public through various outlets such as social media, newsletters, webinars, programs, and as hard copies in our facilities.

Working closely with DEC and Parks we will continue to look to for their advice on upcoming issues and stay up to date on potential invasions to the Hudson Valley. Considering that Denning's Point Park is highly visited by tourists, we hope to support this initiative by being a central place for disseminating invasive species information. Educational brochures and handouts will continually be available to visitors. Such brochures may include resources from the LHPRISM website, NYSDEC website, NYSOPRHP, and those developed by Clarkson University. In addition, we strongly support the messaging set forth by the PlayCleanGo campaign and plan to continue supporting this initiative. Much of the leftover PlayCleanGo products such as rack cards and species information cards purchased in 2020 will continue to be available for visitors going into 2021.

The CU|BIRE team expects to launch the invasive species videos in a specific order that correlates with the timing of conspicuous identifying features. We plan to launch many of the videos of invasive species that are commonly planted as ornamentals early in the spring with messaging around what species to choose for landscaping purposes. The target audience will be gardeners, landscapers, and homeowners who are preparing to select plant species for an area. We hope to encourage them to choose native, non-invasive plants as an alternative to non-native, invasive plants. Timing will be critical for proper delivery of this message, but we believe it will be feasible.

Webinars, social media content, and in-person programs will be administered in a similar manner as the videos, in which content will correspond to the cyclical changes and processes observed in nature. Topics to be discussed will revolve around ecological and biological concepts of invasive species. Clarkson's Beacon team expects to continue tagging the LH PRISM in relevant posts and videos going forward. The CU|BIRE team is working towards sharing content on Facebook at least twice a week to continue advancing its virtual reach. Content composed of invasive species subjects will continue to be prioritized.

Community Science, Volunteer, and Research Opportunities

Research and community science are at the forefront of Clarkson's Beacon Institute's core mission and our team will continue to develop opportunities that engage the local community in invasive species initiatives. Last summer, most days that the outreach crew was out recording videos, there were frequently interactions with individuals who were searching for volunteer opportunities. Due to the pandemic, there is a great need and interest by the community to know what they can do to get involved with invasive species initiatives.

We expect to promote volunteer opportunities for the following spring and summer seasons. Education activities will include creating more videos and social media content, and developing content for informational walks that involve volunteers. Clarkson's Beacon Institute hopes to engage volunteers in fieldwork and research activities such as invasive species removal efforts, surveys for spotted lanternfly and other high alert species, community science projects like iMapInvasives and iNaturalist, and other relevant fieldwork efforts involving invasive species.

Trainings around Tier 1, 2, and 5 species are still a priority for CU-BIRE. This past season, the Beacon team focused on teaching the public how to identify the Tier 2 and Tier 5 species that are found in Denning's Point Park. In the future, we expect to monitor for other potential invaders and educate the public about why these species are prioritized for survey and management efforts. CU-BIRE's outreach team expects to continue learning how to identify species ranked as Tier 1, Tier 2, and Tier 5 species by the Lower Hudson PRISM.

Clarkson Professor Shane Rogers is conducting an ongoing biomass and seed viability study of water chestnuts in the Hudson River at the north and south bays of Denning's Point. CU-BIRE will continue to support these research efforts with an intention to publish findings in the near future. Based on this work, and the recommendations of this report, CU-BIRE will explore options for pilot management and mitigation strategies, in coordination with appropriate public agencies. Likewise, CU-BIRE will actively explore Clarkson faculty collaboration to involve researchers and students in the terrestrial plant surveys, monitoring and management efforts.

In 2020, due to pandemic concerns, CU|BIRE was able to participate in a more limited way than planned in New York's Invasive Species Awareness Week (NYISAW, May 16-23). However, the team plans to offer programming for NYISAW for 2021, and annually going forward. In

addition, we plan to continue to host and organize public events to highlight issues around invasive species. In spring 2021, we plan to host a “Spring Into Action Day,” which will comprise a ribbon cutting event for our boot brush station, distribution of informational invasive species brochures and an invasive species nature walk.

P-12 Education

(1.) School Group Workshops

This project has equipped the team with knowledge and expertise in the realm of invasive species identification and ecology. CUJBIRE plans to offer invasive species programming to P-12 students beginning spring 2021. Clarkson’s Beacon outreach team is adding an invasive species workshop to the program menu, with the first virtual school session scheduled with a Peekskill public high school class in January 2021. This workshop will be strategically implemented, to be intertwined with already discussed ecological themes and topics such as adaptations, biodiversity, and ecosystems. Upon request, we hope to do more in-depth trainings/workshops on invasive species. As with the majority of our workshops, curriculum will be based on the NYS P-12 Science Learning Standards, by emphasizing standards relating to invasive species underlying themes and concepts. In addition, Clarkson’s Beacon Institute’s “Mother Nature and Me” program sessions will continue to integrate invasive species themes and concepts.

Because of the spread of tree-of-heaven on Denning’s Point, we expect to survey for early detection of spotted lantern fly populations as a training exercise for school groups and volunteers.

(2.) Summer Program Workshops and Curriculum

Summer 2020 did not allow for in-person summer programs at scale at Denning’s Point, due to pandemic limitations. CUJBIRE is now working towards alternative solutions to provide virtual camps to students across Dutchess County for summer 2021. Invasive species is expected to be a theme covered during the summer program sessions.

Other Education Efforts

Engaging Contractors and Partners

Beyond activities for the general public, CUJBIRE has the opportunity to engage a construction company, specifically Meyer Construction, working to construct the Beatrice G. Donofrio Environmental Education Complex, a building on Denning’s Point. Much of the land near and around the construction site was unable to be surveyed in 2020 due to this construction of the new Clarkson University center. Going forward, the team plans to survey the area near and around the construction site that may not have been reported in the 2020 survey. The concern of the increased vulnerability of invasive species colonizing the area due to the soil disturbance is also on Clarkson’s Beacon Institute’s monitoring radar. We are fascinated by the possibility for new introductions and how to prevent them. We anticipate engaging an intern in

a project in the future to complete the survey. We have also already had conversations with the construction team, Meyer Construction, regarding the connection between invasive species and their ability to easily colonize disturbed areas. Advancing the knowledge of Meyer regarding invasive species will therefore be prioritized throughout the duration of the construction project. Monitoring the area post-construction is also expected and is noted in the management plan section of this report.

CU-BIRE also has the opportunity to develop workshops for the public to learn about native landscaping alternatives to non-natives by involving the Water Ecology Center's landscaping crew. Participants would learn about the skills and knowledge required to plant and maintain native plants while also learning how to identify native and non-native plants.

CU-BIRE will endeavor to continue or expand engagement with the following partners going forward:

- Beacon Sloop Club
- Scenic Hudson – Long Dock Park and Madame Brett Park
- Wolf Tree Design
- Hudsonia
- Riverkeeper
- LH PRISM
- Beacon City School District

We support the messaging set forth by the PlayCleanGo campaign and plan to continue supporting this initiative. PlayCleanGo educational products purchased via the grant will continue to be available for visitors into 2021.

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