COMMONWEALTH of VIRGINIA

Management Plan for Goodwin Islands: Chesapeake Bay National Estuarine Research Reserve - Virginia

Prepared by:
Virginia Department of Conservation and Recreation
Division of Natural Heritage

Natural Heritage Technical Report 05-03
2005

DCR
Department of Conservation & Recreation
CONSERVING VIRGINIA'S NATURAL AND RECREATIONAL RESOURCES

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U.S. DEPARTMENT OF COMMERCE

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This document may be cited as follows:
Erdle, S. Y. and K. E. Heffernan. 2005. Management Plan for Goodwin Islands: Chesapeake Bay National Estuarine Research Reserve -Virginia. Natural Heritage Technical Report #05-03. Virginia Department of Conservation and Recreation, Division of Natural Heritage. Richmond, Virginia. 46 pp. plus appendices.

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ACKNOWLEDGMENTS

Completion of this project was made possible through a contract and arrangement between Chesapeake Bay National Estuarine Research Reserve in Virginia / Virginia Institute of Marine Science and the Department of Conservation and Recreation, funded through the Reserve operational Grant No.NA03NOS42001323 of the National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resource Management, Estuarine Reserves Division.

We recognize and thank William G. Reay, Director of the Chesapeake Bay National Estuarine Research Reserve System, for supporting biological research and management planning, and for his unfailing assistance with this plan. Additionally, we'd like to acknowledge the Management Plan: Chesapeake Bay Virginia, National Estuarine Research Reserve System (1991) from which we borrowed heavily and/or copied outright in some instances.

This Management Plan for Goodwin Islands was compiled, developed, and completed with the combined expertise and reviews of many individuals from Department of Conservation and Recreation, Division of Natural Heritage (DCR-DNH), as well as individuals representing other state, federal, and private agencies, and private citizens. The authors especially thank numerous boat captains and field assistants – VIMS; Anne Chazal, Phil Coulling, Rick Myers, Tom Smith, Johnny Townsend, and Nancy VanAlstine - DCR-DNH.

Management Plan for Goodwin Islands: Chesapeake Bay National Estuarine Research Reserve -Virginia

PLAN SUMMARY

The Goodwin Islands are one of the four reserve components of the Chesapeake Bay National Estuarine Research Reserve System in Virginia (CBNERRVA). The National Estuarine Research Reserve system (NERRS) is administered nationally by the National Oceanic and Atmospheric Administration (NOAA) for the primary purpose of addressing national estuarine research, education, and management issues.

CBNERRVA is operated by the Virginia Institute of Marine Science (VIMS) within the College of William and Mary. Sites currently comprising CBNERRVA are Goodwin Islands, Catlett Islands, Taskinas Creek, and Sweet Hall Marsh. The Goodwin Islands are owned (fee-simple) by VIMS. Resource management and public use at Goodwin Islands is coordinated by the CBNERRVA program.

The purpose of this management plan is to guide an adaptive resource management process that protects natural resources on Goodwin Islands. This plan has a timeline of approximately five years (2005-2010). Natural resources on this site include: nesting habitat for a multitude of bird species, including American Oystercatchers, Barn Owls, and Great Blue Herons. The Islands also provide important migratory bird stopover habitat, serve as spawning beach for horseshoe crabs, and support several historic and pre-historic sites of historical and cultural value. Issues requiring management attention on Goodwin Islands include invasive species and unauthorized public use of the reserve.

INTRODUCTION

Site Purpose

The core mission of CBNERRVA is to preserve a network of reserves that represent the diversity of coastal ecosystems found within the York River estuary and its principal tidal tributaries and to manage these reserves to support informed management of coastal resources through estuarine research, education, stewardship, and advisory service.

In this context, Goodwin Islands Reserve, an archipelago of marsh islands and associated biological communities, was selected as a site representing high-salinity (Figure 1).

Policy and Management Approach

Management policies for CBNERRVA are provided in Appendix A, and can be summarized as follows:

> *The health and natural integrity of reserve sites will be protected and, where necessary, restored, to provide a productive, stable environment for research,*

> *education, and compatible traditional activities. Reserve programs, activities, and facilities will not augment or replace the conservation, research, education, and historical uses of the site. Reserve programs will also complement traditional uses outside reserve boundaries. Resource protection and non-manipulative research will be given the highest priorities in the management of reserve sites (VIMS, 1991).*

The operation and management of CBNERRVA is the responsibility of VIMS, and is directed by the program director. The Virginia Department of Conservation and Recreation, Division of Natural Heritage (DCR-DNH), as well as additional state and federal agencies, and private organizations are available to serve in advisory roles and provide technical assistance in management of CBNERRVA sites. Visitor use of Goodwin Islands Reserve is by permission of the CBNERRVA director (see Public Access Plan, Appendix B).

BACKGROUND INFORMATION

Description and Location

The Goodwin Islands are located at the mouth of the York River within the Mobjack embayment of the Western Shore of the Chesapeake Bay. This location represents polyhaline salinity conditions (16-22 parts per thousand (ppt)) within the CBNERRVA. The site is an archipelago of marsh islands surrounded by submerged aquatic vegetation (SAV) beds, oyster reefs, and shallow open estuarine waters (VIMS, 1991).

Climate

While detailed climatic data are not specifically available for Goodwin Islands, data for nearby Langley Air Force Base, VA (located just 15.1 kilometers SSE) describe an average annual minimum temperature of 10.9° C (51.7° F) and an average annual maximum temperature of 19.8° C (67.7° F) from 1971 – 2000. Average monthly maximum temps for the same time period are in July (30.4 ° C; 86.7° F) and the average minimum monthly temps are in January (0.1° C; 32.1°F). Precipitation is generally well distributed throughout the year with slightly more than average rainfall in the summer and slightly less in the autumn. Average total precipitation for the same period is 121 centimeters (47.5 inches) (Southeast Regional Climate Center 2005). Soils tend to be wettest in winter and early spring due to reduced evaporation and evapotranspiration. Snow can be expected any time from November to April. The average growing season length is approximately 197 days, and although variable, first fall frosts usually occur in late October and the last spring frosts are often in early to mid-April.

Goodwin Islands Reserve is vulnerable to hurricanes, tropical storms, and northeasters that affect the Chesapeake Bay and surrounding shores. Northeasters, usually the least severe of the three, tend to occur in the autumn, winter, and spring. Hurricanes and tropical storms are less frequent, generally more severe, and usually occur in late summer through autumn. Some northeasters may reach the strength of a tropical storm. These storm events can cause drastic changes to the physiography of the reserve and surrounding area. Most recently, Goodwin Islands Reserve was completely submerged during Hurricane Isabel in September

2003. Changes in the shoreline and vegetation remain apparent in 2005, and wrack lines from the storm can be found in the upland forest near the center of the largest island.

Geology, Landforms, Soils

The York River watershed covers approximately 6915 square kilometers (2,670 square miles), and is one of the Bay's fastest growing tributary basins. Williamsburg, West Point, and Ashland are among the largest urban areas in the watershed.

The Mattaponi and Pamunkey rivers converge to form the York at West Point. Upper reaches of the river make up some of the most pristine freshwater resources on the U.S. East Coast, and unlike the James River to the south and the Rappahannock River to the north, most of the York's tributaries remain free flowing. Headwaters of the York River are in Orange and Louisa counties, and the river empties into the Bay at Yorktown/ Gloucester Point. The York and its tributaries are 226 kilometers (140 miles) long, and its watershed comprises about 12 percent of Virginia's portion of the Chesapeake Bay basin. About 73 percent of the watershed is forested, 19 percent is agricultural, and 8 percent is urban (DCR-Division of Soil and Water Conservation (DSWC) web page, 2005).

The Goodwin Islands consist of ridge-and-swale topography that developed from a series of beach ridges deposited during a late Pleistocene regressing of the sea (Leonard, 1986). Beach ridges are sandy and gravelly features that may develop during storms or during continuous spring-tide high waters.

The stratigraphic sequence of sediments encountered on the Goodwin Islands is Yorktown Formation (Pliocene), Tabb (Pleistocene), Poquoson (Pleistocene), and Holocene. Vegetation patterns reflect the topography, with forests and upland vegetation on the ridges and marshes in the swales. Predominant soil types on the Goodwin Islands are classified as Tomotley-Altavista-Dragston. This soil association consists of deep, poorly drained to moderately well drained, to somewhat poorly drained soils that dominantly have a loamy subsoil and are almost level (VIMS, 1991).

Erosional patterns around the perimeter of Goodwin Islands show a net loss of mass over time. Deposition of dredge material on Goodwin Islands in the 1950s acted to increase the mass of the main island for a time, but did not stop or slow down the ultimate loss of acreage to erosion (VIMS, 1991). Sea level rise in this area of the Chesapeake Bay is approximately 4 mm/year (USGS, 1998).

Hydrologic Conditions

Circulation patterns around the Goodwin Islands are strongly influenced by the discharge of the York River and wind patterns in Mobjack Bay and the Chesapeake Bay. Salinities are similar to those of adjacent Bay waters (16 – 22 ppt) and nearshore waters are shallow and clear enough to permit light penetration for some SAV growth. Surface water temperatures range from 5.6° C to 26.8° C (Brooks, 1983).

Overall phosphorus levels in the York River meet EPA and state criteria -- both nitrogen and phosphorus levels are below the state median -- but phosphorus levels are rising in the

middle section, and nitrogen levels are rising throughout the river. Approximately 57 percent of nitrogen and 47 percent of phosphorus reaching York waters originate from nonpoint sources. The river is similar to its northern neighbor, the Rappahannock River, in that most dissolved oxygen problems occur at the mouth of the river. Water quality in this area is sometimes too poor to support growth of SAV, and in general, SAV beds are diminishing. Conditions at the river's confluence with the Chesapeake Bay are marginal for some fish species and some benthic organisms (DCR-DSWC web page, 2005).

Site History

Although archeological surveys have not yet been conducted at Goodwin Islands, both amateur and professional collectors report finding projectile points, flakes, cores, and some tools dating back to the woodland period. Some of these prehistoric artifacts such as projectile points are often uncovered by storm events, washed up onto the beaches, or retrieved offshore by commercial fisherman. There have been "several prehistoric sites recorded along a stretch of the bank of the York River, from and including the Amoco refinery and the shoreline east," (Bott, 1980). Additionally, a portion of the York River channel, located northwest of Goodwin Islands has been the subject of several studies which conclude that "there are 28 potentially significant targets" in this area, and that "each of these targets could be associated with the remains of a potentially significant shipwreck," (Watts, 1995). Artifacts regularly collected on and around Goodwin Islands likely originate from both terrestrial and underwater sites (Hubbard, pers. comm., 2004).

The Islands were originally patented to John Chew in 1637 by John Harvey, Royal Governor of Virginia. When Chew's heirs deeded the property to Major James Goodwin in 1660, the Islands received the name that persists to this day, and remained in the Goodwin family until 1877. Since that time, the Islands have been owned by the Norfolk Fisheries Corporation (when they were used as a fisheries plant), the Goodwin Islands Land Corporation, the Goodwin Islands Development Corporation, the Environmental Preservation Company, and were finally donated to the Endowment Association of the College of William and Mary in Virginia Inc. In 1990, the Islands were donated by the Endowment to the College's Board of Visitors for incorporation into the CBNERRVA.

Surrounding Land Use

Approximately half of York County's land area is owned by the federal government (military installations, or national park property), or by adjacent jurisdictions (reservoir watersheds). Federal land holdings near Goodwin Islands include the U.S. Coast Guard Reserve Training Center, Naval Fuel Depot, Colonial National Historical Park, Naval Weapons Station, Cheatham Annex, and Camp Peary. Two major industrial plants (Amoco Oil Refinery and a Dominion Power generating plant), the York River Sewage Treatment Plant, and a county landfill are located on the Goodwin Neck Peninsula. Other commercial land uses in the vicinity of Goodwin Islands include neighborhood conveniences and infrastructure in Yorktown and Seaford, and general tourist and commercial activities in Yorktown and along U.S. Route 17. Water-related commercial activities include marinas, seafood businesses, and boat building (VIMS, 1991).

Current recreational uses of Goodwin Islands include both authorized and unauthorized uses. Authorized uses include research, education, and bird watching. Unauthorized uses include artifact collection and deer hunting. Waters surrounding the islands support commercial and recreational fishing and crab harvest in accordance with state laws. Overseeing these uses represents a significant management challenge to VIMS.

Associated Natural Resources

Horseshoe crabs. The horseshoe crab (*Limulus polyphemus*) is an ancient, benthic arthropod that uses both estuarine and continental shelf habitats (Schrading et al., 1998). Horseshoe crabs, easily recognized by their large, rounded shell and spiked tail, have existed almost unchanged for approximately 360 million years. They spawn annually on sandy beaches from Virginia to New Jersey, including Goodwin Islands (Reay, pers. comm., 2004). Spawning activity is nocturnal, around the time of full moons in late spring/early summer. Protein rich eggs laid by horseshoe crabs are a primary seasonal food source for many species of shorebirds, including Sandpipers, Plovers, and Ruddy Turnstones, which feed on the eggs to increase body weight for migration. In addition to providing a crucial food source for many shorebirds, horseshoe crabs are also a preferred prey for juvenile Atlantic loggerhead turtles (*Caretta caretta*), a species federally-listed as Threatened, and are an integral part of the marine ecosystem. The horseshoe crab is specifically mentioned here because at least 20 species of shorebirds rely on horseshoe crab eggs to replenish body fat during migration (Berkson and Shuster, 1999; Travelsted, pers. comm., 1999). At the confluence of the York River and the Chesapeake Bay, Goodwin Islands are advantageously located for both migrating shorebirds and sea turtles. In recent years, horseshoe crabs have been harvested as bait for catching eels, conch, and catfish. The medical industry now uses blood from the horseshoe crab for testing in medical research (Berkson and Shuster, 1999; Walls, 2001). Declining migratory bird numbers have caused researchers to become concerned about horseshoe crab abundance as well as harvesting methods and rates.

Bird habitat. Marsh, scrub, and overwash habitat at Goodwin Islands support numerous breeding birds, including American Oystercatchers (*Haematopus palliatus*), (Watts, pers. comm., 2004). American Oystercatchers are on the Audubon Watchlist and are listed as a high priority species in The U.S. Shorebird Conservation Plan (U.S. Fish and Wildlife Service, 2004).

The Center for Conservation Biology (College of William and Mary) has installed nest boxes for Barn Owls (*Tyto alba*) on Goodwin Islands. These boxes are part of an ongoing study of Barn Owls, a species experiencing population declines throughout most of the U.S. (Reay, pers.comm. 2005).

Historically, Goodwin Islands supported a large nesting colony of Great Blue Herons (*Ardea herodias*). Great Blue Herons build large nests in or near the tops of tall trees, usually located near feeding areas. As waders, Great Blue Herons eat an array of fish, insects, mammals, amphibians, crustaceans, reptiles, and occasionally other birds (Butler, 1992). They are extremely sensitive to human disturbance during the nesting and fledging season, which runs from March through August (Watts and Bradshaw, 1994). By the late 1980s, the colony on Goodwin Islands had grown to approximately 150 pairs, and began to split up, as

small groups of birds moved away. Aerial surveys of Bald Eagle nests and heron nest colonies are flown annually by staff of the Center for Conservation Biology, and the annual survey in 2004 confirmed that a small residual heronry remains on Goodwin Islands (Watts, pers. comm., 2004).

Until a hurricane in the fall of 2003 destroyed the nest, at least one pair of Bald Eagles nested at Goodwin Islands. After the nest and trees were blown down, the pair moved to a location closer to the Amoco refinery and has since established a productive nest there. While Bald Eagles continue to use Goodwin Islands extensively for roosting, loafing, and foraging, because there is presently no appropriate substrate (nesting trees) it is unlikely that another pair will establish a nest site until such time as trees become large enough to support a nest (Watts, pers. comm., 2004).

Submerged aquatic vegetation. Historically, Goodwin Islands sheltered large beds of SAV. Numbers and extent of SAV beds have declined in recent years, prompting annual ongoing monitoring programs (VIMS, 1991). In 2003, there were 224 hectares (553.52 acres) of SAV surrounding Goodwin Islands (Orth et al., 2004).

NATURAL HERITAGE RESOURCES

Overview

Natural heritage resources are defined in the Virginia Natural Area Preserves Act (Section 10.1-209 through 217, Code of Virginia), as "the habitat of rare, threatened, or endangered plant and animal species, rare or state significant natural communities or geologic sites, and similar features of scientific interest benefiting the welfare of the citizens of the Commonwealth." Natural heritage resources are the most likely natural resources to be lost without conservation action in the near future. DCR-DNH inventories and compiles lists of the natural heritage resources of the state.

Biodiversity Significance

A variety of rarity patterns exist based on the geographic range, habitat specificity and local abundance of species (Rabinowitz, 1981). Standard Natural Heritage methodology ranks plants, animals, and natural communities on two scales of rarity. The global rank (G-rank) and state rank (S-rank) are based on the number of occurrences of a species at a global scale and state scale, respectively (see Appendix C). G- and S-ranks help direct conservation actions to the rarest species and communities since these are usually the most vulnerable to extinction.

Natural Communities

The inventory and classification of natural communities constitute an important "coarse-filter" approach to biological conservation that ensures the protection of diverse organisms. The identification and protection of excellent examples of all natural community types facilitates the protection of the majority of component native plant and animal species, including a host of taxa too cryptic, poorly known, or numerous to receive individual management strategies.

At present DCR-DNH classifies communities principally at the level of *ecological community group*, which represents a broadly defined unit based on combinations of topographic, edaphic, physiognomic, and gross floristic similarities (Fleming et al., 2004).

Goodwin Islands supports several ecological communities. A general natural community map (Figure 2) has been developed based on vegetation sampling and a review of aerial photographs. While this map is only a coarse representation of the actual, intricate vegetation patterns on the ground, it provides adequate information from which to develop management units for use in resource stewardship.

Given below are brief descriptions of the primary ecological community groups and their respective ecological community type(s) occurring at Goodwin Islands.

Tidal Mesohaline / Polyhaline Marsh. Depauperate salt marsh vegetation occupies approximately 80% of Goodwin Islands. This ecological community group typically occurs under tidal conditions subject to salt concentrations greater than 5 ppt.

Several distinct community types are recognizable, each dominated by only one or two species. The most abundant and widespread type contains saltgrass (*Distichlis spicata*) and the "short form" of saltmarsh cordgrass (*Spartina alterniflora*). Associates include saltmeadow cordgrass (*Spartina patens*) and dwarf halophytes such as sea-oxeye (*Borrichia frutescens*) and sea-lavender (*Limonium carolinianum*). Throughout the interior portion of Goodwin Islands this community forms a mosaic with nearly monospecific patches of black needlerush (*Juncus roemerianus*). Less extensive are scattered stands of saltmeadow cordgrass and saltgrass or saltmarsh cordgrass. Along tidal channels that run between individual islands or cut into extensive marshes, taller stems of saltmarsh cordgrass form a narrow fringe on microsites subject to longer periods of tidal inundation.

Each of these community types is considered state and globally common. Vegetation dominated by saltmarsh cordgrass is best represented by the *Spartina alterniflora* / (*Ascophyllum nodisum*) Acadian/Virginian Zone Herbaceous Vegetation (G5) in the USNVC (CEGL004192). The *Juncus roemerianus* Herbaceous Vegetation (G5; CEGL004186) and *Spartina patens – Distichlis spicata – Juncus romerianus* (G4G5; CEGL004187) represent USNVC associates with direct analogs in Virginia.

Maritime Dune Grassland. Narrow stands of this community occur on dunes along the perimeter of Goodwin Islands and are most extensively developed at the easternmost end. Characteristic species include saltmeadow hay (*Spartina patens*), bitter seabeach grass (*Panicum amarum* var. *amarum*), beach panic grass (*P. amarum* var. *amarulum*), seaside goldenrod (*Solidago sempervirens*), seaside spurge (*Chamaesyce polygonifolia*), and American searocket (*Cakile edentula*). In places this community forms a mosaic with salt scrub vegetation, particularly on the lee side of dunes, adjacent to interior tidal mesohaline / polyhaline marsh. Occurrences of this vegetation are typically < 30 m wide; as elevation decreases both riverward and to the interior of the Islands, composition grades abruptly to salt marsh dominated by saltmarsh cordgrass (*Spartina alterniflora*). Common reed (*Phragmites australis*) forms several small patches adjacent to stands of this community at

the eastern end of Goodwin Islands, but likely poses little threat to the xeric, unstable dune systems. A more significant threat is habitat loss associated with shoreline erosion.

Although DCR-DNH ecologists have not yet developed a classification of maritime zone communities, the vegetation at Goodwin Islands clearly represents the *Spartina patens – Schoenoplectus pungens – Solidago sempervirens* Herbaceous Vegetation (G2G3) in the USNVC (CEGL004097). The occurrence, however, is too small to warrant recognition as a community element occurrence. The maritime dune grassland at Goodwin Islands was documented by vegetation sample plot YORK005 (Figure 3).

Salt Scrub. Small patches of this shrubland community are irregularly scattered along low dunes throughout the perimeter of Goodwin Islands, most typically in the ecotone between maritime dune grassland and tidal mesohaline / polyhaline marsh. Additional small stands occur in the northwestern and western portions of the Islands adjacent to maritime upland forest. This community is dominated by high-tide bush (*Baccharis halimifolia*), with lesser amounts of marsh-elder (*Iva frutescens*) (although this is the most abundant species in patches in the northwestern corner of Goodwin Islands), as well as saltmeadow hay (*Spartina patens*) and various goosefoot species (*Chenopodium* spp.).

Vegetation of this community is well adapted to fluctuating water levels, inundation by saltwater, and chronic wind and salt spray. Some microsites at Goodwin Islands may be diurnally or irregularly tidal, but predominant hydrology appears to be supratidal.

DCR-DNH recognizes a single community type representing salt scrub, which is represented in the USNVC as the *Baccharis halimifolia* - *Iva frutescens* / *Spartina patens* Shrubland (G5; CEGL3921). Patches of this widespread community are too small to be considered a significant occurrence at Goodwin Islands.

Maritime Upland Forest. The interior of the western portion of Goodwin Islands supports a large stand of mature loblolly pine (*Pinus taeda*) with an understory of *Myrica cerifera* and lesser amounts of poison ivy (*Toxicodendron radicans*) and red bay (*Persea palustris*). The forest is heavily infested with common reed, which has evidently converged from the edge on both the eastern and western sides, where it forms a virtual monoculture adjacent to the tidal mesohaline / polyhaline marsh community. Although pristine examples of this forest community represent a globally rare type confined to the Mid-Atlantic Coast from North Carolina to New Jersey (CEGL006040: *Pinus taeda* / *Morella cerifera* / *Vitis rotundifolia* Forest; G3), this particular stand is too severely modified by the invasion of common reed to warrant recognition as a community element occurrence.

The northwestern corner of Goodwin Islands contains a small and heavily disturbed stand of enigmatic calcareous fringe forest. Tree species include sugarberry (*Celtis* cf. *laevigata*), slippery elm (*Ulmus rubra*), and cottonwood (*Populus deltoides*). The understory consists of a dense layer of Chinese privet (*Ligustrum* cf. *obtusifolium*), and the herb layer is very sparse and notably lacking in calciphiles. Maritime vegetation on shell mounds has been described from other states on the southeastern Coastal Plain, but DCR-DNH has circumscribed no ecological community group which adequately describes this vegetation. The history of this

community is also uncertain; piles of exposed shells abound, but it is unclear whether they are of natural or anthropogenic origin. Given the prevalence of privet, however, this occurrence cannot be considered a significant element of biodiversity, although it may once have constituted a rare community.

Rare / exemplary ecological communities. Presently, there are no rare or exemplary ecological communities on Goodwin Islands. Two communities could potentially be listed as element occurrences – Maritime Upland Forest and Maritime Dune Grassland; however degradation and small size (respectively) prevent these communities from being recognized as element occurrences at this time.

Rare plant species. In June 2004, a brief botanical reconnaissance trip was made to portions of Goodwin Islands. Field botanists visited Goodwin Islands again 24 August 2004 and 25 August 2004 for more extensive surveys. Vegetation community plot data was collected in late August, and early September 2004.

The potential for rare plant species was low in habitats present on the Islands. Open sandy habitat had the highest potential to support rare species with the state rare southern beach spurge (*Chamaesyce bombensis),* known from York County, the most likely species to be found. Less likely was the federally-listed, threatened seabeach amaranth (*Amaranthus pumilus)*, and the globally rare sea-beach knotweed (*Polygonum glaucum).* Sandy habitat on Goodwin Islands was present along the shoreline and on slightly higher sand ridges. These habitats were checked but no rare plant species were found. Additionally, portions of the interior forested areas were also walked by botanists in conjunction with reconnaissance work by DCR-DNH ecologists and to note the presence of invasive plant species, but these held little potential for rare plants, and none were found.

Rare animal species. To initiate inventory of rare animals at Goodwin Islands, existing data on element occurrences within and near the Islands were obtained from the DCR-DNH database and reviewed. Additional information was gathered from zoological literature and from examination of selected collections at several institutions, including the U.S. Museum of Natural History, the Carnegie Museum, Old Dominion University, Virginia Commonwealth University, and the Virginia Museum of Natural History. Aerial photographs and other map sources were consulted to determine the extent of potential rare animal habitats. Subsequently, a field plan based on all available preliminary information was developed to direct investigation of potential rare species habitats for the targeted animal groups. Appropriate survey techniques were planned and methods employed are listed below. In addition to faunal surveys designed to sample a variety of animal groups, certain rare animals previously recorded from Goodwin Islands were considered possibilities, and were targeted during the inventory portion of this project. Surveys were conducted on 23 June 2004, and 12 July – 13 July 2004. Sampling methods employed included: sweep nets, general observation, and UV-light traps.

In addition to faunal surveys designed to sample a variety of animal groups, certain rare animals previously recorded from Goodwin Islands were considered possibilities, and were targeted during the inventory portion of this project. Specifically, attention was given to the

Bald Eagle (*Haliaeetus leucocephalus*), and the Northeastern Beach Tiger Beetle (*Cicindela dorsalis dorsalis*). Breeding Bald Eagles have been documented from Goodwin Islands in recent years, although habitat was damaged by Hurricane Isabel in Fall-2003 (Watts, pers. comm., 2004). While Bald Eagles use Goodwin Islands extensively, there are presently no nests on the Islands. Specific inventory for the Federal and State threatened Northeastern Beach Tiger Beetle failed to find this species although the habitat appeared to be appropriate. Knisley (1998) has surveyed portions of Goodwin Island for this species with similar results.

To date, most of the Odonata (dragonflies and damselflies), Lepidoptera (butterflies and moths), and groups of Coleoptera (beetles) of interest (e.g., tiger beetles) have been identified with no rarities found. Some identifications are still pending confirmation from experts. Surveys for other groups likewise found no rare animals.

Potential Natural Heritage Resources

Two ecological communities mentioned previously, Maritime Upland Forest and Maritime Dune Grassland are not presently listed as element occurrences only because of size and degradation. The potential exists for both of these communities to become element occurrences at some time. The state rare southern beach spurge (*Chamaesyce bombensis*), known from York County, the Federally listed seabeach amaranth (*Amaranthus pumilus*), and the globally rare sea-beach knotweed (*Polygonum glaucum*) are all potential rare plant species for this area. Additionally, Goodwin Islands presently supports many marsh nesting birds and the potential exists for additional nesting activity by any one of the rare or uncommon species that DCR-DNH tracks. Although no records exist for colonial shorebird colonies on Goodwin Islands, there is a possibility for future nesting activity.

It is possible that management activities, coupled with monitoring and additional inventory work, and passage of time, could result in new or regenerated occurrences of some of these species and/or communities.

RESOURCE STEWARDSHIP

Goals and Objectives

The primary goal of management at Goodwin Islands is to maintain or restore a functioning ecosystem with a matrix of communities native to the site that will provide opportunities for long-term habitat-focused research. The philosophy and policy direction for management of CBNERRVA sites are outlined in Appendix A. Reserve-level management and monitoring actions, as well as cooperative management initiatives and protection strategies, are planned based on the best current information and available resources.

Management objectives for Goodwin Islands include:

- Maintain and restore natural communities.
- Provide for natural resource protection.
- Foster research to accomplish conservation goals and contribute to the body of knowledge on flora, fauna, and natural communities of Virginia.

- Manage habitat to benefit the array of natural resources, scenic resources, and historic resources.
- Monitor and evaluate effects of management on plants, animals, and natural communities.
- Maintain populations of rare or uncommon plants and animals.
- Ensure visitor safety and site-security.

Biological Management Issues

Biological resource management actions are taken to return human-altered land or vegetation to a condition that supports continued existence of rare species and/or natural communities by reinstating natural processes or abating threats. Major threats to biodiversity include: habitat degradation/loss, invasive non-native species, pollution, overexploitation, disease, land conversion to development, water development (e.g., dams, drainage projects), some agricultural practices, livestock grazing, some outdoor recreation (e.g. off-road vehicles), pollutants, infrastructure development (e.g. roads), disruption of fire regimes, logging, and mining activities (Wilcove et al., 1998). After habitat loss, invasive non-native species are the greatest threat to terrestrial species. For aquatic species, water pollution is the most significant threat after habitat loss (Richter et al., 1997). Because of these threats to biodiversity, active management is often needed to restore and maintain natural resources (Wilcove and Chen, 1998).

Several biological management issues currently threaten resources at Goodwin Islands; and a number of public use issues presently threaten resources or have potential to negatively impact resources in the future. Biological issues of greatest concern and most likely to cause negative impacts to natural resources at Goodwin Islands are invasive non-native plants, development pressures outside the reserve, and native animal populations lacking natural abundance controls. Public use issues are addressed in the Operations Management section of this plan.

Invasive, non-native plants. Nationwide, invasive species have been identified as the second highest threat to biological diversity, second only to loss of species and habitat from development and urban sprawl (Stein et al., 2000). Control of invasive non-native plants is expensive, resources are limited, and management efforts must be prioritized (Hiebert and Stubbendieck, 1993). The goal of management is to prevent the worst invasive species from becoming established in high-quality natural communities. Eradication is not a practical option for some invasive species already well-established at Goodwin Islands; however, preventing new invasive species from becoming established on the reserve is a viable objective. Control efforts will focus on reducing abundance of the most problematic invasive plants in the highest quality natural communities. The Nature Conservancy has compiled natural history, impacts/threats, management, monitoring, research, and extensive bibliographies for many invasive non-native species into "Element Stewardship Abstracts," (ESAs). Copies of ESAs for the four species discussed below can be found in Appendix D, along with additional inventory methods and results for the 2004 common reed survey at Goodwin Islands.

At Goodwin Islands, the following invasive species were noted: common reed (*Phragmites australis*), Japanese honeysuckle (*Lonicera japonica*), Japanese stilt grass (*Microstegium vimineum*), and border privet (*Ligustrum obtusifolium*).

Common reed (*Phragmites australis*). The invasive wetland grass known as common reed is one of our most serious and problematic invasive plant species (Marks et al., 1993; Norris et al., 2002). Common reed is found in every U.S. state and is well-established and increasing in coastal habitats of Virginia. This fast-spreading plant grows up to 4 meters tall and forms dense monotypic stands, crowding out other native marsh plants. Common reed is long-lived and spreads rapidly due to its ability to reproduce both by seed and dispersed rhizome fragments, establishing readily in disturbed areas. As a result, marsh plant species diversity and habitat quality is drastically reduced for many kinds of marsh-dependant wildlife.

Common reed is now considered to exist in North America, including Virginia, in two genotypic forms. One form is native to the U.S. and appears to have been a non-dominant component of diverse mid-Atlantic and northeastern marsh communities for millennia. Recent DNA studies provide strong evidence that a distinct, non-native common reed genotype is also present in the U.S. (Saltonstall, 2002). This supports an existing theory that an introduced variety of common reed has for decades been aggressively invading and dominating coastal marshes and other wetland communities, in part due to a lack of natural biological control mechanisms. The presence of an invasive, non-native form of common reed would explain how and why this species has rapidly become dominant over thousands of acres of wetland communities during the last two decades in the Northeast and mid-Atlantic regions.

The Virginia portion of the Chesapeake Bay as well as the extensive estuarine and island wetlands of the Eastern Shore Seaside are currently experiencing high rates of invasion by non-native common reed. Disturbances that expose mineral substrate, such as dredging and placing spoil or natural disturbances such as wildfire and hurricanes, can heighten both the risk and rate of common reed colonization and/or spread. Ground and aerial surveys to determine distribution and abundance of common reed at Goodwin Islands were conducted during September (Appendix E). Populations were mapped (Figures 4 and 5) using GPS and were combined into a single data layer in ArcView 3.3.

Japanese honeysuckle (*Lonicera japonica*). Japanese honeysuckle is a semi-evergreen vine of the Caprifoliaceae family. A serious pest throughout eastern North America, it outcompetes native vegetation for both soil nutrients and light (Nuzzo and Randall, 1997). Japanese honeysuckle was the most frequently observed nonnative species in a study of almost 2000 DCR-DNH ecological community classification plots located across the state of Virginia (Heffernan et al., 2001). In 2004, Japanese honeysuckle was observed in one survey area on Goodwin Islands in a forest community (Figure 6) (Van Alstine, pers. comm., 2004). It is likely present in other areas of the forest that are difficult to access due to downed trees and dense undergrowth, and the full extent is unknown at this time. In fire-adapted communities, periodic spring burning will control this species. Glyphosate herbicides applied in the fall when the surrounding vegetation has become dormant – but before a hard

freeze (25 degrees Fahrenheit) – will allow for control of this species without negatively impacting non-target plants (Nuzzo, 1997).

Japanese stilt grass (*Microstegium vimineum*). A native of Asia, Japanese stilt grass is now widespread east of the Mississippi (Miller, 2003; Merhoff et al., 2003). In 2004, three patches of Japanese stilt grass were seen on Goodwin Islands in an interior forested area (Figure 6) in low spots under the canopy (Van Alstine, pers. comm., 2004). Japanese stilt grass is typically an annual grass, although a perennial form has apparently been discovered (Ehrenfeld, 1999), that spreads into mesic forest habitats. It spreads rapidly into disturbed areas but can invade undisturbed upland areas by forming satellite populations brought in by animals or flooding. It is generally slow to invade undisturbed areas, but rapidly fills disturbed areas such as flood-scoured stream sides, tip-up mounds, and along roads and trails (Tu, 2000). Highly shade tolerant, it forms a dense monotypic ground layer and produces numerous seed that may persist for many years (Merhoff et al., 2003).

An individual plant of Japanese stilt grass can produce up to 1000 seeds, which can remain viable in the soil for three to five years. Once established, Japanese stilt grass is able to crowd out native herbaceous vegetation in wetlands and forests within three to five years (Barden, 1987). Manual/mechanical, environmental/cultural, and chemical methods have all been used with some success for control of Japanese stilt grass. Prescribed burns have not been successful in controlling this species so far, but fall burns may have the potential for partial control. If controlled during the early stages of invasion, the potential for successful management is high. The potential for large-scale restoration of wildlands where Japanese stilt grass has become established is probably moderate (Tu, 2000). Grass-specific herbicides may need to be used to control Japanese stilt grass at the cost of sacrificing some native grass species populations. The best combination of control for Japanese stilt grass will likely involve mowing/cutting in late summer prior to seed set and spot treatments of herbicide in early summer, along with the use of pre-emergent herbicides in late winter.

Border privet (*Ligustrum obtusifolium*). A number of introduced privets, shrub species in the Oleaceae family, are invasive in the eastern United States from Maine to Georgia (Merhoff et al., 2003; Swearingen et al., 2002; Miller, 2003). Although not as frequently sighted as other privet species, DCR-DNH staff have observed border privet exhibiting invasive behavior in North Carolina and Virginia (Townsend, pers. comm., 2005). The species is also reported as invasive throughout eastern and central United States (Batcher et al., 2000). Border privet, in the form of shrubs and seedlings, is scattered under the mixed canopy of the hardwoods (*Celtis* sp., *Quercus pagoda*, *Populus deltoides*) and loblolly pine stand (Figure 6) on the northwest portion of the main island and within a hackberry (*Celtis*) dominated area further south. Control methods for this species include hand-pulling seedlings, cutting or mowing, and herbicide application. Herbicides based on glyphosate, triclopyr, and metsulfuron provide control of border privet (Batcher et al., 2000).

Native animal problem species. Due to overabundance, certain native species of animals have become problematic – from both ecological and economic perspectives. While these species are native to Virginia, recent population increases have resulted in negative effects on habitat. Overabundance of some species is often incompatible with a broad array of resource

management objectives. For ecological and/or economic reasons, natural resource managers must sometimes control burgeoning populations of native animals.

White-tailed deer (*Odocoileus virginianus*). A large body of research (Russell et al., 2001) presents evidence that dense populations of deer in many eastern U.S. ecosystems can negatively impact tree and herb regeneration, recruitment and composition (Alverson and Waller, 1997, Horsley et al., 2003), alter natural community composition (Rooney and Dress, 1997), eliminate certain plant species from areas (Augustine and Frelich, 1998), and disrupt bird populations (deCalesta, 1994; McShea and Rappole, 1997). Deer also avoid browsing on the invasive non-native plants, such as Japanese stilt grass (Tu, 2000) further exacerbating the nefarious effects of these weeds on native flora. Of particular concern for natural areas management are negative effects of high deer densities on herbaceous plants (Balgooyen and Waller, 1995; Augustine and Frelich, 1998) and rare plants (Miller et al., 1992). At the end of the 19th century, deer were over- hunted to the point of near extirpation from Virginia. Since then, implementation of strict game laws, elimination of natural predators, and the changing landscape (with more edge habitat) has given rise to a burgeoning deer population that today, in most areas of the state, exceeds estimated presettlement deer densities (Knox, 1997). Monitoring programs can be designed to estimate and track deer population densities and deer impacts in order to guide management actions. Additional information on white-tailed deer monitoring and control can be found in Appendix D.

Urban interface factors. Increasing development in the York River watershed, and specifically along the river itself, has immediate and long-term impacts on Goodwin Islands. In particular, the network of roads that accompanies new development creates negative ecological impacts beyond just the effect of construction of new buildings. Increased impervious surfaces alter surface water flow and aquifer recharge, in addition to increased soil loss and sedimentation, which contribute to water quality degradation. Even more distantly-located emissions from motor vehicles, power plants, industry, and other fossil-fuel producers have negative air and water quality impacts at Goodwin Islands.

Sea level rise. Sea level is currently rising at approximately 3-4 mm/year (Michael, 2004) in the lower Chesapeake Bay. Indications are that this trend will continue and could accelerate in the future, with projections that by the year 2100 sea level will have increased by approximately 61 to 91 cm above the current level (Michael, 2004; USGCRP, 2005).

Fire management. Fire management is frequently an important facet of natural areas management in Virginia. Fire management activities include both prescribed fire implementation and wildfire management. While some wildfires are potentially destructive and should be suppressed, some situations – such as in the case of the Goodwin Islands - should be explored as an opportunity to realize the benefits of fire in a natural setting.

Historically, lightning-induced wildfires as well as fires started by American Indians would have occurred with some frequency on Goodwin Islands, helping to shape the natural communities and species habitats found there. Fire scars are still visible from a June 1986 lightning-induced wildfire that burned between 32-47 hectares (80-115 acres) of upland forest, shrub-scrub/forested wetland, and high marsh. Historically, lightning-induced

wildfire likely occurred with some frequency on Goodwin Islands. To prepare for and provide guidance in the event of a wildfire in the future, a wildfire contingency plan should be developed for Goodwin Islands. Such a plan should explore the past role of fire on the Reserve, clearly state the potential benefits and disadvantages of wildfire on the Islands under current landowner and management contexts, outline management objectives, and provide a viable set of management options should a wildfire occur. Development of a wildfire contingency plan would best be accomplished by VIMS staff working closely with agencies and organizations that frequently deal with fire management issues, including DCR, Department of Forestry (DOF), and The Nature Conservancy.

Although wildfires could potentially damage island-based research equipment and duck blinds, the unique safety net provided by the island situation makes this Reserve an ideal location for a "let burn" wildfire contingency plan.

Operations Management Issues

Operations management is a crucial aspect of natural areas management, especially on lands where recreational uses by members of the public may conflict with the primary management objectives of research and natural resource protection. Managers must design and maintain infrastructure such as signs to best protect resources from adverse human effects. Routine operations management activities include boundary line maintenance, site security, visitor safety, and law enforcement. Since VIMS lacks its own law enforcement staff, it will be necessary to partner with other natural resource agencies such as VDGIF and VMRC when law enforcement issues affecting natural resource protection arise.

Federal and state natural resource laws. Laws potentially affecting management of the Goodwin Islands Reserve are noted in Appendix G. The conservation emphasis of management at CBNERRVA sites means that VIMS will rarely engage in land or water modifications subject to regulation. Decisions to permit fishing or hunting will comply with all federal and state game laws. At all CBNERRVA sites, efforts to control invasive species, protect rare and endangered species, and protect existing natural and historic resources fulfill the requirements of several natural resource laws.

Visitor management. As stated in the Policy and Management Approach sub-section, access to Goodwin Islands is only by permission of VIMS for research, environmental education, or other appropriate and approved activities (see Appendix B).

Inappropriate public use issues at Goodwin Islands include trespass and subsequent illegal artifact collection and unauthorized hunting. These activities either threaten resources directly, or have potential to threaten resources in the future. In addition, these activities raise concern regarding visitor and researcher safety and application of state and federal regulations.

Appropriate uses. The college of William and Mary maintains a limited-use public access policy for the Goodwin Islands. In accordance with that policy, Goodwin Islands are managed exclusively for research and education. Beach areas can be used for picnicking, beachcombing, and other non-destructive activities if visitors do not willingly or negligently

disturb the environment or scientific experiments/equipment (Appendix B). Hunting at Goodwin Islands may be permitted to meet certain resource management objectives only and not as general recreational activities. At this time, limited waterfowl hunting is permitted (see Appendix F).

Inappropriate uses. Deterring the following inappropriate public uses of Goodwin Islands will require some level of operational work, e.g., boundary marking, on-site staff presence, public contact and outreach efforts, or law enforcement (enforcement will require marked Reserve boundaries).

- *Non-permitted collection of plants and animals* can quickly decimate populations of rare plants and animals. Any and all collection of plant and animal specimens is for research and educational purposes only and requires a permit issued and approved by VIMS staff.

- *Artifact collection* degrades cultural and historic sites, and disrupts substrates and vegetation. Cultural artifacts found at the Reserve consist mostly of projectile points uncovered by storm events or washed up onto the beaches. According to the Virginia Department of Historic Resources (DHR), artifacts on Goodwin Islands are likely to be either Native American artifacts, or items washed from shipwrecks (Turner, pers. comm.). These sites may date back to the Middle to Late Woodlands periods (3200-400 B.P.). Most of the submerged, or terrestrial sites, though not well known or described at this time, hold great potential for additional information about early inhabitants and land uses of the area.

- *Unleashed dogs and feral cats* disrupt or prey on ground-nesting birds (Yalden and Yalden, 1990; Mitchell and Beck, 1992) and terrestrial fauna. Feral cats, dogs, or livestock that become established at Goodwin Islands should be trapped and removed from the Reserve.

- *Camping* causes long-term concentrated impacts on soils and vegetation from trampling and fire rings (Marion and Cole, 1996), and is an inappropriate use of CBNERRVA sites. Nearby private and State Parks offer a wide array of camping opportunities.

Data Gaps and Research Needs

A variety of data gaps and research needs exist in regard to management issues at Goodwin Islands. Further research and inventory will be required to address these questions, which include:

- What new developments are there in control of the invasive, non-native species that threaten Goodwin Islands? Will Habitat™ be an effective product for Phragmites control at the Reserve?
- What are the aquatic communities on the Reserve? What is the aquatic invertebrate diversity like? Are there management concerns for these communities/species?
- What is the breeding bird use and capacity at Goodwin Islands?
- How many deer and other mammals routinely use the Islands and what impact do they have on native vegetation and breeding bird populations?

- What are the effects of sea level rise and shoreline erosion on Goodwin Islands and what are the implications for long-term resource management?
- What is the historical/archaeological significance of artifacts on the Reserve? Where do these artifacts occur and how should they be managed?
- What are the effects of hunting and fishing activities on the natural resources of Goodwin Island? Are these activities managed in an adequate manner?
- Who are the unauthorized users of Goodwin Islands Reserve?

Monitoring. A wide variety of monitoring techniques are used to assess change in natural community composition and rare species population status. Monitoring can determine if natural processes essential to natural resource health are occurring and whether or not management actions have been effective. Monitoring is also needed to document effects of human visitation and public use patterns on resources and other natural features protected within natural areas and reserves. The term "monitoring" describes several different types of data collection related to resource management and includes inventory, natural history study, research, implementation monitoring, trend measurement, baseline measurement, and long-term ecological studies. Monitoring in a strict sense is "the collection and analysis of repeated observation or measurements to evaluate changes in condition and progress towards meeting a management objective" (Elzinga et al., 1998).

Research. Research to improve understanding of natural history, biology, and population dynamics of rare species and ecosystem functions is needed for sound and defensible management planning. Scientific studies are conducted by VIMS or sponsored through funding support to answer basic natural history questions, and to inform management decisions and actions. Studies conducted on all CBNERRVA sites require submission of an application, which must be reviewed and subsequently approved by VIMS staff.

Management Recommendations

Invasive species control. The primary goal of invasive species management at Goodwin Islands is to reduce common reed cover. A secondary goal is to reduce or eliminate cover of Japanese honeysuckle, border privet, and Japanese stiltgrass, and to encourage recolonization of the infested areas by native vegetation.

Common reed is the primary invasive species at Goodwin Islands and will require timely management actions to control its spread in order to protect natural communities and valuable wildlife habitat. Twenty-two patches of common reed currently (2004) cover 15 hectares (37 acres) (see Appendix E).

Common reed has often been treated with glyphosate-based herbicides (Norris et al., 2002). Use of these products has been shown to require carefully timed and annually repeated treatments for two to three years to achieve desired control. A new product, Habitat™, has begun to come into use for treating common reed. Based on imazapyr and approved for wetland use in 2003, early reports suggest that it provides control with only one treatment, or with relatively minor "mop-up" treatments (Hutto, pers. comm., 2004). The effective application window for imazapyr is also much wider than for glyphosate. Glyphosate is recommended for use during the late growing season, which has the downside of coinciding

with higher occurrence of tropical storm activity. Imazapyr can be applied earlier during the growing season; therefore, managers have more flexibility in planning and executing control treatments.

Additional notes on imazapyr. Imazapyr is a non-selective herbicide used to control grasses, broadleaf herbaceous plants, and woody species. It inhibits the synthesis of broad-chained amino acids, which are only found in plants. Animals obtain this group of amino acids by eating plants. Imazapyr is degraded in soils by microbial breakdown. Its half-life in soils ranges from one to five months. When exposed to sunlight in a water column, the half-life may be as low as one to two days. Testing of imazapyr has shown it is not toxic to birds or mammals, but it can cause severe eye damage. Although imazapyr has been shown to have no toxic effects on bobwhite quail and mallard ducks, it has not been tested specifically on shorebirds (Entrix, Inc., 2003). It does not affect algae or submersed vegetation. It has a low toxicity to fish (Tu et al., 2001).

Estimated cost of aerial Habitat™ application is $465/hectare ($186/acre), including chemical, helicopter, and crew. This estimate assumes aerial spraying at Goodwin Islands in conjunction with aerial spraying at Catlett Islands, which has 0.45 hectares (1.1 acres) of common reed. Costs for ground-based and boat-based herbicide control of Phragmites are highly variable and dependent upon a multitude of parameters. Estimated costs of boat-based spraying using Habitat™ are $140-$370/acre; estimated costs of boat-based spraying using generic glyphosate products are $75-$240/acre; and estimated costs of backpack-based ground control are $100-$320/acre. The lower estimates are for "in-house" staff (trained and certified), while the higher end of the range assumes use of contractor services.

The common reed infestation at Goodwin Islands should be reduced by at least 50% and as much as 95% through a single aerial application of an imazapyr-based herbicide. While initially some native vegetation will be lost to herbicide treatments, native vegetation quickly re-colonizes areas from which common reed is exterminated. In addition to common reed, there are small occurrences of three other invasive plant species, Japanese honeysuckle, border privet, and Japanese stiltgrass which occur in small, scattered patches on the western end of the Island in open and edge habitat. Each of these has the potential to infest large areas and become virtually impossible to manage due to cost or unacceptable levels of non-target damage from control methods. Backpack sprayer application of imazapyr can effectively control these species as well (Tu et al., 2001), and treatment should be during the growing season. Management of these species can be conducted at the same time as that described for common reed. Given the present low abundance of these species at Goodwin Islands, it is highly recommended that VIMS initiate management as soon as possible (Figure 7).

Control recommendations.

- Control invasive species through a combination of aerial and ground-based application of imazapyr herbicide (Table 1). Aerial application at Goodwin Islands in conjunction with the same action at Catlett Islands will be the most cost-effective approach.

- Conduct aerial application of herbicide to the open marsh common reed patches. Approximately 20 acres of common reed on Goodwin Islands is found in open marsh (Figure 7). Common reed patches in open marsh and over a quarter acre in size are treated with imazapyr-based Habitat™ herbicide using aerial application by helicopter. Treatment may be anytime during the growing season, preferably in July or August, when the plants have become readily visible from the air. Application at this time would also avoid negative impacts to birds nesting on Goodwin Islands, such as American Oystercatcher.
- Mop-up very small remnant patches of common reed, Japanese honeysuckle, border privet, and Japanese stiltgrass with imazapyr herbicide applied using backpack or boat-based portable sprayer. A portable sprayer has a treatment range limited by hose length, which may be 15 to 91 meters (50 to 300 feet). A two-person crew should be able to treat up to one acre per day. Timing of treatment may be anytime during the growing season.
- Monitor invasive species response to herbicide treatment. Monitoring efforts can be scaled to available resources. Comparison of pre- and post-treatment plot data would show what degree of change in common reed cover occurred. At a minimum, low intensity qualitative monitoring using permanent photomonitoring plots is recommended. A monitoring protocol frequently used by DCR-DNH measures live invasive species stems, average stem height, and visual estimate of cover of common reed and non-common reed vegetation in a permanent 0.25 m by 2 m quadrat. Quadrats are established along transects within a common reed patch. The number of transects/ quadrats depends on the desired level of monitoring intensity.
- Monitor common reed in pine and scrub communities to measure changes in response to herbicide treatment of adjacent open marsh reed. Common reed rhizomes can grow up to 10 m in a growing season (Ailstock, 1999). Forest and scrub communities at Goodwin Islands were likely invaded from common reed patches in adjacent marsh communities. It is not known how much, if any, of the portions of common reed patches that extend under forest canopy would be affected by herbicide treatment of the open marsh portion of the patches. Therefore, monitoring should include observation of the response of the common reed found under pine and wax myrtle canopy.
- Monitor common reed in pine and scrub communities to measure changes due to natural succession or disturbances. These communities at Goodwin Islands appear to be young (Coulling, pers. com., 2005). As they mature and understory light availability decreases, common reed cover may reduce. Alternatively, canopy gaps created by storms or tree pests could allow common reed to increase abundance within these areas and suppress regeneration of native species. Long term research would provide much needed insight into the dynamics of understory common reed infestations.
- Conduct monitoring surveys once every 3-5 years for presence and abundance of invasive plant species. Seek guidance from experienced resource managers if additional invasive species are found.

Suggested common reed management timeline.

Year one	Year two	Year three & beyond
1. Install monitoring plots during common reed growing season (June through September) before first herbicide application. 2. Apply herbicide treatment using aerial application (June through September)	1. Conduct post-treatment monitoring. 2. Assess need for further herbicide treatment of remnant common reed patches. 3. If treatment is needed, use ground crew and backpack sprayers or boat-based herbicide sprayers and imazapyr herbicide.	1. Continue post-treatment monitoring at least one year following the last herbicide treatment. 2. Assess need for further herbicide treatments. 3. If necessary, conduct herbicide application to remnant or new common reed patches.

Fire contingency plan. It is recommended that VIMS work closely with the Department of Forestry (DOF), DCR, and The Nature Conservancy to develop a wildfire contingency plan that would provide protection of resources and infrastructure while still allowing for the possibility that, under certain conditions, wildfires could provide benefits to the natural resources at Goodwin Islands.

Heronry. It is recommended that the heron rookery be monitored at least annually, and that signs warning against disturbance and harassment be posted. The Center for Conservation Biology suggests a buffer of at least 305 meters (1000 ft) during nesting and fledging (from approximately March through August). Additional management assistance may be available from staff at the Center for Conservation Biology (College of William and Mary) or DGIF – Wildlife Diversity Division.

Hunting. Virginia law provides that any appropriately licensed person can hunt waterfowl in public waters during established seasons and using legal methods so long as they are not within 457 meters (500 yards) of an existing licensed stationary waterfowl blind. Therefore, if VIMS does not license, establish, and use (for the purpose of hunting) stationary waterfowl blinds on Goodwin Islands, then members of the public may obtain a license and build a stationary hunting blind in public waters surrounding and adjacent to the Reserve. Where stationary blinds are not established, hunters could also legally hunt from licensed floating blinds in the waters adjacent to the Reserve. It is recommended that VIMS work with DGIF biologists and game wardens to develop a waterfowl hunting plan (see Appendix F), a deer hunting plan if necessary, and appropriate signs that address trespass and appropriate and inappropriate activities.

Spill contingency plan. It is recommended that VIMS work closely with the U.S. Coast Guard, the Virginia Department of Environmental Quality (DEQ), and other appropriate agencies and organizations with expertise in petroleum or toxic materials spills to develop a

contingency and response plan to protect Goodwin Island resources in the event of an incident in the York River or Chesapeake Bay.

Unauthorized artifact collection. It is recommended that VIMS staff work with DHR and the College of William and Mary (Geology Department) to discover the type and extent of historical sites and artifacts found on Goodwin Islands, and also to better determine protection needs and focus conservation efforts. DHR and other land managers with experience in protecting cultural resources can assist with developing and locating signs to discourage trespass and subsequent illegal artifact collection. DHR may also provide assistance with developing effective outreach programs. VMRC could be requested to increase patrols in the area in an effort to further discourage this activity.

LAND ACQUISITION AND PROTECTION NEEDS

To adequately protect and conserve the larger landscape ecosystem of Goodwin Islands may require further conservation and/or open space easements. Habitat fragmentation will increasingly threaten nearby lands, and to mitigate some of these impacts, VIMS might consider pursuit of conservation and open-space easements and management agreements on key tracts near the Reserve. Land acquisition/conservation easement targets for inclusion in CBNERRVA, Goodwin Islands or to serve as important buffer lands are prioritized below and illustrated in Figure 8.

High Priority. The areas delineated as high priority are primarily undeveloped marsh/upland tracts located south, southwest from Goodwin Islands (across the shallow channel), or north of Goodwin Islands, across the mouth of the York River. The delineated areas likely serve as nearby foraging, nesting, and loafing habitat for bird species also using Goodwin Islands, such as Bald Eagles, American Oystercatchers, Osprey, Northern Harriers, Great Blue Herons, and numerous shore and marsh birds. These areas also likely serve as stop-over habitat for migratory birds. Inclusion of these lands in the Goodwin Islands site, protection through inclusion in the CBNERRVA program, or protection/conservation through easements and management agreements would help buffer the islands and species that use them.

It is possible that either (or both) of these locations presently serve as a partial sand sources (by littoral transport) for Goodwin Islands. Some of the potential rare species at Goodwin Islands rely on increasingly rare dynamic sandy beaches. Protection of a sand source helps ensure continuation of natural processes for the islands for some time. It is important to note that sea level rise is a pervasive concern and must be taken into consideration with all management, conservation, and protection decisions.

Medium Priority to Low Priority. Areas delineated as medium to low priority are primarily developed, populated areas on the mainland just south, southwest of Goodwin Islands. Individuals living and working in these areas are most likely, the individuals that know Goodwin Islands, use the islands, and may, in some cases, use the islands inappropriately. Community outreach and education in these areas might help alleviate, or at

least, decrease inappropriate uses of the islands. Community, or neighborhood meetings might give citizens opportunities to ask questions, provide information in both directions, and help garner a sense of protection and conservation for the area.

CONCLUSION

Management to protect and maintain biological diversity at Goodwin Islands will require ongoing research and assessment to ensure that resources are conserved. Complexity of ecosystems and a shortfall of stewardship resources (staff time and money) will usually preclude a full understanding of the effects of ongoing biological change and management actions used to direct that change. Since the human-dominated landscape of Virginia today is far different than that of the "natural" landscape of pre-industrial/pre-urban expansion America 500 years ago, "doing nothing" as a management strategy will often not conserve natural resources. By taking an active and adaptive ecosystem management approach at Goodwin Islands, by using and building on an existing baseline of inventory data, and by monitoring trends in natural communities following management actions (e.g., assess the effectiveness of controlling an invasive species on plant species composition in a high quality stand of a natural community) it is likely that successful stewardship of natural resources will be attained.

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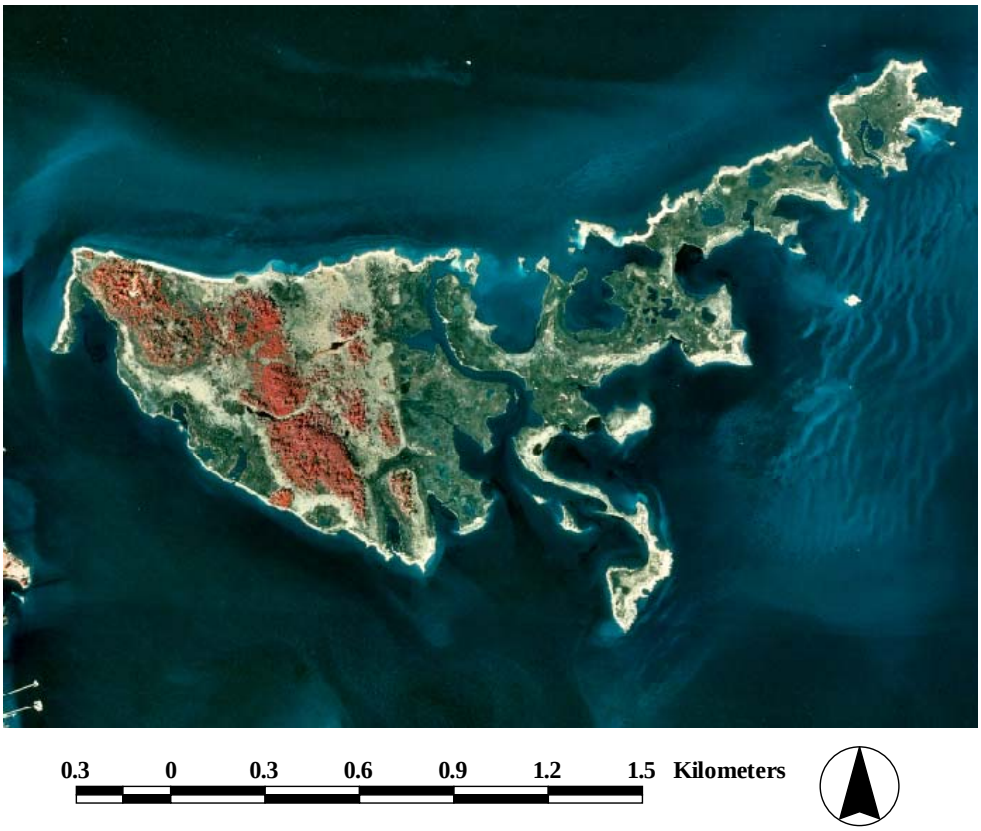
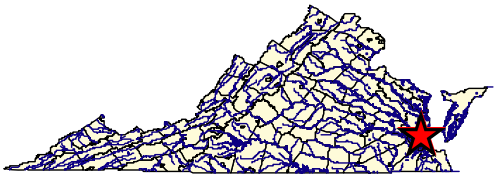


Figure 1. Goodwin Islands-CBNERRVA:
boundary and location

(June 2005)



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Department of Conservation & Recreation

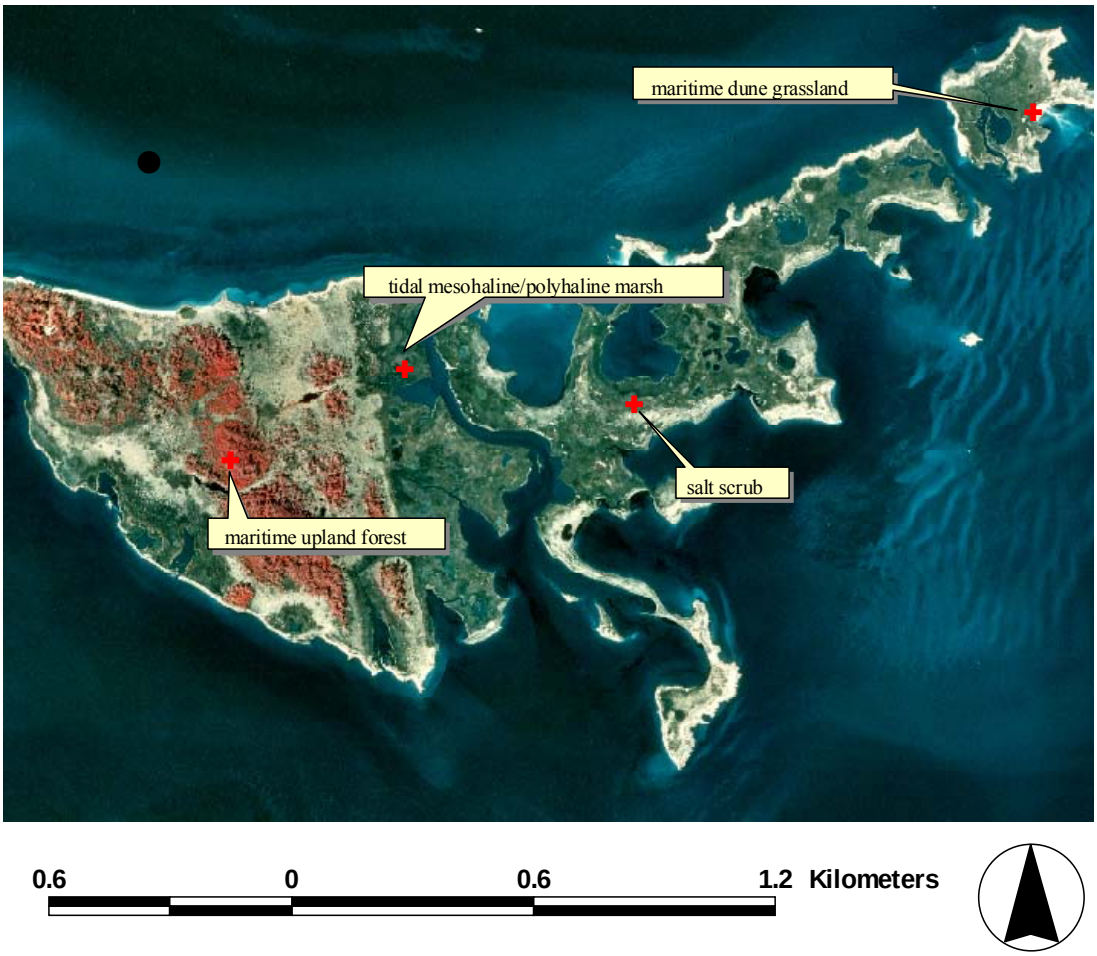

Figure 2. Natural communities of Goodwin Islands

(June 2005)

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Figure 3. DCR-DNH community vegetation sample plot location installed: summer 2004 on Goodwin Islands. Map scale 1:12,000.

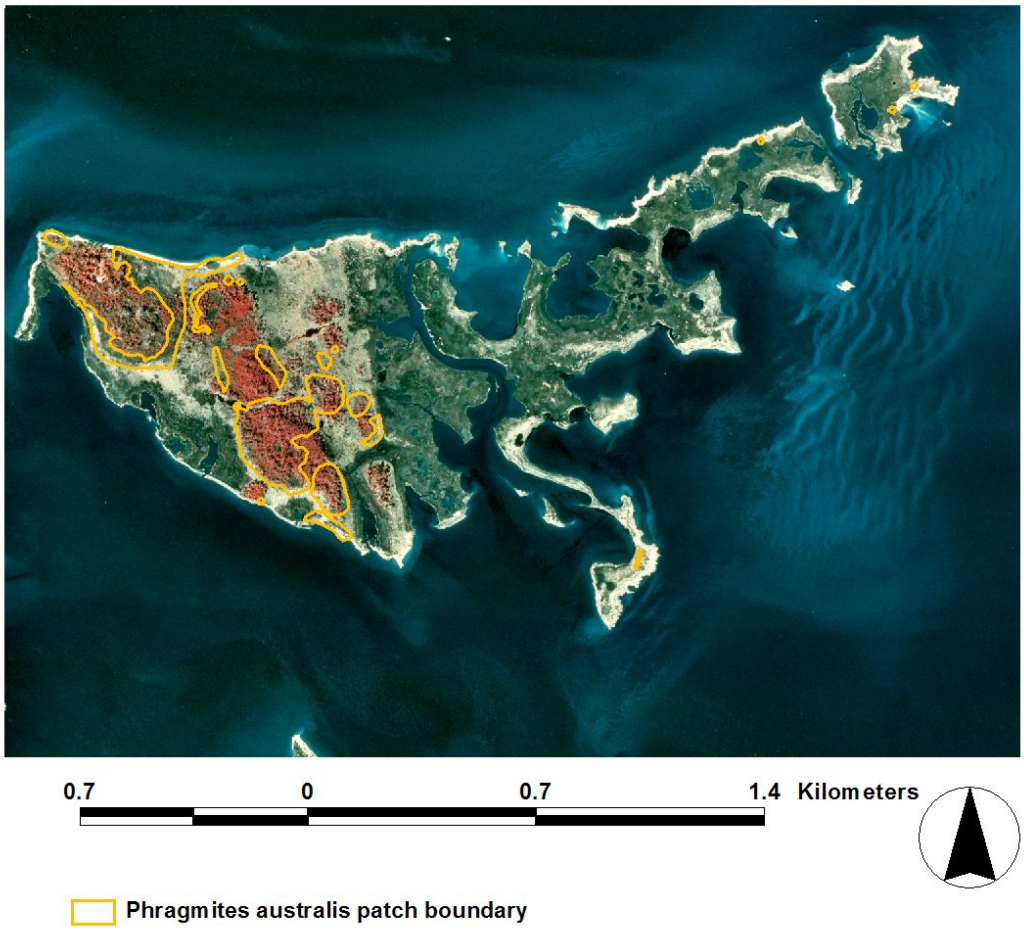

Figure 4. Goodwin Islands Phragmites australis patch delineation

(June 2005)

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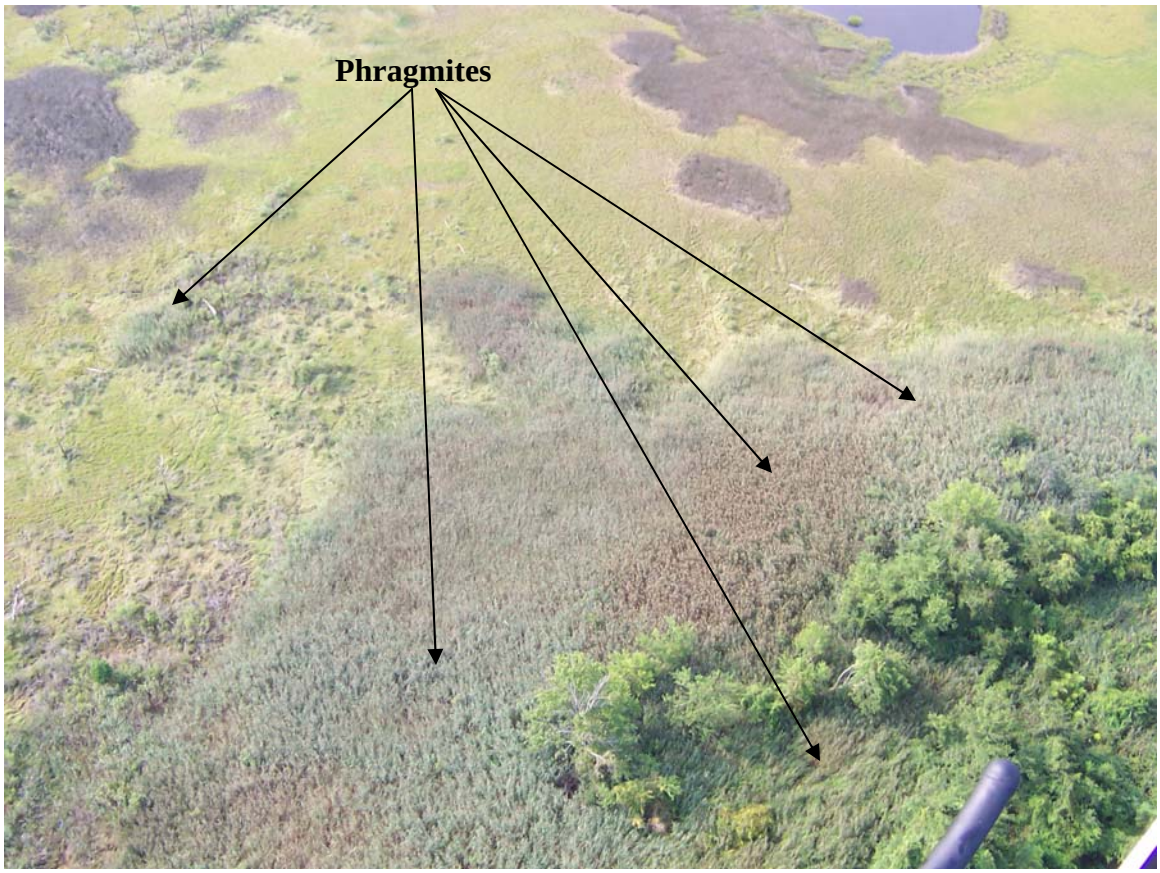

Phragmites is readily discernible from above.

Figure 5. Aerial view showing readily discernible patches of *Phragmites australis* on Goodwin Islands (July 2004)

0.5 0 0.5 Kilometers

Figure 6. Locations of three species of invasive, non-native plants on Goodwin Islands mapped in summer 2004.

▲ **Japanese stiltgrass (Microstegium vimineum)**
■ **blunt-leaved privet (Ligustrum obtusifolium)**
⬟ **Japanese honeysuckle (Lonicera japonica)**

(June 2005)

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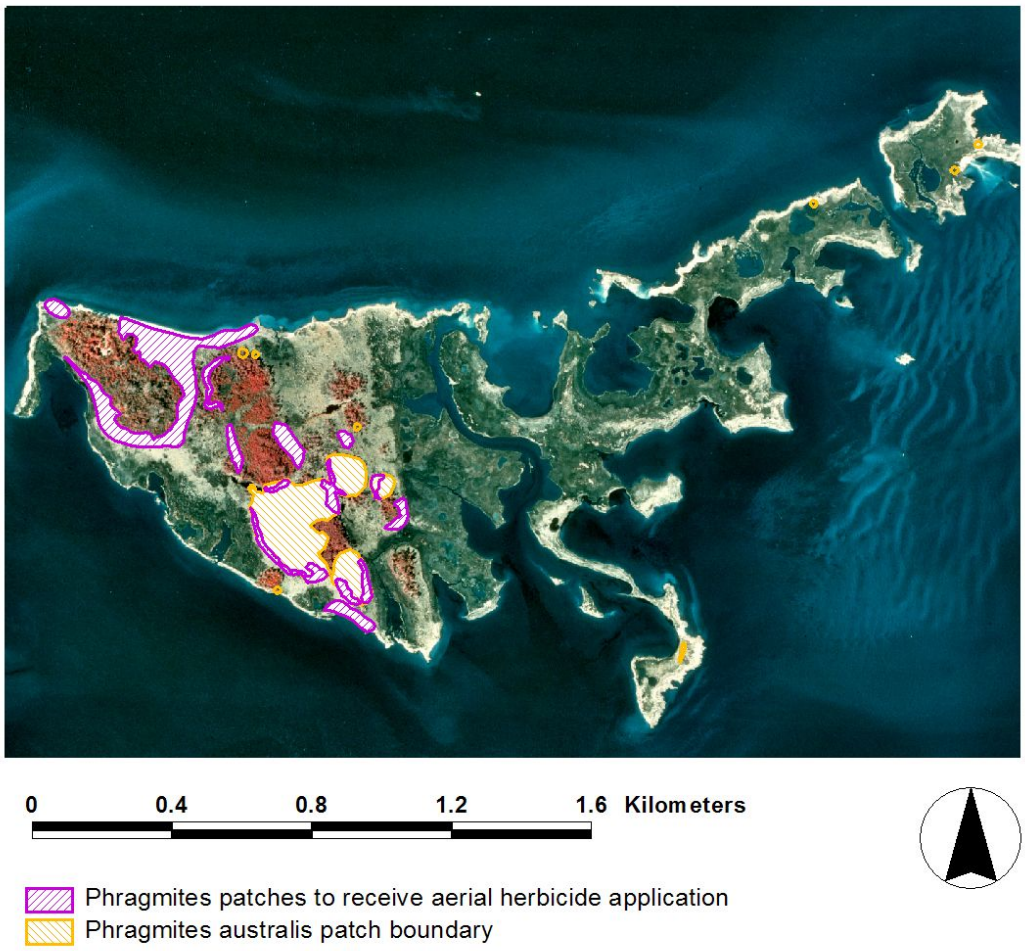

Figure 7. Recommended locations for aerial herbicide application to control Phragmites australis on Goodwin Islands

(June 2005)

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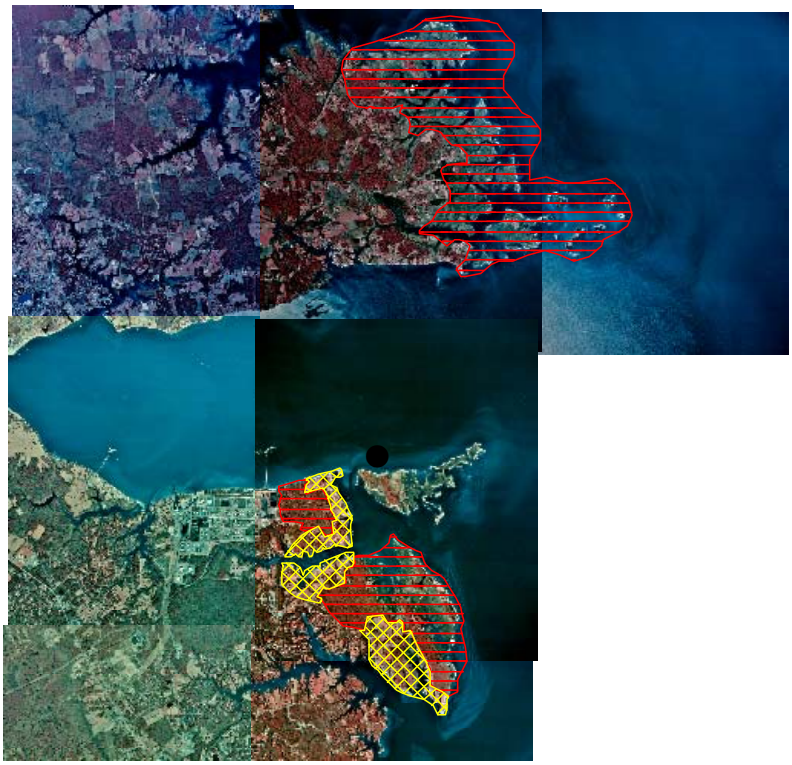

4000 0 4000 8000 Meters

Figure 8. Goodwin Islands: conservation and protection needs and possibilities

Medium to low priority
High priority

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(Jan 2005)

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Appendix A. Management policies for CBNERRVA

From: Virginia Institute of Marine Science. 1991. Management Plan-Chesapeake Bay National Estuarine Research Reserve System – Virginia. VIMS-The College of William and Mary, Gloucester Point. 177 pp. plus appendices.

Management Plan

January 1991

CHESAPEAKE BAY

NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM

VIRGINIA

Commonwealth of Virginia
L. Douglas Wilder, Governor

Virginia Institute of Marine Science
The College of William and Mary
P.O. Box 1346
Gloucester Point, Va. 23062

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Ocean and Coastal Resource Management
1825 Connecticut Ave., N.W.
Washington, D.C. 20235

APPENDIX B
MANAGEMENT POLICIES FOR YORK RIVER SITES

Designated Research Reserves shall be managed to maintain its aesthetic, topographical, and biological integrity. The Reserve shall be maintained as open space, fish and wildlife habitat, and natural field laboratory for nonmanipulative research. The following policies will apply.

Geology

Surface and subsurface features possessing unique geological characteristics shall be maintained and protected so as to preserve those characteristics from unwarranted disturbance and/or destruction. Visitor access to these features will be limited to insure protection of the features and the safety of the visitor. VIMS will work with the Department of Mines, Minerals and Energy to have a geological survey conducted at each reserve site. Surveys must be conducted by a qualified geologist, recognized in the areas of field investigation.

Pertinent statutes, regulations and guidelines
Virginia Cave Protection Act
Coastal Primary Sand Dune Protection Act

Soils

Excavation, mining, or removal of loam, gravel, rock, sand, coal, petroleum, or minerals or alteration of topography shall not be permitted except as related to the collection of geological and geophysical data. Areas devoted to agricultural use or areas subject to user impact, such as trails, should be developed and/or maintained to minimize damage to and loss of existing soils. Soil maps and soil suitabilities shall be obtained or developed for each research reserve.

Pertinent statutes, regulations and guidelines
Virginia Erosion and Sediment Control Law
Agriculture—Best Management Practices
Guidelines on Construction and Maintenance of Trails (to be developed)

Shorelines

Shorelines shall be preserved in their natural state and existing condition. Restoration of severely eroding shorelines by planting native vegetation may be allowed with approval on an individual basis as an applied research. Opposition to existing and/or proposed off-site activities will be considered if such activities may adversely affect existing shoreline and/or water resources along or within reserve boundaries.

Pertinent statutes, regulations and guidelines
Virginia Erosion and Sediment Control Law
Hydrologic Modifications—Best Management Practices
Subaqueous Guidelines
Coastal Primary Sand Dune Protection Act
Federal Clean Water Act, Section 401
Federal Coastal Zone Management Act

Stream Beds and Channels

Stream beds and channels shall be preserved in their natural state and existing condition. There shall be no manipulation or alteration of natural water courses, channels, or other water bodies, nor shall there be conducted activities on or around the reserve site that could alter natural water level, flow, or both except in conjunction with applied research projects where the impact will be temporary and nondestructive. Opposition to existing and/or proposed off-site activities will be considered if such activities may adversely affect natural water courses, channels, levels, flow, or other resources within the reserve boundaries.

Pertinent statutes, regulations and guidelines
Hydrologic Modifications—Best Management Practices
Watercourses Generally
Minimum Instream Flow Generally
Subaqueous Guidelines
Federal Clean Water Act, Section 401

Water Quality

There shall be no human activities or uses of the reserve site that are detrimental or

adverse to the maintenance, improvement or conservation of existing surface and ground water supplies and quality. All activities within a reserve must be conducted so as to avoid violation of established State Water Control Board Water Quality Standards.

Pertinent statutes, regulations and guidelines

Waters of the State, Ports and Harbors
Federal Clean Water Act
Standards of Water Quality (established by State Water Control Board)
Minimum Instream Flow Generally
Sources Affecting Ground Water—Best Management Practices
Hazardous Waste Management Reglations

Air Quality

No activities shall be permitted in the reserve that have the potential to cause air pollution which exceeds acceptable air quality standards. Air quality will be monitored at appropriate sites.

Pertinent statutes, regulations and guidelines

Federal Clean Air Act
Virginia Air Pollution Control Law
Regulations for the Control and Abatement of Air Pollution

Wetlands

All tidal and nontidal wetlands located within or along reserve boundaries shall be protected in a natural condition. Wetlands include bogs, swamps, freshwater and tidal vegetated marshes, and unvegetated flats.

Pertinent statutes, regulations and guidelines

Virginia Wetlands Act
Federal Clean Water Act, Section 404 and Section 401

Forests

Timber management within the core area of reserve lands should be directed toward the development and preservation of significant old growth stands, except where selective harvesting of mature trees is a traditional use of the property. Disease, insect, or exotic plant control, facility development, and/or stand improvement considerations in the buffer zones shall be the controlling or motivating factors behind decisions to harvest or treat timber. Any harvesting of timber will be conducted in accordance with guidelines established by VDOF. The research reserve program shall work with the Virginia Department of Forestry to develop an inventory and evaluation of standing timber at each site. VIMS will work with the Virginia Department of Agriculture and Consumer Affairs to survey timber stands for forest pests, disease, and exotic and rare/endangered plant species and to develop appropriate pest/disease management procedures.

Pertinent statutes, regulations and guidelines

Forestry—Best Management Practices
Gypsy Moth Control Guidelines (to be developed)

Fish and Wildlife

Game and nongame species shall be managed to preserve the overall health of the various populations within the reserve and to maintain fish and wildlife habitat. Traditional hunting, fishing, oystering, and trapping will be allowed, consistent with applicable laws. VIMS will work cooperatively with the Virginia Department of Game and Inland Fisheries to establish reserve-specific wildlife management plans.

Pertinent statutes, regulations and guidelines

Forestry—Best Management Practices
Agriculture—Best Management Practices
Game and Inland Fisheries Hunting Regulation
Virginia Marine Resources Commission Fishing Regulations

Rare, Threatened or Endangered Species

Areas identified as possessing rare, threatened or endangered species shall be managed, according to recommended regulations and guidelines, to preserve and protect the

species. The presence of an endangered or threatened species shall not necessarily preclude continued or proposed uses of an area. The flora and fauna on research reserves will be surveyed, identified and classified with the assistance of the Virginia Natural Heritage Program and Department of Game and Inland Fisheries.

Pertinent statutes, regulations and guidelines

Federal and State Endangered Species Act
Virginia Endangered Plan and Insect Species Act

Traditional Uses

Traditional hunting, trapping, oystering, and fishing activities will be allowed in accordance with applicable laws. Private landowners may place noncommercial blinds on the reserve for personal use or use by assigns. Agricultural and silvicultural activities within the buffer areas of research lands will be conducted in accordance with environmentally sound practices (BMPs).

Pertinent statutes, regulations and guidelines

Game and Inland Fisheries Hunting Regulations
Virginia Marine Resources Commission Fishing Regulations
Virginia Erosion and Sediment Control Law
Virginia Pesticide Law
Agriculture—Best Management Practices

Structures, Roads and Trails

No new buildings, facilities, structures, piers, roads or trails shall be constructed on the reserve site, except those designed, constructed, utilized in, and accessary to research, education, hunting and naturalistic uses of the reserve site. Such construction shall only be permissable only after the environmental impact of any such construction is fully assessed and approved. Similarly, removal of existing structures shall be assessed for potential environmental impact. There shall be no compulsion to remove existing structures.

Signs and Billboards

Display of signs, billboards, or other advertisements shall not be permitted on or over the reserve sites, except to state the name and/or address of the owner, to provide notice of the designation as a Chesapeake Bay National Estuarine Research Reserve, and/or to post the property against trespass or littering.

Fire

A proactive fire plan to consider wildland fire prevention and supression will be developed in cooperation with the Department of Forestry. A two-phased approach to the prevention, management, and suppression of fire will be encouraged. The plan will take into consideration that fire is a natural process in forest ecology and will not seek to control all fires. However, proactive plans to protect structures, and other significant resources which are sensitive to fire damage and to protect human safety will also be developed. Any prescribed burns to be used for resource management purposes will be conducted only under the supervision of a qualified master burner.

Pertinent statutes, regulations and guidelines

Forest Wardens and Fires

Trash, Rubbish and Waste

No soil, trash, ashes, garbage, hazardous waste, or offensive materials shall be dumped or deposited on the research reserve site. No wetland, pond, or waterway shall be filled.

Off-Road Vehicles

No motor vehicles, trail bikes, or all-terrain vehicles shall be operated at the reserve site, except in designated buffer areas and/or for official reserve management operations.

Archaeological and Historical Sites and Objects

Reserve sites shall be inventoried to locate sites and objects possessing prehistoric and/

or historic significance and plans to protect such sites and objects shall be prepared. Activities which may in some way affect significant sites or objects shall require review and/or permitting by the Division of Historic Landmarks and approved by reserve manager.

Pertinent statutes, regulations and guidelines
Virginia Antiquities Act
Virginia Cave Protection Act
1986 Appropriations Act
National Historic Preservation Act

Historic Buildings, Structures and Objects

Historic structures shall be protected and preserved and the history of such structures shall be incorporated in the reserve's interpretive offerings where appropriate. Eligible structures shall be surveyed and evaluated for nomination to the Virginia Landmarks Register and the National Register of Historic Places. Buildings and structures possessing historic significance shall be protected by established statutes and regulations. Plans for the alteration, remodeling, or redecoration of historic structures on the Virginia Landmarks Register must be submitted to the Division of Historic Landmarks for review and comment to insure that the historic and/or architectural integrity of these properties is maintained.

Pertinent statutes, regulations and guidelines
1986 Appropriations Act
Division of Engineering and Buildings Directive No. 1
National Historic Preservation Act

Collection of Natural, Historical or Cultural Resources

All collecting of plant, animal, mineral, or fossil specimens shall require the prior issuance of a collecting permit by VIMS and the Division of State Parks, where appropriate. The collection of historic or archaeological artifacts will be allowed only with collecting permits approved by the Division of Historic Landmarks. Use of metal detectors by public visitors is prohibited.

Pertinent statutes, regulations and guidelines
Division of Parks and Recreation Regulation No. 5
Virginia Antiquities Act
Virginia Cave Protection Act

Manipulative Research

In order to protect the natural integrity of the research reserve, no manipulative research activities with a significant or long-term adverse impact on reserve resources shall be allowed. Habitat manipulation for resource management purpose shall not be allowed, except as allowed under policies for shorelines, timber, fish, wildlife, and fire management. If waivers of certain policies or portions of policies are determined to benefit the overall management of the research reserve system, they could be considered on an individual basis.

Industrial and Commercial Activities

No industrial or commercial activities shall be conducted in the research reserve core area, with the exception of commercial fishing.

RELEVANT STATE STATUTES AND REGULATIONS AFFECTING PROPOSED RESERVE SITES

Endangered Plant and Insect Species Act

The Endangered Plant and Insect Species Act (Va. Code Ann. Sec. 3.1-1020 et seq.) makes it unlawful for any person to dig, take, cut, process, or otherwise collect, remove, transport, possess, sell, offer for sale, or give away any species native to or occuring in the wild in Virginia that are listed as threatened or endangered.

A license is required to cut or collect any threatened species and records of purchases must be kept. Any person who violates the

Appendix B. General Public Access Plan – CBNERRVA

General Public Access Plan

Last Modified: September 12, 2004

A. Mission and Goals

CBNERRVA is responsible for the long-term management of its reserve components in order to protect the ecological integrity of the natural system and provide a stable environment to support research, monitoring and education missions. In some cases, the reserve component can be managed to meet this objective while still supporting some level of public use.

B. General Policy

Public access to the four CBNERRVA components is regulated on a site-specific basis. The objectives of regulated access are to maintain each site's integrity for research and education while permitting traditional uses which do not conflict with reserve goals or agreements with private landowners. CBNERRVA and site property owners reserve the right to impose additional restrictions to curtail any activity threatening to disturb natural conditions or ongoing research and education activities. It should be noted that specific public uses are not compatible, for example bird and wildlife watching is not compatible with concurrent waterfowl hunting. In such cases, CBNERRVA will strive to minimize conflicts through spatial and temporal separation strategies. If negative impacts are observed, the causative public use(s) will be determined and re-evaluated. When warranted, the assistance of local and state law enforcement agencies may be called upon to enforce access regulations. Prosecution of violators will serve as a deterrent against vandalism, littering and arson.

C. Public Access Rules and Schedules

Goodwin Islands

The College of William and Mary maintains a limited-use public access policy for the Goodwin Islands. In accordance with that policy, Goodwin Islands are managed exclusively for research and education. Goodwin Islands are only accessible by shallow draft boats. There are no docking facilities or designated trails on Goodwin Islands. The following access rules apply to Goodwin Islands:

- Public access is limited from dawn to dusk and therefore overnight camping is prohibited.
- Beach areas can be used for picnicking, beachcombing and other non-destructive activities if visitors do not willingly or negligently disturb the environment or scientific experiments/equipment.
- Bicycles, off-road vehicles, and horses are prohibited.
- Building of any type of fire is prohibited.
- Waterfowl hunting from floating blinds is allowed, however, a reserve issued permit is required. No stationary blinds are allowed. Upland and wetland hunting activities are not permitted.
- Fishing, crabbing and collection of shellfish is allowed if in accordance with applicable state laws and regulations.
- Collection of plants, animals (other than that allowed by applicable state laws and regulations), minerals, or artifacts is prohibited.
- Dogs or other domestic animals accompanying visitors must be kept on a leash at all times.

Catlett Islands

With the exception of a single tract acquired by VIMS, the Catlett Islands are privately owned. Visitation is controlled by the property owner(s) and general public access is not permitted on the Catlett Islands. The islands are posted against trespass. Hunting, trapping and oyster gathering are the exclusive rights of the property owners and their assigns. In waters around Catlett Islands, commercial and recreational harvest of fish and crabs is allowed if in accordance with applicable state laws and regulations.

Taskinas Creek

Taskinas Creek reserve is within the boundaries of York River State Park. Access is controlled by park regulations. The park is open year-round from 8am to dusk. The eastern portion of Taskinas Creek within park boundaries is used for passive recreation and nature study. This region contains the park's Visitor Center and outdoor amphitheater, which are open seasonally (closed in the winter) to provide opportunities to learn about coastal environments and local history. Visitors are encouraged to use more than 25 miles of self-guided hiking, biking and equestrian trails. The park and/or park concessionaire charges a nominal park entrance fee and rental fee for picnic shelters, canoes and other recreational items. Picnic tables are available throughout the park on a first-come, first-served basis. Playground equipment, horseshoe pits and volleyball courts are also available. Many of the facilities and trails are ADA compliant.

Croaker Landing, which provides access to the York River, includes a parking area, a boat launch and dock on the York River, and restrooms is open twenty-four hours a day for boating and has a 10 p.m. closing time posted for non-boating activities. Overnight facilities, in terms of limited primitive group tent camping, are available. Fishing and boating opportunities exist within an upland freshwater pond, Taskinas Creek and the York River proper. Boat (pond only) and canoe rentals are available seasonally. Croaker Landing provides access to the York River and includes a newly constructed fishing pier, a parking

area, a boat launch and dock, and restrooms; parking and launch fees are required at all times. Hunting is only allowed in season (November/December) during special controlled hunts. During the hunts, the park is closed to all other visitors. Access to the western portion of Taskinas Creek, which incorporates the reserve, is generally not encouraged.

Sweet Hall Marsh

Sweet Hall Marsh is privately owned. Visitation is controlled by the property owner(s) and general public access is not permitted. Hunting and trapping are the exclusive rights of the property owners and their assigns. In waters around Sweet Hall Marsh, commercial and recreational harvest of fish and crabs is allowed if in accordance with applicable state laws and regulations.

Appendix C. Natural Heritage Rarity Ranks and Status Explanation

Natural Heritage Rarity Ranks and Status Explanation

Each of the significant natural features (species, community type, etc.) monitored by DCR-DNH is considered an element of natural diversity, or simply an element. Each element is assigned a rank that indicates its relative rarity on a five-point scale (1 = extremely rare; 5 = abundant; Table 1). The primary criterion for ranking elements is the number of occurrences, i.e., the number of known distinct localities or populations. Also of great importance is the number of individuals at each locality or, for highly mobile organisms, the total number of individuals. Other considerations include the condition of the occurrences, the number of protected occurrences, and threats. However, the emphasis remains on the number of occurrences, so that ranks essentially are an index of known biological rarity. These ranks are assigned in terms of the element's rarity within Virginia (its State or S-rank), the element's rarity within a Nation (its National or N-rank), and the element's rarity across its entire range (its Global or G-rank). Subspecies and varieties are assigned a Taxonomic (T-) rank in addition to their G-rank. A Q indicates taxonomic uncertainty. Taken together, these ranks give an instant picture of an element's rarity. For example, a designated rank of G5S1 indicates an element which is abundant and secure range-wide, but rare in Virginia. In some cases, ranks are provisional or lacking, due to ongoing efforts by the Natural Heritage network to classify community syntaxa and cryptic plants or animals. Rarity ranks used by DCR-DNH are not legal designations, and they are continuously updated to reflect new information.

Table E-1. Definition of Natural Heritage state rarity ranks. Global ranks are similar to state ranks, but refer to a species' range-wide status. Note that GA and GN are not used and GX means extinct. GM and GW are ranks used only for communities, and refer to highly modified (GM) and ruderal (GW) vegetation respectively. National ranks are similar as well, and refer to a species' rarity within a nation, such as the United States or Canada. Sometimes ranks are combined (e.g., S1S2) to indicate intermediate or somewhat unclear status. Elements with uncertain taxonomic validity are denoted by the letter Q, after the global rank. These ranks should not be interpreted as legal designations.

S1 Extremely rare; usually 5 or fewer occurrences in the state, or in the case of communities, covering less than 50 hectares in aggregate; or may have a few remaining individuals; often especially vulnerable to extirpation.

S2 Very rare; usually between 5 and 20 occurrences, or in the case of communities, covering less than 250 hectares in aggregate; or few occurrences with many individuals; often susceptible to becoming endangered.

S3 Rare to uncommon; usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances.

S4 Common; usually more than 100 occurrences, but may be fewer with many large populations; may be restricted to only a portion of the state; usually not susceptible to immediate threats.

S5 Very common; demonstrably secure under present conditions.

SA Accidental in the state.

SH Historically known from the state, but not verified for an extended period, usually more than 15 years; this rank is used primarily when inventory has been attempted recently.

SM Applied to vegetation extensively modified by disturbance but considered recoverable by management, time, or restoration of ecological processes.

SN Regularly occurring migrants or transient species which are non-breeding, seasonal residents. (Note that congregation and staging areas are monitored separately).

SU Status uncertain, often because of low search effort or cryptic nature of the element.

SW Applied to vegetation dominated by ruderal or exotic species.

SX Apparently extirpated from the state.

The spot on the landscape that supports a natural heritage resource is an element occurrence. DCR-DNH has mapped over 7,500 element occurrences in Virginia. Information on the location and quality of these element occurrences is computerized within the Division's BCD system, and additional information is recorded on maps and in manual files.

In addition to ranking each element's rarity, each element occurrence is ranked to differentiate large, outstanding occurrences from small, vulnerable ones. In this way, protection efforts can be aimed not only at the rarest elements, but at the best examples of each. Species occurrences are ranked in terms of quality (size, vigor, etc.) of the population; the condition (pristine to disturbed) of the habitat; the viability of the population; and the defensibility (ease or difficulty of protecting) of the occurrence. Community occurrences are ranked according to their size and overall natural condition. These element occurrence ranks range from A (excellent) to D (poor). Sometimes these ranks are combined to indicate intermediate or somewhat unclear status, (e.g., AB or CD). In a few cases, especially those involving cryptic animal elements, field data may not be sufficient to reliably rank an occurrence. In such cases a rank of E (extant) may be given. A rank of H (historical) is used to indicate an historical occurrence that could not be relocated by recent survey. Element occurrence ranks reflect the current condition of the species' population or community. A poorly-ranked element occurrence can, with time, become highly-ranked as a result of successful management or restoration.

Element ranks and element occurrence ranks form the basis for ranking the overall significance of sites. Site biodiversity ranks (B-ranks) are used to prioritize protection efforts, and are defined in Table E-2.

Table E-2. Biodiversity ranks used to indicate site significance.

B1 Outstanding Significance: only site known for an element; an excellent occurrence of a G1 species; or the world's best example of a community type.

B2 Very High Significance: excellent example of a rare community type; good occurrence of a G1 species; or excellent occurrence of a G2 or G3 species.

B3 High Significance: excellent example of any community type; good occurrence of a G3 species.

B4 Moderate Significance: good example of a community type; excellent or good occurrence of state-rare species.

B5	General Biodiversity Significance: good or marginal occurrence of a community type or state-rare species.

The U.S. Fish and Wildlife Service (USFWS) is responsible for the listing of endangered and threatened species under the Endangered Species Act of 1973, as amended. Federally listed species (including subspecific taxa) are afforded a degree of legal protection under the Act, and therefore sites supporting these species need to be highlighted. USFWS also maintains a review listing of potential endangered and threatened taxa known as candidate species. Table E-3 illustrates the various status categories used by USFWS and followed in this report. The status category of candidate species is based largely on the Service's current knowledge about the biological vulnerability and threats to a species.

As of February 27, 1996, species formerly referred to as Category 2 (C2) candidates for listing as threatened or endangered are no longer considered "candidates" under the Endangered Species Act. The USFWS no longer maintains a formal, comprehensive list of such species. However, the Virginia Field Office of the USFWS intends to maintain an informal list of these and other "Species of Concern" that may warrant future consideration as candidates. These "Species of Concern" can be regarded as species for which the Service has insufficient scientific information to support a listing proposal. Former Category 1 (C1) species are now considered "candidates" (C) for listing. "Candidate" species are species for which the USFWS has enough scientific information to warrant a proposal for listing. The designation of Category 3 species (3A, 3B, 3C) has been discontinued. However, the USFWS will continue to maintain its files on these species in case new information indicates a need for reevaluation.

Table E-3. U.S. Fish and Wildlife Service species status codes, with abbreviated definitions

LE	Listed endangered
LT	Listed threatened
PE	Proposed to be listed as endangered
PT	Proposed to the listed as threatened
C	Candidate: status data supports listing of taxon as endangered or threatened
SOC	Species of Concern: no official status, evidence of vulnerability, but insufficient data exists.

In Virginia, two acts have authorized the creation of official state endangered and threatened species lists. One act (Code of Virginia ' 29.1-563 through 570), administered by the Virginia Department of Game and Inland Fisheries (DGIF), authorizes listing of fish and wildlife species, not including insects. The other act (Code of Virginia ' 3.1-1020 through 1030), administered by the Virginia Department of Agriculture and Consumer Services (VDACS), allows for listing of plant and insect species. In general, these acts prohibit or regulate taking, possessing, buying, selling, transporting, exporting, or shipping of any endangered or threatened species appearing on the official lists. Species protected by these acts are indicated as either listed endangered (LE) or listed threatened (LT). Species under consideration for listing are indicated as candidates (C).

(November 2000)

Appendix D. Invasive Species / Problem Native Species Information

ESA – *Ligustrum* spp.

ESA – *Lonicera japonica*

ESA – *Microstegium vimineum*

ESA – *Phragmites australis*

White-tailed deer and Virginia Natural Area Preserves: a discussion by Mike Leahy, Stewardship Regional Land Steward, Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA

Impacts and Economic Costs of Deer in Suburban Landscapes – Dr. Paul D. Curtis, Extension Wildlife Specialist, Department of Natural Resources, Cornell University, Ithaca, NY.

ELEMENT STEWARDSHIP ABSTRACT
for
Ligustrum spp.
Privet

To the User:

Element Stewardship Abstracts (ESAs) are prepared to provide The Nature Conservancy's Stewardship staff and other land managers with current management related information on species and communities that are most important to protect or control. The abstracts organize and summarize data from many sources including literature and from researchers and managers actively working with the species or community.

We hope, by providing this abstract free of charge, to encourage users to contribute their information to the abstract. This sharing of information will benefit all land managers by ensuring the availability of an abstract that contains up-to-date information on management techniques and knowledgeable contacts. Contributors of information will be acknowledged within the abstract.

For ease of update and retrievability, the abstracts are stored on computer at The Nature Conservancy. Anyone with comments, questions, or information on current or past monitoring, research, or management programs for the species described in this abstract is encouraged to contact The Nature Conservancy's Wildland Invasive Species Team.

This abstract is a compilation of available information and is not an endorsement of particular practices or products.

Please do not remove this cover statement from the attached abstract.

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THE NATURE CONSERVANCY

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SCIENTIFIC AND COMMON NAMES

Ligustrum amurense (Carr.): Amur privet

Ligustrum japonicum (Thun.): Japanese privet

Ligustrum lucidum (Ait.f.): Tree privet; glossy privet

Ligustrum obtusifolium (Sieb. and Zucc.): Blunt-leafed privet; border privet

Ligustrum ovalifolium (Hassk.): California privet; waxy-leaved privet

Ligustrum quihoui (Carr.): Wax-leaf privet

Ligustrum sinense (Lour.): Chinese privet

Ligustrum vulgare (L.): European privet, common privet

DESCRIPTION AND DIAGNOSTIC CHARACTERISTICS

Ligustrum spp. are deciduous, semi-evergreen, or evergreen shrubs and small trees in the Oleaceae (olive family). There are approximately 50 *Ligustrum* species that are native to Europe, North Africa, and Asia. *Ligustrum* spp. have been cultivated and developed into several horticultural varieties, and were introduced to North America as a common hedge in landscaping. *Ligustrum* spp. can easily escape cultivation to invade adjacent areas and can form dense monospecific thickets.

Some *Ligustrum* spp**.** can grow to 5 m tall and have a stem diameter of 2.5-25 cm. *Ligustrum* spp. bark is whitish-tan to gray in color and smooth in texture. Slender twigs are straight, rounded or four-angled below the nodes, and gray-green in color. Winter buds are ovoid with two outer scales. Terminal buds are present. Leaves are elliptic to ovate in shape, oppositely arranged on slender twigs, often leathery and thick. Flowers have both male and female parts, and the corollas are white. The calyx is small, obconic or campanulate, and 4-toothed. Each flower has petals that are fused into a tube below with four separate lobes above. Flowers are borne on small panicles terminating the main axis and on short lateral branches. Bloom time is usually June-July. The fruit is a subglobose or ovoid drupe containing 1-4 seeds. Fruit clusters generally ripen during September and October and persist through the winter. Mature specimens can produce hundreds of fruit (Rehder 1977).

L. amurense grows to 5 m. Leaves are elliptic to oblong or oblong-ovate, 2.5-6 cm long, acute or obtuse, rounded or broad-cuneate at base; ciliolate, sometimes lustrous above, and smooth except on the midrib below. Petioles are 2-4 mm long, pubescent. Panicles are 3-5 cm long and pubescent. The calyx is glabrous or slightly pubescent. The corollas (from base of tube to tip of lobe) are 7-9 mm long, with the tube far longer than the lobes.

L. japonicum generally grows to 3 m, rarely to 6 m. Leaves are broad-ovate to ovate-oblong, 4-10 cm long, obtusely short-acuminate or acute to obtuse, rounded at the base with reddish margins and midrib and with 4-5 pairs of indistinct veins. Petioles are 6-12 mm long. Panicles are 6-15 cm long. Flowers are short-stalked with the corolla tube longer than the calyx. Stamens are slightly longer than the corolla lobes.

L. lucidum grows as a large shrub or medium-sized tree, to 10 m high, with spreading branches. Leaves are ovate to ovate-lanceolate, 8-12 cm long, acuminate or acute, usually broad-cuneate with 6-8 veins, usually distinct above and beneath. Petioles are 1-2 cm long. Panicles are 12-20 cm long and nearly as wide. Flowers are subsessile. The corolla tube is as long as the calyx. Stamens are as long as the corolla lobes. Fruits are oblong, 1 cm long, bluish or purplish-black.

L. obtusifolium grows to 3 m with spreading or arching branches. Leaves are elliptic to oblong or oblong-obovate, 2-6 cm long. Leaves are acute or obtuse, cuneate or broad-cuneate, glabrous above, pubescent below (or occasionally only on midrib). Petioles are 1-4 mm long, pubescent. Panicles are

2-3.5 cm long, nodding. Corollas are 8-10 mm long with anthers nearly as long as the corolla lobes. Fruits are subglobose, black and slightly bloomy (glaucous).

L. ovalifolium grows to 5 m. Leaves are elliptic-ovate to elliptic-oblong, 3-6 cm long, acute, broad-cuneate, dark lustrous green above, yellowish green below. Petioles are 3-4 mm long. Flowers are creamy-white with an unpleasant scent, subsessile in panicles 5-10 cm long. Corollas are 8 mm long with anthers as long as lobes. Fruits are 5-7 mm across, black.

L. quihoui grows to 2 m with spreading, rigid branches. Leaves are elliptic to elliptic-oblong or obovate to obovate-oblong, 2-5 cm long, obtuse, sometimes emarginate, glabrous, subcoreaceous. Petioles are 1-3 mm long, puberulous. Flowers are sessile, in small clusters on long spikes collected into 10-20 cm long panicles. Corolla tubes are as long as the lobes with anthers exceeding the lobes. Flowers appear in late summer.

L. sinense is a shrub or small tree to 7 m. Leaves are elliptic to elliptic-oblong, 3-7 cm long, acuminate, acute to obtuse, dull green above, pubescent on the midrib below. Petioles are 6-15 mm long. Flowers are small, distinctly stalked, on panicles 10-16 cm long. Fruits are dull black.

L. vulgare grows to 5 m with spreading branches. Leaves are oblong-ovate to lanceoloate, 3-6 cm long, obtuse to acute, glabrous. Petioles are 3-10 mm long. Flowers are pediceled in dense puberulous panicles, 3-6 cm long. Anthers exceed the corolla tube. Fruits are subglobose or ovoid, 6-8 mm long, black and lustrous.

STEWARDSHIP SUMMARY

Several *Ligustrum* species have become common invaders of cultivated landscapes, disturbed areas and wildlands throughout the U.S. *L. amurense* is found in many eastern and some south-central states. *L. japonicum* is found in the Southeast and in Puerto Rico. *L. lucidum* is present from Maryland south and west to Texas. *L. sinense* and *L. obtusifolium* are found throughout the eastern and central U.S. *L. ovalifolium* is common in California and in parts of the central and eastern U.S. *L. quihoui* is seen in the southeast. *L. vulgare* is widely naturalized throughout much of the U.S. and southern Canada.

Ligustrum spp. may invade natural areas such as floodplain forests and woodlands. They may displace shrubs in regenerating communities and remain persistent in these areas. *Ligustrum* spp. can form dense thickets that outcompete many kinds of native vegetation.

In North America, *Ligustrum* spp. are seen along roadsides, in old fields and in other disturbed habitats and in a variety of undisturbed natural areas, including bogs, wetlands, floodplains, old fields, calcareous glades and barrens, and mesic hardwood forests.

Ligustrum spp. control methods include mowing and cutting, seedling removal, herbicide application, and burning. Mowing and cutting are appropriate for small initial populations or environmentally sensitive areas where herbicides cannot be used. Stems should be cut at least once per growing season as close to ground level as possible. Repeated mowing or cutting will control the spread of *Ligustrum* spp., but may not eradicate it. *Ligustrum* spp. can also be effectively controlled by manual removal of young seedlings. Herbicide control measures include foliar spraying in late autumn or early spring with glyphosate, triclopyr, or metsulfuron; cut stump applications using glyphosate or triclopyr; and basal bark applications of triclopyr. Some reports indicate that burning top-kills *L. vulgare* and *L. sinense* and, if repeated, can eliminate them over time.

RANGE

Ligustrum spp. are native to east Asia, Europe and North Africa: *Ligustrum amurense* is native to north China; *L. japonicum* to Korea and Japan; *L. lucidum* to China, Korea and Japan; *L. obtusifolium* to Japan; *L. ovalifolium* to Japan; *L. sinense* to China; and *L. vulgare* to the Mediterranean region.

Reported occurrences of the different *Ligustrum* spp. in North America include:

L. amurense: Arkansas, Kentucky, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Pennsylvania, South Carolina, Tennessee, Texas, and Virginia.

L. japonicum: Alabama, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Texas, Virginia, and Puerto Rico.

L. lucidum: Alabama, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, and Texas.

L. obtusifolium: Connecticut, District of Columbia, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Michigan, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Tennessee, Utah, Vermont, and Virginia.

L. ovalifolium: California, Connecticut, Delaware, District of Columbia, Florida, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Missouri, New Jersey, North Carolina, Ontario, Pennsylvania, Texas, Vermont, Virginia, and Puerto Rico.

L. quihoui: Louisiana, North Carolina, Texas, and Virginia.

L. sinense: Alabama, Arkansas, Connecticut, Florida, Georgia, Iowa, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, Missouri, New Jersey, North Carolina, Oklahoma, Rhode Island, South Carolina, Tennessee, Texas, and Virginia.

L. vulgare has the broadest range of the invasive *Ligustrum* species established in North America. It has been documented in: Alabama, Arkansas, British Columbia, Connecticut, Delaware, District of Columbia, Florida, Georgia, Great Smoky Mountain National Park, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Missouri, New Hampshire, New Jersey, New York, Newfoundland Island (Newfoundland), North Carolina, Nova Scotia, Ohio, Ontario, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia, West Virginia, and Wisconsin.

IMPACTS AND THREATS POSED BY EXOTIC PRIVETS

Ligustrum spp. can form dense thickets that outcompete native vegetation. The privets can invade natural areas such as floodplain forests, woodlands, and disturbed agricultural fields. They generally expand along fence-rows, windbreaks and roadsides (Haragan 1996). In New Zealand, *L. sinense* may displace the shrub layer and marginal shrubs of alluvial forests, and remain persistent in these areas. *L. lucidum* replaces mid-canopy trees in forests and may completely dominate an area of forest or forest fragments if not controlled (New Zealand Weeds Web Site 1999). *L. japonicum* and *L. sinense*

invade woodlands in the eastern and southeastern U.S. (Faulkner et al. 1989; Stone 1997). Forest gaps can also become invaded since birds often disperse *Ligustrum* seeds.

HABITAT

In North America, *Ligustrum* spp. often grow along roadsides, in old fields and in other disturbed habitats and in a variety of undisturbed natural areas. Examples of *Ligustrum* invasions include:

1) *L. obtusifolium* was found invading an old field succession site in Illinois. The field had an average of more than 6,082 plants per ha (2.5 acres) (Tennessee Exotic Pest Plants Council 1996).

2) *L. sinense* has been reported in bogs, an oak-hickory-pine forest, a longleaf pine-turkey oak forest, and mesic hardwood forests in Alabama. In Arkansas, *L. sinense* has been reported in virtually all non-xeric habitats. In Georgia, *L. sinense* has been reported in floodplain/wetland habitats, and in North Carolina, in woodland edges (Randall and Rice. unpublished.).

3) *L. vulgare* has been recorded in bottomlands and mesic and riparian forests in Arkansas. In Ohio, *L. vulgare* is found in old fields, primary woodlands, and closed canopy forests. In Tennessee, the species has been recorded in calcareous glades and barrens and in deciduous cove forests (Randall and Rice. unpublished.).

4) In New Zealand, *L. sinense* is found in alluvial forest remnants, waste places, shrublands, and open stream systems, particularly in coastal areas. *L sinense* is widespread and common, especially near towns. It is a common farm hedging plant. *L. lucidum* is found in forests (lowland and coastal), forest fragments, shrublands, along roadsides, in farm hedges, wastelands, and domestic gardens (New Zealand Weeds Web Site).

ECOLOGY AND BIOLOGY

Ligustrum spp. are perennial shrubs that grow readily from seed or from root and stump sprouts. They can escape from cultivation when the fruits are consumed by wildlife, particularly birds, which often excrete the seeds unharmed at distant locations where they may germinate and become established. Germination rates have been variously reported as low as 5%-27% (Tennessee Exotic Plants Council 1996) and as high as 77% (Schopmeyer 1974). Unlike most woody species, experimental defoliation did not result in reduced percentages of flowers producing fruits, decreased seed number, or decreased seed quality (Obeso and Grubb 1993).

Ligustrum spp. leaves are high in phenolic compounds that defend against herbivores, especially insects. These work by inhibiting digestive enzymes and proteins (Konno et al. 1998). Despite this, *L. sinense* has been identified as an important forage plant for deer in the southeastern U.S. (Stromayer et al. 1998).

L. vulgare grows well in high light, low nutrient soils, but will tolerate lower light levels if nutrients are increased (Grubb et al. 1996).

MANAGEMENT

Potential for Restoration of Invaded Sites

In North America, *Ligustrum* spp. have no important pests or predators. The various species are widespread and occasionally locally abundant. Manual and mechanical, environmental/cultural, and chemical methods are all useful in varying degrees in controlling *Ligustrum spp*. Fire management may be useful in some cases where the density of *Ligustrum spp.* is low and sufficient fuels available. Restoration potential is likely to be lowest where *Ligustrum spp.* occur in high densities and there is a high likelihood of continued dispersal of seeds into the restoration area. *Ligustrum* spp. have a high degree of reproductive vigor, a wide range of adaptability, and, in its present settings, few pests and predators. *Ligustrum spp.* produce large numbers of viable seed that are readily dispersed by birds and germinate at high rates in a wide range of conditions.

The potential for large-scale restoration of unmanaged natural areas or wildlands infested with *Ligustrum* spp. is probably low. Restoration potential for managed natural areas or wildlands infested *Ligustrum spp*. is probably moderate. If attacked during the early stages of colonization, the potential for successful management is high.

Mechanical Controls

Mowing and cutting are appropriate for small populations or environmentally sensitive areas where herbicides cannot be used. Stems should be cut at least once per growing season as close to ground level as possible. Repeated mowing or cutting will control the spread of *Ligustrum* spp., but may not eradicate it (Tennessee Exotic Pest Plants Council 1996). Managers of The Nature Conservancy preserves in Ohio reported eradication of *L. vulgare* after two cutting treatments (Randall and Rice, unpublished).

Ligustrum spp. can be effectively controlled by the manual removal of young seedlings. Plants should be pulled as soon as they are large enough to grasp but before they produce seeds. Seedlings are best pulled after a rain when the soil is loose. Larger stems (up to 6 cm in diameter) can be removed using a weed wrench or similar uprooting tools. The entire root must be removed since broken fragments may resprout (Tennessee Exotic Pest Plants Council 1996).

Biological Controls

Ligustrum spp. have no known biological controls, although a few pathogens are known to attack them in North America. *Cercospora adusta, C. lilacis*, and *Pseudocercospora lugustri* are fungal leaf spots that affect *L. vulgare* and *L. amurense*. *Nectriella pironi* creates galls on *L. sinense, L. lucidum* and *L. quihoui*. *Pseudomas syringae* impacts members of the olive family including *L. amurense. Agrobacterium tumefaciens*, *Ganoderma lucidum* and *Glomerella cingulata* affect *L. vulgare* (Sinclair et al. 1987).

Herbicides

Foliar Spray Method: This method may be effective for large thickets of *Ligustrum* spp. where risk to non-target species is minimal. Air temperatures should be above 17°C to ensure that herbicides are absorbed. The ideal time to treat is while plants are in leaf in late autumn or early spring but when many native species are dormant.

Glyphosate (brand name Roundup and others): A number of concentrations have been used successfully. The Tennessee Exotic Pest Plants Council (1996) suggests a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. The New Zealand Weeds Web Site (1999) recommends, for a handgun sprayer, 1 liter Roundup and 100 mls of a surfactant per

100 liters of water (1% solution); for a backpack sprayer, the recommendation is 100 ml Roundup and 20 mls of a surfactant per 10 liters of water. (Roundup is a non-selective herbicide.)

Triclopyr (brand name Garlon, Pathfinder II and others): The Tennessee Exotic Pest Plants Council (1996) suggests a 2% solution of triclopyr and water plus a 0.5% non-ionic surfactant, sprayed to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray-drift damage to non-target species. (Triclopyr is a selective herbicide for broadleaf species only.)

Metsulfuron (brand name Escort and others): The New Zealand Weeds Web Site (1999) recommends, for a handgun sprayer, 35 g metsulfuron and 100 mls of a surfactant per 100 liters of water; for a backpack sprayer, the recommendation is 5 g metsulfuron and 10 mls of a surfactant per 10 liters of water. Metsulfuron methyl was identified as the most cost-effective herbicide in an experimental treatment comparing metsulfuron methyl, triclopyr ester and 2,4-D (Madden and Swarbrick 1990). (Metsulfuron is a selective herbicide active upon broadleaf and some annual grass species.)

Cut Stump Method: This control method should be considered when treating individual shrubs or where the presence of desirable species precludes foliar application. The Tennessee Exotic Pest Plants Council (1996) recommends this treatment only as long as the ground is not frozen, but other researchers have found it effective on *Rhamnus* spp. in frozen ground (Reinartz 1997). Immediately after cutting stems at or near ground level, apply a 25% solution of glyphosate and water or triclopyr and water to the cut stump, being careful to cover the entire surface (Tennessee Exotic Pest Plants Council 1996). Effectiveness of the herbicide is increased if holes are cut in the top of the freshly felled stump, to hold the herbicide in for better absorption by plant (New Zealand Weeds Web Site 1999).

Basal Bark Method: Apply a mixture of 25% triclopyr and 75% horticultural oil to the basal parts of the shrub to a height of 30-38 cm (12-15 in) from the ground. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line. Like the cut stump application, this method may be effective throughout the year, if *Ligustrum* spp. responds similarly to *Rhamnus* spp. (Reinartz 1997). In New Zealand, researchers have killed standing *Ligustrum* trees by drilling downward-sloping 20 mm wide holes 5 cm into the trunk at no greater than 5 cm spacing around the trunk, and filling the holes with a stump paint-herbicide mix (New Zealand Weeds Web Site 1999).

Prescribed Burning

Faulkner et al. (1989) reported that in experimental trials of prescribed burning, there was no significant difference in the abundance of *L. sinense* in burned vs. unburned plots. *Ligustrum* litter has a low flammability and fires did not carry well in these treatments.

The Nature Conservancy land managers in Alabama reported that burning top-kills *L. vulgare* and *L. sinense* and eliminates them over time, and that burning is effective at controlling *L. sinense* if done annually with low fuel moisture and high Keetch-Byram Drought Index (Randall and Rice. unpublished).

EXAMPLES OF *LIGUSTRUM* SPP. CONTROL ON TNC PRESERVES

Ligustrum spp. have been reported as problems weeds on TNC preserves in Alabama, Arkansas, Louisiana, Georgia, Florida, Mississippi, Tennessee, North Carolina, and in Ohio.

In Alabama and in Florida, Carlen Emanuel and Greg Seamon, respectively, reported that annual burning was effective in controlling *L. sinense*. Furthermore, cutting is also effective if done when conditions are dry. George Ramseur Jr. in Mississippi found that a combination of pulling and burning provided good control of *L. sinense*.

Richard Martin reports that *L. sinense* is one of the worst weeds on Louisiana preserves, and has found that the application of Garlon 4 (triclopyr) has produced excellent control results, but RoundUp (glyphosate) did not provide good results. In North Carolina, however, Robert Merriam found that RoundUp was useful in controlling large infested areas of *L. sinense*. Additionally, cutting was very effective if coupled with the use of Arsenal (imazapyr) on cut stumps. Rates of herbicide application should follow those recommended by the manufacturer. Rates that have been applied successfully for control of *Ligustrum* are described above.

In Arkansas, Scott Simon reports that burning only top-kills *L. vulgare* and *L. sinense*, but will eventually eliminate the plants over time if burns are repeated. Burning is not effective however, in moist bottomland areas.

L. vulgare was successfully controlled in central Ohio preserves. Ross Lebold reported that the cut-stump method, using RoundUp (glyphosate) was effective, and that repeated cutting also seemed effective. In Tennessee, *L. vulgare* was partially controlled by cutting, and Gabby Call reports that the use of goats to control privet works well. The goats however, must able to reach and destroy adult privet plants.

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MONITORING

In natural areas management, monitoring programs will likely follow changes in abundance of *Ligustrum* spp. AND changes in abundance of desirable native species or changes in community attributes that are the targets of management. Such programs should have explicit objectives that can be measured and that are meaningful from both a biological and management standpoint. These

objectives may vary depending on the abundance of *Ligustrum* spp. and other invasive plants. For instance, the objective of managing a forest with 40% cover of *Ligustrum* spp. may be to reduce *Ligustrum* cover to 20%. On the other hand, on a site with 10% an appropriate management objective might be to prevent an increase of more than 10% of total cover (20% total). In addition, increasing regeneration of native species may be an important objective. Monitoring the status of other conservation targets such as invertebrates dependent on specific nectar sources or plant species that are conservation targets may be more important than tracking invasive plant species abundance. In general, the objectives of monitoring should track those of management.

In terms of effort (number of plots established and monitored), transects or long linear plots are more effective in providing the statistical power to necessary to detect changes than square, broadly rectangular, circular or other regularly shaped quadrats. Analyses of plant species composition and abundance can be simplified by (1) collecting data on abundance of dominant species; (2) collecting data on all species and pooling data on less abundant species; and (3) pooling data on species by placing them in guilds (e.g. invasive grasses, invasive legumes, native grasses, etc.).

While generally a research technique, measuring change, or lack thereof, in control (unmanaged) areas can be an effective way of assuring that changes observed in treated areas actually result from the treatmentand not from other factors such as fire, rainfall, etc. In forest communities that are in early successional stages or recently disturbed, declines in abundance of the *Ligustrum* spp. may occur with time without management.

RESEARCH

Additional research is needed on more efficient control methods, especially where cutting is used. Standard tools such as weed whackers, brush hogs, and other equipment are not designed for cutting this species or for use in the kinds of habitat which *Ligustrum* species often invade.

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EDITION DATE: August 2000

ELEMENT STEWARDSHIP ABSTRACT

for
Lonicera japonica

Japanese Honeysuckle

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The Nature Conservancy

Element Stewardship Abstract

For *Lonicera japonica*

SCIENTIFIC NAME (GNAME)
Lonicera japonica Thunb.

The common name "Japanese honeysuckle" refers to the species *Lonicera japonica* Thunb. including the more aggressive cultivar *Lonicera japonica* var. halliana, also known as Hall's honeysuckle and the less common *Lonicera japonica* var. chinensis (P.W. Wats.) Baker. The original Latin name of the species was *Nintooa japonica* (Gleason and Cronquist 1963), but the species has been referred to as *Lonicera japonica* since at least 1889 (Wood and Willis 1889).

The genus name *Lonicera* refers to German naturalist Adam Lonitzer (1528-1586), the species epithet *japonica* to Japan, and the variety name *halliana* to Dr. George Hall, who introduced the variety to the United States in 1862 (Coombes 1991).

COMMON NAME

JAPANESE HONEYSUCKLE is the name most commonly used to refer to *Lonicera japonica* and its varieties, *L. japonica* var. halliana (Hall's Japanese honeysuckle) and *L. japonica* var chinensis. Hall's Japanese Honeysuckle is more common and aggressive than the species. In old floras *Lonicera japonica* was occasionally referred to as "woodbine" (Lounsbury 1899) and "Chinese honeysuckle" (Wood and Willis 1889; probably *L. japonica* var. chinensis).

DESCRIPTION (DIAGNOSTIC CHARACTERISTICS)

Lonicera japonica is a perennial trailing or climbing woody vine of the honeysuckle family (Caprifoliaceae) that spreads by seeds, underground rhizomes, and aboveground runners (USDA 1971). It has opposite leaves that are ovate, entire (young leaves often lobed), 4-8 cm long, with a short petiole, and variable pubescence. In the southern part of the range the leaves are evergreen, while in more northern locales the leaves are semi-evergreen and fall off in midwinter (Fernald 1970). Young stems are reddish brown to light brown, usually pubescent, and about 3 mm in diameter. Older stems are glabrous, hollow, with brownish bark that peels in long strips. The woody stems are usually 2-3 m long, (less often to 10 m). *Lonicera japonica* creates dense tangled thickets by a combination of stem branching, nodal rooting, and vegetative spread from rhizomes.

Lonicera japonica (including the varieties) is easily distinguished from native honeysuckle vines by its upper leaves and by its berries. The uppermost pairs of leaves of *Lonicera japonica* are distinctly separate, while those of native honeysuckle vines are connate, or fused to form a single leaf through which the stem grows. *Lonicera japonica* has black berries, in contrast to the red to orange berries of native honeysuckle vines. The fruits are produced September through November. Each contains 2-3 ovate to oblong seeds that are 2-3 mm long, dark-brown to black, ridged on one side and flat to concave on the other.

The fragrant white (fading to yellow) flowers of *Lonicera japonica* are borne in pairs on solitary, axillary peduncles 5-10 mm long, supported by leaflike bracts. The species has white flowers tinged with pink and purple. Individual flowers are tubular, with a fused two-lipped corolla 3-4(-5) cm long, pubescent on the outside. Flowers are produced late April through July, and sometimes through October. *Lonicera japonica* var. halliana may be distinguished from the species by its pure white flowers (fading to yellow; Dirr 1983) and more vigorous growth. *Lonicera japonica* var. *chinensis* has purple, essentially glabrous leaves, red flowers, and a more limited range than the species,

occurring north to New Jersey and Pennsylvania (Fernald 1970), with an outlier in southern Illinois (Mohlenbrock 1986).

This description was derived from Gleason and Cronquist (1991) and Fernald (1970). Excellent illustrations of *Lonicera japonica* are contained in USDA (1971).

STEWARDSHIP SUMMARY

Lonicera japonica invades fields, forest edges and openings, disturbed woods, and floodplains, in eastern North America, where it spreads rapidly and outcompetes native vegetation by vigorous above- and below-ground competition. Once established, the vine may literally engulf small trees and shrubs, which collapse under the weight, and few plants survive beneath the dense canopy. It has also escaped cultivation at scattered locations in California and in Hawaii where it has the potential to become a severe pest in mesic and wet forest areas.

Lonicera japonica has few natural enemies in North America and is difficult to control once established. Thus, the best and most effective control method is to prevent its establishment by surveying a site for its presence regularly and immediately destroying every plant located. Unfortunately *Lonicera japonica* is difficult to locate when small and without careful attention may go unnoticed until it is well established.

Because Japanese honeysuckle is so difficult to control once established, an appropriate control program goal is 100% kill of all plants in the target area. Removing above-ground stems by cutting pulling or burning will temporarily weaken, but not kill, *Lonicera japonica* as it will resprout from subterranean buds and roots, and from cut branchlets.

In northern states, *Lonicera japonica* retains some leaves through all or most of the winter (semi-evergreen or evergreen), when most native plants have dropped their leaves. This provides a windows of opportunity from mid-autumn through early spring when it is easier to spot and treat with herbicides, fire or other methods without damaging native species. The most effective treatment is a foliar application of glyphosate herbicide (trade names Roundup, Rodeo or Accord; 1.5 v/v), applied after native vegetation is dormant and when temperatures are near and preferably above freezing. Applications within 2 days of the first killing frost are more effective than applications later in the winter. *Lonicera japonica* is less susceptible to herbicides after the first hard frost (-4^{o}C). Combining fire and herbicides may prove to be more effective than either method by itself if late autumn or winter burns are used to reduce Japanese honeysuckle biomass and all resprouts are then treated with a foliar application of glyphosate about a month after they emerge. Prescribed burns may also be used to help prevent spread of Japanese honeysuckle because seedlings and young plants are most susceptible to fires. Soil disturbance should be avoided in infested areas to minimize germination of seed in the seedbank.

IMPACTS (THREATS POSED BY THIS SPECIES)

Lonicera japonica damages natural communities it invades by outcompeting native vegetation for both light (shoot competition [Thomas 1980, Bruner 1967]) and below-ground resources (root competition [Dillenburg et al. 1993a, 1993b, Whigham 1984]), and by changing forest structure (Sasek and Strain 1990, 1991). *Lonicera japonica* grows very rapidly, sending out numerous runners that give rise to still more runners. The vines overtop adjacent vegetation by twining about, and completely covering, small trees and shrubs. Dense Japanese honeysuckle growth can topple trees and shrubs due to its weight alone (Williams 1994, McLemore 1981). As Lonicera japonica becomes

established in forest openings it forms a dense blanket that excludes most shrubs and herbs (Oosting 1956). Few tree seedlings can penetrate the mat and those that do are often quickly overgrown and bent down by the vine, and consequently die (Slezak 1976, Thomas 1980). Forests invaded by *Lonicera japonica* gradually lose their natural structure as canopy openings are invaded, and understory herbs shrubs and replacement trees suppressed and killed by thick mats of honeysuckle. This results in a simplified, increasingly open understory. *Lonicera japonica*, in turn, becomes even more vigorous with the increased light (Thomas 1980). These openings also promote further invasion by other non-native species including aggressive vines like kudzu (*Pueraria lobata*) and English ivy (*Hedera helix*) (Miller 1985; Thomas 1980).

Shading under the extensive and rapid aerial growth of *Lonicera japonica* poses the most obvious threat to native species. However, Dillenburg et al. (1993a, 1993b) demonstrated that in the early stages of invasion, below-ground competition by *Lonicera japonica* reduced tree growth, particularly leaf size and expansion rate, significantly and more than above-ground competition. After two growing seasons, *Lonicera japonica* root competition significantly reduced growth of young sweetgum trees (*Liquidambar styraciflua*) and greatly exceeded root competition from the native vine *Parthenocissus quinquefolia* (Dillenburg et al. 1993b). The combined effects of above- and below-ground competition can suppress growth or result in direct mortality of trees and seedlings (Whigham 1984). Bruner (1967) documented that after five years of co-occurrence, 33% of yellow-poplar seedlings were dead, 22% were overwhelmed, and 45% were heavily draped with *Lonicera japonica* that germinated from seed in the first year.

Lonicera japonica has an additional competitive edge as it grows during part or all of the winter, when many native species are dormant (Carter and Teramura 1988a). This evergreen or semi-evergreen character allows *Lonicera japonica* to photosynthesize at winter temperatures and light levels. The shade it casts during early spring may inhibit ephemeral herbs that complete their life cycle in the six weeks prior to deciduous tree leaf-out.

Alteration of forest understory and overstory structure by *Lonicera japonica* may lead to a decline or alteration in songbird populations (Nyboer 1990). However, no studies have been conducted on interactions between *Lonicera japonica* and native animals, with the exception of white-tailed deer (*Odocoileus virginianus*) which favors *Lonicera japonica* leaves as food (Handley 1945, Harlow and Hooper 1971). In fact, wildlife managers in some states actively promoted growth of this aggressive vine to provide winter forage for deer (Dyess et al. 1994; Segelquist and Rogers 1975, Stransky 1984). Japanese honeysuckle foliage is most digestible and nutritious in spring, but it is still relatively high in nutritional value in winter (Blair et al 1983) when other food sources are less available to deer (Dyess et al. 1994). Seeds and leaves are eaten by cottontail rabbits, as well as birds (Dyess et al. 1994), and the tangled thickets provide cover for birds and small mammals.

Lonicera japonica is a severe threat in the southeastern and eastern states (Florida to Texas, north to Kansas, Missouri, central Illinois and New York), and a severe potential threat in northern states outside the current (1995) range. On the northern edge of the range, *Lonicera japonica* flower production is inhibited by winter temperatures (Swink and Wilhelm 1994), and the vine is thus a moderate threat. For example, in Illinois, *Lonicera japonica* is not a serious pest in the colder, northern third of the state, but is increasingly common in the central part of the state (Nyboer 1990). *Lonicera japonica* continues to spread gradually northward (Wagner 1986), possibly due to increasing cold tolerance, or to warm winters, or to other factors.

As of 1995 *Lonicera japonica* northern range was limited by winter temperatures, and its western range by drought-induced stress at the seedling stage (Sasek and Strain 1990). If atmospheric CO_2

concentrations increase as predicted, resulting in a 3°C increase in average and minimum winter temperatures, the northern range of *Lonicera japonica* is predicted to shift up to 400 km north (Sasek and Strain 1990). Further westward expansion may be limited by decreased summer precipitation, although *Lonicera japonica* has improved water use efficiency and increased drought tolerance at higher CO_2 levels (Sasek and Strain 1990). *Lonicera japonica* is also predicted to become a more serious competitor of native trees at higher CO_2 levels, as it experiences much greater growth rates at higher CO_2 levels than do native woody erect species (Sasek and Strain 1991).

Virginia and Illinois have produced honeysuckle control circulars (Williams 1994, Nyboer 1990). Minnesota ranks the species as a severe potential threat (MN DNR 1991).

GLOBAL RANGE

Lonicera japonica is native to east Asia, including Japan and Korea (Gleason and Cronquist 1991, Lee et al. 1990). From this native range it has spread to Hong Kong (Thrower 1976), England (Clapham et al. 1962), Wales (Martin 1982), Portugal (De Baceler et al. 1987), Corsica (Jeanmonod and Burdet 1992), Hawaii (Wagner et al. 1989), Brazil, (Bove 1993), Argentina (Bonaventura et al. 1991), possibly the Ukraine (Panova 1986), and the continental United States, primarily by way of horticultural introductions.

The species was introduced into the U.S. in 1806 on Long Island, NY (Leatherman 1955), and the similar but more aggressive variety halliana was introduced to the country in 1862 in Flushing, N.Y. As with many invasive species, Japanese honeysuckle initially had a very gradual rate of spread, primarily to the south and east. *Lonicera japonica* was not included in Chapman's Flora of the Southern States (1884; in Hardt 1986) but in 1889 Wood and Willis included the variety *chinensis* in their flora of the eastern United States and a decade later Britton and Brown (1898) reported that the species ranged from New York and Pennsylvania to North Carolina and West Virginia. In 1899 *Lonicera japonica* was described in a wildflower book as the most widely planted of the honeysuckles (Lounsbury 1899). *Lonicera japonica* was reported from Florida in 1903, and from Texas in 1918 (Hardt 1986). By 1912, it had "escaped from cultivation", and ranged from Connecticut to Florida (Atkinson 1912), and within a few years was identified as an invasive problem species from the Gulf of Mexico to Massachusetts, creating "a network of tangled cords that covers the ground wherever this ruthless invader gets a foot hold" (Andrews 1919).

Lonicera japonica now occurs throughout the eastern half of the United States, south of a line extending from Massachusetts west to Lake Michigan, Illinois, and Missouri, and then southwest through Texas to Mexico, an area encompassing 26 states (USDA 1971, Leatherman 1955). The northern range limit coincides with maximum 30-year winter temperatures of -25°C (Sasek and Strain 1990). The area of greatest infestation is in the center of this range, where annual precipitation averages 100-120 cm, and 30 year low temperatures are -8°C to -15°C (Sasek and Strain 1990). *Lonicera japonica*'s range is limited to the north by severe winter temperatures, and to the west by insufficient precipitation and prolonged droughts which limit seedling establishment (Sasek and Strain 1990). At the northern edge of the range, plants have reduced growth due to a shorter growing season, and produce few or no flowers (Swink and Wilhelm 1994). *Lonicera japonica* continues to spread northward, however, possibly due to increasing cold tolerance or warmer winters (Wagner 1986). It may spread up to 400 km north if global temperature increases 3°C (Sasek and Strain 1990).

Japanese honeysuckle sporadically escapes from cultivation in California where it is present in scattered locations, primarily below 1000 m elevation (Hickman 1993). It has also escaped cultivation in scattered locations in the Hawaiian islands, particularly in mesic to wet forest in Kokee State Park

on Kauai and near Volcano on the island of Hawaii (Wagner et al. 1990). It apparently does not produce seed at most locations in Hawaii and will likely become a much more serious pest there if fertile strains develop. Unfortunately, most plants in an escaped population in Manoa Valley on Oahu reportedly set seed (Wagner et al. 1990). A recent report from Kauai also indicates the Japanese honeysuckle population there may be spreading and has potential to become a severe pest in the Kokee area (Flynn, personal communication).

HABITAT

Lonicera japonica is native to east Asia. In Korea, *Lonicera japonica* is part of the understory in later successional forests dominated *Carpinus cordata, Fraxinus rhynchophylla* and *Cornus controversa* (Lee et al. 1990).

In North America, *Lonicera japonica* primarily occurs in disturbed habitat, including successional fields, roadsides, forest edges, and fencerows (Williams 1994). It is common in dry-mesic to wet-mesic upland forest, floodplain forest, and southern pine stands, and particularly common in forest openings created by disturbance, such as treefall, logging, or disease. *Lonicera japonica* continues to be planted for landscape purposes in gardens and along highways.

Lonicera japonica grows most vigorously in full sun and on rich soil, but is shade and drought tolerant and therefore able to grow in a wide variety of habitats (Leatherman 1955). It develops high frequency and cover in young forests while densely shaded, mature forests support fewer, and smaller, colonies (Robertson et al. 1994). *Lonicera japonica* usually invades disturbed communities and rarely colonizes deeply shaded, mature forests unless canopy openings are created by human disturbances or natural processes (disease, wind throw, drought, etc.) (Slezak 1976; Thomas 1980). In Virginia *Lonicera japonica* quickly invaded a former forest site destroyed by avalanche (Hull and Scott 1982), and it grew vigorously in a forest opening in Arkansas (McLemore 1981). This species can persist in low numbers in relatively undisturbed forest and then "break out" following disturbances that open the canopy, e.g.; windthrow, ice storm, disease, scouring flood, or drought. Once established, *Lonicera japonica*'s dense canopy inhibits establishment of later successional species (Myster and Pickett 1992). *Lonicera japonica* rarely invades deeply shaded, mature forests unless the canopy is somehow opened (Robertson et al. 1994).

In Pennsylvania, *Lonicera japonica* is a major component of the third stage of succession in old fields, increasing after fields have been abandoned for four years (Keever 1989). In New Jersey *Lonicera japonica* invaded an oldfield 13 years after abandonment, and was present for at least 18 years (Myster and Pickett 1992). In Virginia *Lonicera japonica*, is most abundant in the piedmont and coastal plant forests (Williams 1994). In Illinois *Lonicera japonica* grows where overstory canopy provides filtered light, especially oak forests, cedar glades, and barrens, and along the banks of streams where the natural break in canopy creates a light opening (Nyboer 1990). Plants then spread into adjacent shaded forest. *Lonicera japonica* has been found on Michigan sand dunes (Wagner 1986), and persists near abandoned homesites in the Chicago region (Swink and Wilhelm 1994). In Indiana, *Lonicera japonica* is abundant in urban forest preserves, but is absent from woodlots isolated by agricultural fields and distant from urban areas (Brothers and Springarn 1992).

BIOLOGY-ECOLOGY

Lonicera japonica is a strong competitor due to wide seed dispersal, rapid growth rate, extended growing season, ability to capture resources both above- and below-ground, wide habitat adaptability,

and lack of natural enemies. Some of these factors have received considerable study, while others have been given little or no attention.

Lonicera japonica blooms most prolifically in full sun (Leatherman 1955), and decreases flowering activity as light decreases; in 8% of full light no flowers are produced (Blair 1982, Robertson et al. 1994). The blooming period extends from April to December in Georgia (Andrews 1919), late May to October in Kentucky (Sather, personal communication), May to June in Illinois (Mohlenbrock 1986), and June in Michigan. Flowers open a few hours before sunset, and remain open for approximately three days (Roberts 1979). In Wales, the majority of flowers are pollinated the day after opening by bumblebees (*Bombus lucorum* and *B. pascuorum*). Other bee species may be potential pollinators, as nectar is available to species with tongues $\geq$ 4 mm long (Roberts 1979). Flowers remain open at night, indicating the possibility for moth pollination (Roberts 1979). In the United States *Lonicera japonica* is probably pollinated by a variety of insects, due to its extended blooming season and wide geographical range.

Relatively few studies have documented seed production, seed viability, germination requirements, or seedling establishment.

The inconspicuous black berries contain 2-3 seeds (USDA 1971). Fruit production is much higher in full sun than in shade (average 222 vs. 11 g seeds per plant, respectively) in Texas (Halls 1977). Fruit production decreases as soil nitrogen increases (Segelquist and Rogers 1975). Seed viability is highly variable. Leatherman (1955) determined that 85% of seed were viable, and obtained 63% germination. Haywood (1994) attempted to study long-term seed viability, but seed was unsound when collected. This variation is typical of the *Lonicera* genus, which is characterized by having variable seedcoat dormancy, embryo dormancy, and/or no dormancy both within and among species (Hartmann and Kester 1968). Bruner (1967) reported rapid growth from seed in South Carolina, and Carter and Teramura (1988b) stated that *Lonicera japonica* reproduces abundantly from seed. Berries are consumed by a number of birds including robin, turkey, quail, bluebird, and goldfinch (Martin et al. 1951, Jackson and Cooper 1974), which then disseminate the seeds (Nyboer 1990).

Rate of growth from the seedling stage is not known; most researchers and nurseries propagate *Lonicera japonica* from stem cuttings, particularly the var. halliana, which forms roots "wherever the canes touch moist ground" (Hartmann and Kester 1968). Leatherman (1955) suggested that seedlings likely photosynthesize shortly after germination, due to the low food reserves in each seed. Seedlings are known to establish in shaded understories, which implies that light may not be necessary for seed germination. Seedling growth is apparently slow for the first two years (Little and Somes 1967). *Lonicera japonica* is drought sensitive, particularly at the seedling stage (Sasek and Strain 1990). Biomass appears to decline with summer drought (Faulkner et al. 1989).

Once established, *Lonicera japonica* is capable of extremely vigorous growth. In a moist bottomland forest vines overtopped a 4.5 m tree in one year (Bruner 1967), although growth rates of 1.5 m/year may be more typical (Leatherman 1955). Bell et al. (1988) recorded a maximum shoot elongation of 4.6 mm/day in Maryland. This rapid growth rate allows *Lonicera japonica* to outcompete native trees; In one year, *Lonicera japonica* overtopped three-year old sweetgum (*Liquidambar styraciflua*) trees (Dillenburg et al. 1993a). *Lonicera japonica* vines spread both vertically and horizontally (Williams 1994).

Individual vines have numerous long vegetative runners; the combined length of lateral and sublateral runners from one sprout in one year exceeded 15 m (Little 1961). Vines in high light have been recorded with $\geq$ 7 runners, each over 60 cm long (Slezak 1976). The runners develop roots at nodes in

contact with soil, and thus form dense mats. If the above ground parts are severed, each new root system develops into a separate, but genetically identical, plant. The root system has been recorded at up to 3 m across and 1 m deep (Leatherman 1955). Roots are highly competitive with native species (Carter and Teramura 1988a, 1988b).

Lonicera japonica's climbing architecture is adapted to early successional forest (Carter and Teramura 1988a), which typically has small diameter trees and a dense understory. The vines twine about vegetation in closely spaced spirals, thus creating a strong support structure that permits them to remain upright after the host tree is killed. Individual shoots may be very long, but due to the numerous spirals, a vine's height above the ground may not be great. Japanese honeysuckle vines typically climb stems <15 cm diameter (Andrews 1919). Larger stems are rarely used as hosts, as *Lonicera japonica* cannot climb wide boles unless small branches or other vines are present to provide support (Andrews 1919).

Longevity of individual plants has not been measured. As *Lonicera japonica* reproduces vegetatively, life span of individual stems or roots is not a measure of genet longevity.

Lonicera japonica is adapted to growing in 25-100% of full light, and grows vigorously in full sun. Stem density is greatest in full light, and decreases with increasing shade: In Pennsylvania, Robertson et al. (1994) recorded mean stem densities of 25.4/m^2 in an oldfield, 15/m^2 in a thicket, 13.6/m^2 in a woodland, and 8.6/m^2 and 8.1/m^2 in riparian forest and upland mature forest, respectively. Stem density was similarly high in both oak and maple associations (Robertson et al. 1994). In Washington D.C. *Lonicera japonica* produced good growth at 47% of full sun (Thomas 1980). In this location winter light measurements in closed forest range from 49% to 86% of full light. *Lonicera japonica* is able to persist in deciduous forest at low summer light intensities, and put on growth in winter, or when canopy gaps occur.

Lonicera japonica tolerates low light conditions, and may spread vegetatively, but rarely produces flowers or fruits under low light (25% of full light; Robertson et al. 1994). Honeysuckle plants are severely stressed in low light, and lose substantial amounts of aboveground biomass after long periods of low light: Blair (1982) reported that leaf biomass declined 94% after two years at very low light (8% of full sunlight), and plants suffered stem dieback and leaf loss, but did not die. Leatherman (1955) similarly reported that half of her experimental cuttings survived at 10% of full light, and the majority survived at 25% of full light. Once established, *Lonicera japonica* can persist at low light levels with little or even negative growth, and respond to winter sun and canopy openings with more vigorous growth (Carter and Teramura 1988a). Interestingly, as a twining vine *Lonicera japonica* is less physiologically adapted to low light levels than native tendril climbing vines, such as *Parthenocissus quinquefolia* (Carter and Teramura 1988a), which can rapidly climb up supporting trees to reach higher light levels.

Lonicera japonica has a long photosynthetic season due to its evergreen nature and its ability to grow in cold temperatures. *Lonicera japonica* shoots grow until the first frost, apparently because they are able to lignify rapidly, which gives them greater cold-hardiness than more tender species (Panova 1986). In southern locales *Lonicera japonica* retains its old leaves over winter (Schierenbeck and Marshall 1993) permitting year-round photosynthesis. In these areas, *Lonicera japonica* leaves are physiologically active during the winter and can grow when minimum predawn air temperatures are at or above -3^{o}C. At these temperatures, net photosynthetic rates on warm winter days are comparable to those in summer (Carter and Teramura 1988b). The presence of old leaves during the period of new-leaf formation (January - March), combined with the higher photosynthetic rates in new leaves, increases total carbon gain and thereby growth rate and invasiveness (Schierenbeck and Marshall

1993). Shoots produce an early burst of growth in spring, before native species leaf out (Dillenburg et al. 1993a).

In the northern states *Lonicera japonica* retains its leaves until late December or January (semi-evergreen), while native trees lose their leaves in October. The vines continue to photosynthesize for several months after overstory trees have dropped their leaves, which allows them to maintain presence in low light communities (Robertson et al. 1994, Carter and Teramura 1988a). In Maryland, *Lonicera japonica* is physiologically active for 9 weeks after native deciduous vines have gone dormant (*Parthenocissus quinquefolia* and *Vitis vulpina*) (Bell et al. 1988). In spring *Lonicera japonica* begins growth some two months earlier than native species, from the period when temperatures are above freezing, until deciduous trees produce new leaves (Hardt 1986). Thomas (1980) calculated that in the Washington D.C. area there are an average of 52 days/year between first and last frost when temperature and light conditions in closed canopy forests are adequate for *Lonicera japonica* photosynthesis.

Lonicera japonica leaves are unaffected by minimum temperatures of -0.6^{o}C, and continue to function, at lower efficiency, until temperatures drop below -3.0^{o}C (Carter and Teramura 1988b). The relatively high rate of leaf gas exchange in autumn, winter, and spring indicates that carbon gain during this period may contribute substantially to *Lonicera japonica*'s rapid growth rate. Although *Lonicera japonica* leaves photosynthesize in winter, the lowered activity reduces effectiveness of foliar herbicides applied after the first frost (Regehr and Frey 1988). In Tennessee, defoliation occurred at -26^{o}C, but plants were not apparently killed (Faulkner et al. 1989).

Lonicera japonica is spread primarily by birds, which consume the fruits and pass the seeds, carrying them from landscape plantings to natural areas and disseminating them in forest openings and disturbance zones. Once established, *Lonicera japonica* can develop a large seedbank that germinates when the soil is disturbed. This attribute led to a dramatic increase in southern states in the 1950's, when timber companies promoted intensive site preparations (discing, burning, bush-hogging) to facilitate tree regeneration after clearcutting (Prine and Starr 1971). Honeysuckle grew so rapidly from both seedbank and top-killed plants that tree seedlings were outcompeted (Prine and Starr 1971). Consequently, forest companies have conducted much of the research to identify herbicides that control *Lonicera japonica* (Edwards and Gonzalez 1986, McLemore 1981).

Originally introduced as a landscape plant, *Lonicera japonica* is still considered a desirable species by some landscapers, highway designers, and wildlife managers. Wildlife managers promote increased growth of *Lonicera japonica* to provide winter forage, particularly for deer (Dyess et al. 1994). Landscape architects plant *Lonicera japonica* for its fragrant flowers and rapid growth (Georges et al. 1993, Nam and Kwack 1992, Bradshaw 1991), and highway designers use the plant for erosion control and bank stabilization (Stadtherr 1982, Hardt 1986).

In China *Lonicera japonica* is a valued medicinal herb that contains anti-complementary polysaccharides (Shin et al. 1992). Polyphenolic compounds isolated from *Lonicera japonica* inhibit human platelet activation and provide protection from cellular injury, and thus help maintain human vascular homeostasis (Chang and Hsu 1992). Aden I, a mixture of *Lonicera japonica* flower buds and parts of other plants, has both antibiotic and antiviral effects, comparable to results produced by standard antibiotics (Houghton et al. 1993). Leaves and flowers are used in the therapy of chicken pox (Luo 1989), and may be used as a food additive to increase productivity of broiler chickens in Korea (Cho 1992).

CONTROL

Prevention/Legislation

In Illinois, the sale and distribution of *Lonicera japonica* is prohibited under the Illinois Exotic Weed Act (1988).

Biological control

The only technique that could control *Lonicera japonica* on a regional scale is biological control, but as of 1997 no formal program had been established. Interestingly, in China, a biocontrol program using *Sclerodermus* spp. was established to protect *Lonicera japonica* from the cerambycid *Xylotrechus grayi* (Tian et al. 1986). *Lonicera japonica* is utilized by some insects in its native habitat and the U.S. In Sichuan, China, *Lonicera japonica* growing near cottonfields is an early spring host for aphids that feed on crops later in the growing season (Li and Wen 1988). In North Carolina, the two-spotted spider mite (*Tetranychus urticae*), an agricultural pest in corn and peanut fields, overwinters on *Lonicera japonica* growing on field margins (Margolies and Kennedy 1985). *Lonicera japonica* is also a suitable host for the cicadellid cotton pest (*Empoasca biguttula*) in Hunan, China (Chen et al. 1987), and may be a host for tobacco leaf curl virus, which was detected in the horticultural variety *Lonicera japonica* var. aureo-reticulata (Macintosh et al. 1992). The vine is susceptible to honeysuckle latent virus (Brunt et al. 1980), and to tobacco leaf curl bigeminivirus (TLCV) transmitted by whiteflies (MacIntosh et al. 1992).

Burning

Fire removes above-ground vegetation, and reduces new growth, but does not kill most *Lonicera japonica* roots, and surviving roots produce new sprouts that return to pre-burn levels of cover within a few years (Oosting and Livingstone 1964). A single spring fire reduced Japanese honeysuckle cover 50% in Illinois (Nyboer 1990). Two sequential fires topkilled *Lonicera japonica*, reducing crown volume (m^3/ha) by 80%, but new growth from root sprouts maintained *Lonicera japonica* as a dominant groundcover species in North Carolina (Barden and Matthews 1980). In Virginia burning is used to reduce abundance of *Lonicera japonica*, and inhibit spread for 1-2 growing seasons (Williams 1994). Prescribed burning significantly reduced *Lonicera japonica* biomass in Tennessee, by 93% when burned in October, and by 59% when burned January - March (Faulkner et al. 1989). Top-killed honeysuckle resprouted in spring (March - April), apparently from roots or runners just below the unburned litter layer. In this situation, follow-up application of 2% glyphosate in spring, 2 - 6 months after burning, appeared to control honeysuckle better on unburned than burned plots, possibly because tall herbaceous vegetation that grew up after the fire on the burned plots intercepted the herbicide before it could reach the shorter honeysuckle resprouts (Faulkner et al. 1989). In Texas, burning in February removed all above ground foliage, but did not kill plants (Stransky 1984). However, burned plants produced fewer and shorter runners than unburned plants, and fire therefore reduced total vegetative growth (Stransky 1984).

Combining fire and herbicides may prove to be more effective than either method by itself if late autumn or winter burns are used to reduce Japanese honeysuckle biomass when most native species are dormant and all resprouts are then treated with a foliar application of glyphosate about a month after they emerge (Johnson, personal communication). Prescribed burns may also be used to help prevent spread of Japanese honeysuckle because seedlings and young plants are most susceptible to fires (Richter, personal communication) .

Chemical

The evergreen and semi-evergreen nature of *Lonicera japonica* allows application of herbicides when many native species are dormant. Timing of application is critical to effectiveness; in general, applying herbicide shortly after the first killing frost, and before the first hard frost (ca. -4.0^{o}C) is most effective. Herbicide effectiveness can be reduced in areas where large stones or fallen logs protect root crowns from soil-active herbicides (Miller 1985) or where overtopping vegetation intercepts foliar herbicides (Faulkner et al. 1989). Many herbicides produce a short-term reduction in foliar coverage, but do not kill the plant and buds left undamaged by the herbicide can produce new growth that often exceeds growth from untreated plants within a year (Prine and Starr 1971). A foliar application of 1.5% glyphosate shortly after the first frost appears to be the most effective treatment. Treated plants should be re-examined at the end of the second growing season, as plants can recover from herbicide application (McLemore 1981).

GLYPHOSATE (brand names include: Roundup, Rodeo, Accord)

• October applications of 0.75% and 1.5% v/v glyphosate killed 99% of treated *Lonicera japonica* within six months in Delaware, and few plants resprouted within 30 months of treatment (Regehr and Frey 1988). The two application rates were equally effective. The same experiment conducted in December resulted in 68% mortality at the lower concentration, and 86% mortality at the higher concentration, and regrowth from buds was much greater than in plants treated in October. The authors concluded that timing of application was critical; applying glyphosate within 2 days of the first frost resulted in very high mortality. After the first frost, higher concentrations of glyphosate were needed to achieve somewhat lower mortality. Defoliation after glyphosate treatment was very slow; only 5-15% of leaves were gone one month after treatment, although 78-90% of stems were dead.

• A mid-August application of 2.2 kg/ha glyphosate controlled 83% of actively growing *Lonicera japonica* in North Carolina; control was reduced under drought conditions (Younce and Skroch 1989). Glyphosate (2 lb active ingredient/gal) at 1 to 1.5 gallons/acre controlled "most" *Lonicera japonica* in Alabama (Miller 1985).

• In Arkansas, a 6.72 kg active ingredient/ha application resulted in 85% control after one growing season, and 80% control after two growing seasons (McLemore 1981). Lower application rates were less effective two years after treatment.

• Effectiveness of glyphosate increased linearly with increasing herbicide concentration (0.48-4.8% w/w), but no concentration gave complete control with one application; repeated treatment with 4.8% glyphosate produced complete shoot necrosis in only 50% of plants (Ahrens and Pill 1985).

• Efficacy of glyphosate was not increased by addition of surfactants (Younce and Skroch 1989, Regehr and Frey 1988).

DICHLORPROP + 2,4-D

• Dichlorprop mixed with 2,4-D at 3.6 grams active ingredient/liter (1.5% v/v) resulted in 94% mortality when applied within two days of the first frost in October, but only 46% mortality when applied in December. Thirty months after treatment, 14% of stems sprayed in October resprouted, and 75% of stems sprayed in December produced new growth (Regehr and Frey 1988).

2,4-D + PICLORAM (brand names include: Tordon)

• Picloram is a restricted use soil-active herbicide that is prohibited in California, as it is relatively persistent and subject to leaching.

• Tordon 101 (4:1 2,4-D amine + picloram, at 1 to 2 gal/acre) "reduced existing honeysuckle to a few surviving crowns" (Miller 1985). Tordon 10K at 50 lb/acre had similar effectiveness (Miller 1985).

• Tordon 101 at 10 gal acre reduced foliage by 72.5% one year after treatment; a second application of Tordon 101 reduced foliage by a total of 90% one year after re-treatment (Prine and Starr 1971)

• A foliar spray of Tordon 101 at 2.8-8.4 kg/ha gave 84-94% control in a pine stand (McLemore 1982), similar to control provided by amitrole at 2.24 and 4.48 kg/ha. (McLemore 1982).

TEBUTHIURON (brand names include: Spike)

• Spike 80W (80% tebuthiuron) and Spike 20p (20% tebuthiuron) provided very effective control when applied at 4-5 lbs active ingredient/acre, "resulting in essentially bare plots with yellowing sprigs of vegetation" (Miller 1985).

DICAMBA (brand names include: Banvel, Brushkiller)

• Banvel 720 (2 lb 2,4-D and 1 lb dicamba) was very effective when applied at 4 gal/acre, but had only partial effectiveness at 3 gallons/acre (Miller 1985).

• Lower rates of Dicamba, as in Brushkiller 4-41 and 10-51, resulted in limited or no mortality (Miller 1985). In fact, *Lonicera japonica* growth was stimulated by application of Brushkiller 10-51 (Miller 1985).

SULFOMETURON (brand names include: Oust)

• A February application of sulfometuron methyl in South Carolina at .25 lb/acre active ingredient, applied when vegetation is less than 30-45 cm high, is recommended for control of *Lonicera japonica* in loblolly pine stands (Michael 1985).

• In Georgia, *Lonicera japonica* was not controlled by a late application of Sulfometuron applied at 3 oz/acre (Withrow et al. 1983)

• *Lonicera japonica* was almost completely killed (99% mortality) by a May application of 2 oz metsulfuron-methyl + 0.25% surfactant in central Georgia (Edwards and Gonzalez 1986)

INEFFECTIVE

• In Illinois, herbicides that are not used by the Department of Conservation due to ineffectiveness or environmental persistence are: picloram; amitrole; aminotriazolel atrazine; dicamba; dicamba + 2,4-D; 2,4-D; DPX 5648; fenac; fenuron; simazine; and triclopyr (brand names for triclopyr include Garlon 3A, Garlon 4 and Brush-B-Gone) (Nyboer 1990).

• Hexazinone at 2.24 and 6.72 kg Active ingredient/ha was ineffective (McLemore 1981), as was application at 1 or 2 lb active ingredient/acre (Michael 1985). Hexazinone pellets at 8 lb active ingredient/acre reduced *Lonicera japonica* cover from 100% to 25% cover after three years, while a 2 lb/acre rate resulted in a decrease in cover from 100% to 52% over the same time period (Michael 1984).

• Oryzalin is apparently ineffective, as it is recommended for use in controlling weeds that threaten *Lonicera japonica* planted as a groundcover (Bowman 1983)

• Brushkiller 10-51 at 1.5 gal/acre "encouraged" growth of *Lonicera japonica* (Miller 1985). Brushkiller 170 resulted in a 45% decrease in foliar cover one year after June treatment (Prine and Starr 1971).

• June application of 2,4-D (4 lb active ingredient/acre at 10 gal/acre) increased foliar growth of *Lonicera japonica* by 48% one year after treatment (control plants increased by 0.9%) (Prine and Starr 1971).

• June application of Banvel resulted in increased foliar growth one year after treatment (Prine and Starr 1971).

• Triclopyr in both ester and salt formulations (3 and 4lb/gal, respectively) and as an ester combined with 2,4-D (1 and 2lb/gal respectively) failed to control *Lonicera japonica* one year after treatment (Dreyer 1988). However, in Illinois the latter formulation is reputedly effective (Nyboer 1990).

Mowing, Discing and Pulling

Removing the above-ground portion of *Lonicera japonica* reduces current-year growth but does not kill the plant, and generally stimulates dense regrowth. Cut material can take root and should therefore be removed from the site (not practical with most infestations).

Mowing is an ineffective control method, stimulating growth and encouraging formation of dense, albeit shorter, mats. Plants mowed in February formed a dense, 20 cm tall mat within two months, growing from cut stems and rooting from severed runners; by the following November (21 months later) mowed plants were 60 cm high (Stransky 1984). Twice-yearly mowing in Virginia slowed vegetative spread but increased stem density (Williams 1994).

Bush-hogging is an ineffective control, as *Lonicera japonica* re-invades within one growing season (McLemore 1985).

Discing is apparently an effective control method: McLemore (1985) reported that "control of the honeysuckle was still effective after two years". Discing depth was not indicated. Discing is a highly destructive procedure that destroys native groundlayer species, and may stimulate *Lonicera japonica* seed bank germination.

Hand-pulling is a time-consuming procedure with limited effectiveness, as the entire plant (roots and shoots) must be removed. Pulling may be a practical method to remove small patches of seedlings.

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LAST UPDATED 15 April 1997

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ELEMENT STEWARDSHIP ABSTRACT

for

Microstegium vimineum

Japanese stilt grass, Nepalese browntop, Chinese packing grass

To the User:

Element Stewardship Abstracts (ESAs) are prepared to provide The Nature Conservancy's Stewardship staff and other land managers with current management related information on species and communities that are most important to protect or control. The abstracts organize and summarize data from many sources including literature and from researchers and managers actively working with the species or community.

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Abstract Written: 8/00

THE NATURE CONSERVANCY

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SCIENTIFIC NAME

Microstegium vimineum (Trin.) A. Camus

SYNONYMS

Andropogon vimineus Trin.
Eulalia viminea (Trin.) Kuntze
Microstegium imberbe (Nees ex Steud.) Tzvelev
Microstegium willdenovianum Nees ex Lindl.
Pollinia imberbis Nees ex Steud.
Pollinia viminea (Trin.) Merr.
Pollinia willdenoviana (Nees ex Lindl.) Benth.

COMMON NAMES

Japanese stilt grass, Nepalese browntop, Chinese packing grass

DESCRIPTION AND DIAGNOSTIC CHARACTERISTICS

Microstegium vimineum is a shade tolerant, annual C_4 grass (family Poaceae). It is a straggling or decumbent plant, usually 6-10 dm in height, and the reclining stems can grow up to 1.0 m (40 in) long. Its culms (stems) are typically branched, rooting at the lower nodes, and the nodes and internodes are smooth and hairless. The lanceolate leaf blades are 5-8 cm long and 2-15 mm wide, sparsely pubescent on both surfaces, and distinctly tapered at both ends. The ligules are membranous, usually ciliate, and are 0.5-2.0 mm long (Radford et al. 1968).

The terminal or axillary inflorescence is a raceme, 2-7 cm long, with an elongate peduncle and an angled disarticulating rachis. The hirsute fertile spikelets are deciduous, and occur in pairs, with one spikelet sessile and the other pedicellate. The glumes are equal in length (4.5-5.0 mm) and awnless. The first glume is flat and 2-3 veined. The second glume is keeled and 3-veined. There are two lemmas per spikelet, with the lower one sterile and the upper, fertile one awnless or often with a slender awn 4-8 mm. Both cleistogamous (flowers closed at pollination) and chasmogamous (flowers open) conditions have been reported for *M. vimineum* in Japan, with the axillary flowers all being cleistogamous (Tanaka 1975, in Barden 1987).

The fruit or caryopsis (grain) of *M. vimineum* is yellowish to reddish, and ellipsoid (2.8-3.0 mm) in shape. Fruiting occurs in September and October in North America (Radford et al. 1968; Hitchcock 1971; Gleason & Cronquist 1991).

M. vimineum can be distinguished from other grasses by its thin, pale green, tapered leaf blades, and by its multiple spikelets that may be either terminal or arising from leaf axils. The alternate leaves have a silvery stripe of reflective hairs down the middle of the upper leaf surface. In the fall, identification becomes somewhat easier after the plant develops a slight purplish tinge (LaFleur 1996; Swearingen 2000).

While *M. vimineum* is an annual, there has been some confusion regarding whether *M. vimineum* also occurs as a rhizomatous, perennial (Ehrenfeld 1999; Mehrhoff 2000). According to Mehrhoff (2000), this confusion resulted when specimens of a native perennial, *Leersia virginica*, were incorrectly identified as *M. vimineum*. The annual *M. vimineum* can be distinguished *L. virginica* (which it

frequently grows alongside) by the former's ciliate leaf sheath collars and paired spikelets (versus *L. virginica'*s glabrous or pubescent leaf sheaths and 1-flowered spikelets).

STEWARDSHIP SUMMARY

M. vimineum is an annual C_4 grass native to Asia from India and Japan. It possesses characteristics typical of many invasive species: it grows quickly, fruits within a single season, produces abundant seed, and easily invades habitats that have been disturbed by natural (e.g., flood scouring) and anthropogenic (e.g., mowing, tilling) sources. *M. vimineum* was first discovered in the United States in 1919 (Fairbrothers & Gray 1972), and has since spread rapidly to all states east of the Mississippi, and south of and including Connecticut. *M. vimineum* is locally abundant, able to displace native wetland and forest understory vegetation with its dense, expanding monospecific patches. It is usually found under moderate to dense shade in moist conditions, but it does not persist in areas with periodic standing water, nor in full sunlight (Barden 1987, 1991). Once established, the removal of *M. vimineum* requires major eradication and restoration efforts (Bruce et al. 1995).

Manual or mechanical techniques may be the best method for controlling *M. vimineum*, since it is a shallowly-rooted annual. Hand pulling, however, is extremely labor-intensive, is feasible only for small infestations, and will need to be repeated and continued at least seven years to exhaust the seed supply in the seed bank (Virginia Native Plant Society 2000). Mowing or burning early in the season does not control the plant as the plants resprout and new seeds germinate. Following these treatments, plants can still set seed by the end of the season. Mowing may be an effective control method if carried out in late summer, when the plants are in peak bloom but before seed is produced (J. Ehrenfeld, pers. comm.). For extensive infestations, where mechanical methods are not practical, systemic herbicides such as imazameth (tradename Plateau) or glyphosate (tradename RoundUp, or Rodeo in wetland sites), or grass-specific herbicides like sethoxydim (tradenames Vantage or Poast) may be effective (Johnson 1997; Swearingen 2000). No biological controls are currently available for this plant.

RANGE

M. vimineum was introduced to North America from Asia, where it is native to India, Nepal, China, and Japan. It was first identified in the United States in 1919 in Tennessee, and by 1960 had spread (probably by hay and soil) to Ohio and Pennsylvania, and all Atlantic coastal states from Florida to New Jersey. It was widely used as a packing material for porcelain from China, and this was likely the means of its introduction into the U.S. *M. vimineum* occupies riparian habitats, lawns, woodland thickets, damp fields, and roadside ditches. Reported occurrences of *M. vimineum* in North America currently include: Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maryland, Mississippi, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, West Virginia, and Puerto Rico (USDA-NRCS 1999).

IMPACTS AND THREATS POSED BY *MICROSTEGIUM VIMINEUM*

M. vimineum is capable of invading wildland areas and swiftly replacing natural communities with nearly monospecific stands. It is generally slow to invade undisturbed areas, but rapidly fills disturbed areas such as flood-scoured stream sides and sewer line rights-of-way that are mowed once a year. An individual plants of *M. vimineum* can produce up to 1000 seeds, and the seeds remain viable in the soil for three to five years. Once established, *M. vimineum* is able to crowd out native herbaceous vegetation in wetlands and forests within three to five years (Hunt 1992; Barden 1987).

M. vimineum is a C_4 plant, and C_4 plants are typically adapted to high temperatures and high light regimes. However, unlike most C_4 plants, *M. vimineum* is adapted to low light levels and is able to grow and produce seed in only 5% full sunlight (Winter et al. 1982). Additionally, *M. vimineum* may be responsible for altering natural soil conditions, creating an inhospitable environment for many native species. Kourtev et al. (1998) reported that in areas that have been invaded by *M. vimineum*, both litter and organic soil horizons were thinner than in uninvaded areas, and that the pH of soils in invaded sites was significantly higher than in uninvaded sites. There is no indication that *M. vimineum* produces allelopathic chemicals (Woods 1989).

Established populations of *M. vimineum* usurp quality nesting habitat from quail and other wildlife. In addition, it creates excellent habitat for rats, especially cotton rats (*Sigmodon* spp.), that often prey on the nests of native bobwhite quail and attract other predators as well (A. Houston, pers. comm.).

HABITAT

In North America, *M. vimineum* occurs in a variety of disturbed sites. It thrives in along mesic roadsides, ditches, woodland borders, floodplains, and streamsides (Fairbrothers & Gray1972; Hunt & Zaremba 1992). It can also be found in mesic upland sites, and is almost always found in moderate to dense shade (Redman 1995). It does not survive, however, in areas with periodic standing water, nor in areas with full sunlight.

BIOLOGY AND ECOLOGY

Light, Moisture, and Temperature

M. vimineum possesses characteristics typical of many invasive species: it grows quickly, fruits within a single season, produces abundant seed, and easily invades naturally (e.g., flood scouring) and artificially (e.g., mowing, tilling) disturbed habitats. Once established, the removal of *M. vimineum* requires major eradication and restoration efforts (Bruce et al. 1995).

M. vimineum is unusual in that although it is a C_4 plant, it is adapted to low light conditions (Winter et al. 1982; Barden 1991). It can grow and produce seeds at as little as 5% full sunlight, but maximum growth and seed production occurs at 25-50% full sunlight (Winter et al. 1982; Horton & Neufeld 1998).

Most sites invaded by *M. vimineum* in the United States, have acidic soils (pH 5.8 to 4.8), but some populations are on soils derived from limestone or marble with surficial soil that is neutral or only slightly acidic in reaction. Soils on which *M. vimineum* occurs are typically average in levels of potassium and phosphorus, and high in nitrogen (Redman 1995). The overall acidity of the soils, however, may limit nutrient availability. Soils are usually moist, and are often well-drained silty loams, sandy loams, or loams. Clay was not a significant component of the upper soil horizons in any of the soils invaded by *M. vimineum* at sites studied by Hunt & Zaremba (1992).

No information was found regarding the optimal growing temperatures or the temperature limits of this species. The coldest winter temperature at which invasive populations of *M. vimineum* occur is approximately -21° to -23° C (Redman 1995).

Seed Dispersal

M. vimineum fruits and seeds disperse by water, animals, and by humans. (It was originally introduced as packing material or for basket-weaving.) The floating fruits of *M. vimineum* can

disperse throughout an entire wetland or alluvial floodplain during high-water events (Woods 1989; Mehrhoff 2000). Even though *M. vimineum* does not exhibit any special adaptations for seed/fruit dispersal such as hooks or barbs, its seeds are small and often adhere to animal fur or clothing. Further, the fruits have been observed being transported on automobiles (Mehrhoff 2000).

M. vimineum relies entirely on its seed bank for its annual recruitment. Seeds of *M. vimineum* may need a period of stratification (cool temperatures and high moisture) before they will germinate (Woods 1989). *M. vimineum* seeds stored in the soil may remain viable as long as five years (Barden 1991). *M. vimineum* seeds may have low germination rates (Woods 1989), but many seeds are produced by each plant. Seeds of *M. vimineum* are also able to survive submersion in water for periods of up to 10 weeks. Barden (1991) reports that seeds can germinate while under water, but the plants do not grow. If standing water is removed, more seeds will germinate shortly afterwards.

ECONOMIC USES

In the early 1900s, *M. vimineum* was used extensively as a packing material for porcelain, especially fine China porcelain, which may have contributed to its invasion into the United States. Culms of this grass have also been used for basket weaving. *M. vimineum* has not been documented as being intentionally planted as an ornamental, for erosion control, or for forage.

MANAGEMENT

Potential for Restoration of Invaded Sites

Manual and mechanical, environmental/cultural, and chemical methods are all useful to varying degrees in controlling *M. vimineum*. Prescribed burns have not been successful in controlling this species so far, but fall burns may have the potential for partial control. *M. vimineum* produces a large number of viable seed that can remain in the soil seed bank for seven years or more. If controlled during the early stages of invasion, the potential for successful management is high. The potential for large-scale restoration of wildlands where *M. vimineum* has become established is probably moderate.

Manual and Mechanical Control

Hand pulling of *M. vimineum* is the preferred method of removal as it is highly specific and provides minimal impact (except trampling and soil disturbance) to the surrounding environment. Hand pulling is an effective method of control if it is thorough and timed correctly. It is, however, labor-intensive and time-consuming. Pulling late in the season (September-early November) before seed production reduces the unintentional spread of the current year's seeds. Pulling early in the season (before July), however, allows germination of new plants from the seed bank which will mature during the remaining season and produce seeds. In the northeast, August and late September are good times to pull plants by hand (LaFleur 1996). Yearly weeding is necessary because new plants can appear as a result of seed banking or re-infestation from new seed being dispersed into the area (G. Edinger, letter to J. Randall).

Mowing using a weed whacker (or a weed-eater) is an effective control method if carried out in late summer just before seeds are produced. Mowing at any other time is not useful as the plants have the ability to resprout and can produce seed heads in the axils of their lower leaves (Woods 1989; Barden 1991). Mowing can also be useful in reducing the amount of litter and plant biomass prior to herbicide application, making the herbicide more effective.

Grazing

Grazing is not a control option for *M. vimineum* since cattle, deer, and even goats avoid feeding on it (A. Houston, pers. comm.; Barden 1991).

Flooding

Flooding for more than three months, or intermittent flooding during the growing season, may be an effective control method for mature plants of *M. vimineum.* The seeds of *M. vimineum,* however, can survive periods of inundation of at least ten weeks (Barden 1991).

Prescribed Burning

Spring burns are ineffective at controlling *M. vimineum* because a new cohort of seeds will germinate soon after the burn. Burns in the late fall, however, may be useful in controlling this species (Barden 1991). Burning is also useful in reducing the amount of litter and plant biomass prior to herbicide applications.

Herbicides

For large infestations of *M. vimineum*, the use of herbicides may be the only viable option for good control. A series of control experiments using herbicides was carried out at the Ames Plantation (University of Tennessee), and the researchers reported that it is relatively easy to kill *M. vimineum*, but that managing for a desirable plant community is difficult. They found that the herbicide imazameth (tradename Plateau) was the herbicide of choice for controlling *M. vimineum*. This is because imazameth (applied at a rate of 6 ounces per acre) kills *M. vimineum*, but allows the development of (a.k.a., does not kill) the desirable native sedges, ragweeds, and legumes.

The grass-specific herbicide fluazifop-p (tradename Fusilade) applied at the rate of 1.2 liters per hectare (1 pint per acre) also controlled *M. vimineum*, but left a less desirable plant community. Glyphosate (tradename RoundUp) was also tested, but resulted in a complete kill of all plants, which could potentially lead to possible re-invasion by *M. vimineum* or other undesirable species. Barden (1991) also found glyphosate useful in killing *M. vimineum*. Formulations of glyphosate registered for use aquatic systems (Rodeo), has been effective for *M. vimineum* control in wetlands. Woods (1989) in Tennessee found that the grass-specific herbicide sethoxydim (tradenames Poast, Vantage), applied during late summer at rates of 1 pint per acre, also provided excellent (more than 95%) control of *M. vimineum* and released dicots from competition without injuring them. Pre-emergent herbicides such as diphenamid (tradename Enide) and benefin (tradename Balan) have also demonstrated excellent control of *M. viminium* seedlings under conditions of good herbicide-to-soil contact (Woods 1989), but do not encourage the germination of native species.

Allan Houston (pers. comm.) reports that if there is a heavy build-up of litter (dead plant material) in *M. vimineum* stands, burning the debris may first be necessary to get adequate herbicide coverage. He suggests applying herbicide when the plants reach a height of 5-10 centimeters (2-4 inches).

Biological Control

No biological controls are currently available for *M. vimineum.*

EXAMPLES OF *MICROSTEGIUM VIMINEUM* MANAGEMENT ON TNC PRESERVES

According to TNC's 1998 Weed Survey, *M. vimineum* has been reported from TNC preserves in New Jersey, North Carolina, Virginia, Georgia, Alabama, Arkansas, Maryland, and in Connecticut. Several preserves reported *M. vimineum* is one of their worst weed problems, but only a few had begun active control measures.

In Maryland, Donnelle Keech reported that burning is not effective in controlling *M. vimineum*. In North Carolina, Robert Merriam reported hand pulling was effective. Elizabeth Farnsworth in Connecticut, however, indicated that hand pulling may be effective in small populations, but seems futile for large populations since it is difficult to eliminate the seed sources. She added that it is important to attack small infestations as soon as possible, and to attack them vigorously!

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MONITORING

The distribution of *M. vimineum* should be monitored annually or biannually where there is a threat to protected species. Following all control treatments, further control efforts and monitoring is needed for at least seven years due to the viability of seeds in the seedbank or re-invasion from nearby propagule sources (Barden 1991).

Since *M. vimineum* usually occurs in dense, nearly monospecific stands, permanent line intercepts (or transects) across population borders are an easy technique for periodic monitoring of changes in *M. vimineum* distribution. Where it is less abundant, visual estimates of percent cover changes in permanent plots, or photographic documentation, carried out at the same (phenologic) time each year, may be for monitoring change over time. Additionally, new invasions of *M. vimineum* should be identified as soon as possible, since small populations are the easiest to eradicate.

Research Needs

The following research topics need attention: 1) What are the impacts of *M. vimineum* on native communities? 2) What are the mechanisms of *M. vimineum* invasion in a variety of landscapes? 3) Is biological control by inoculation with fungal pathogens a possible control technique? 4) Which species replace *M. vimineum* when control succeeds? And 5) What is the most effective method (for each specific area) of *M. vimineum* control, and how can this method encourage the regeneration of native species?

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ELEMENT STEWARDSHIP ABSTRACT
for

Phragmites australis

Common Reed

To the User:

Element Stewardship Abstracts (ESAs) are prepared to provide The Nature Conservancy's Stewardship staff and other land managers with current management-related information on those species and communities that are most important to protect, or most important to control. The abstracts organize and summarize data from numerous sources including literature and researchers and managers actively working with the species or community.

We hope, by providing this abstract free of charge, to encourage users to contribute their information to the abstract. This sharing of information will benefit all land managers by ensuring the availability of an abstract that contains up-to-date information on management techniques and knowledgeable contacts. Contributors of information will be acknowledged within the abstract and receive updated editions. To contribute information, contact the editor whose address is listed at the end of the document.

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Authors of this Abstract:
Marianne Marks (original version), Beth Lapin & John Randall

The Nature Conservancy
Element Stewardship Abstract
For *Phragmites australis*

I. IDENTIFIERS

Common Name: COMMON REED Global Rank: G5

General Description:
Phragmites australis is a large perennial rhizomatous grass, or reed. The name Phragmites is derived from the Greek word for fence, phragma, in reference to its fence-like growth along streams.

Diagnostic Characteristics:
Members of the genus Phragmites are superficially similar to Arundo. Sterile specimens of P. australis are sometimes misidentified as Arundo donax, a grass introduced to North America from Asia and now troublesome in natural areas, especially in California. The genera can be distinguished when in flower because the glumes of Phragmites are glabrous while those of Arundo are covered with soft, whitish hairs 6-8 mm long. In addition, the glumes are much shorter than the lemmas in Phragmites.

II. STEWARDSHIP SUMMARY

Communities that have stable Phragmites populations present but have been exposed to disturbance should be closely monitored. Management is necessary when evidence indicates that Phragmites has spread, or is spreading and threatening the integrity of rare communities, invading the habitat of rare plants or animals or interfering with the wildlife support function of refuges. Cutting, burning, application of herbicides (in particular Rodeo), or water management schemes are possible control measures. The measure(s) used will depend on a number of factors including the size and location of the infestation, the presence of sensitive rare species and the work-force available.

III. NATURAL HISTORY

Range:
Phragmites australis is found on every continent except Antarctica and may have the widest distribution of any flowering plant (Tucker 1990). It is common in and near freshwater, brackish and alkaline wetlands in the temperate zones world-wide. It may also be found in some tropical wetlands but is absent from the Amazon Basin and central Africa. It is widespread in the United states, typically growing in marshes, swamps, fens, and prairie potholes, usually inhabiting the marsh-upland interface where it may form continuous belts (Roman et al. 1984).

Because Phragmites has invaded and formed near-monotypic stands in some North American wetlands only in recent decades there has been some debate as to whether it is indigenous to this continent or not. Convincing evidence that it was here long before European contact is now available from at least two sources. Niering and Warren (1977) found remains of Phragmites in cores of 3000 year old peat from tidal marshes in Connecticut. Identifiable Phragmites remains dating from 600 to 900 A.D. and constituting parts of a twined mat and other woven objects were found during archaeological investigations of Anasazi sites in southwestern Colorado (Kane & Gross 1986; Breternitz et al. 1986).

There is some suspicion that although the species itself is indigenous to North America, new, more invasive genotype(s) were introduced from the Old World (Metzler and Rosza 1987). Hauber et al.

(1991) found that invasive Phragmites populations in the Mississippi River Delta differed genetically from a more stable population near New Orleans. They also examined populations elsewhere on the Gulf coast, from extreme southern Texas to the Florida panhandle, and found no genetic differences between those populations and the one near New Orleans (Hauber, pers. comm. 1992). This increased their suspicion that the invasive biotypes were introduced to the Delta from somewhere outside the Gulf relatively recently.

Phragmites is frequently regarded as an aggressive, unwanted invader in the East and Upper Midwest. It has also earned this reputation in the Mississippi River Delta of southern Louisiana, where over the last 50 years, it has displaced species that provided valuable forage for wildlife, particularly migratory waterfowl (Hauber 1991). In other parts of coastal Louisiana, however, it is feared that Phragmites is declining as a result of increasing saltwater intrusion in the brackish marshes it occupies. Phragmites is apparently decreasing in Texas as well due to invasion of its habitat by the alien grass ARUNDO DONAX (Poole, pers. comm. 1985). Similarly, Phragmites is present in the Pacific states but is not regarded as a problem there. In fact, throughout the western U.S. there is some concern over decreases in the species habitat and losses of populations.

Habitat:
Phragmites is especially common in alkaline and brackish (slightly saline) environments (Haslam 1972, 1971b), and can also thrive in highly acidic wetlands (Rawinski, pers. comm. 1985). However, Phragmites does not require, nor even prefer these habitats to freshwater areas. Its growth is greater in fresh water but it may be outcompeted in these areas by other species that cannot tolerate brackish, alkaline or acidic waters. It is often found in association with other wetland plants including species from the following genera: SPARTINA, CAREX, NYMPHAEA, TYPHA, GLYCERIA, JUNCUS, MYRICA, TRIGLOCHIN, CALAMAGROSTIS, GALIUM, and PHALARIS (Howard et al. 1978).

Phragmites occurs in disturbed areas as well as pristine sites. It is especially common along railroad tracks, roadside ditches, and piles of dredge spoil, wherever even slight depressions hold water (Ricciuti 1983). Penko (pers. comm. 1993) has observed stunted Phragmites growing on acidic tailings (Ph 2.9) from an abandoned copper mine in Vermont. Various types of human manipulation and/or disturbance are thought to promote Phragmites (Roman et al. 1984). For example, restriction of the tidal inundation of a marsh may result in a lowering of the water table, which may in turn favor Phragmites. Likewise, sedimentation may promote the spread of Phragmites by elevating a marsh's substrate surface and effectively reducing the frequency of tidal inundation (Klockner, pers. comm. 1985).

A number of explanations have been proposed to account for the recent dramatic increases in Phragmites populations in the northeastern and Great Lakes States. As noted above, habitat manipulations and disturbances caused by humans are thought to have a role. In some areas Phragmites may also have been promoted by the increases in soil salinity which result when de- icing salt washes off roads and into nearby ditches and wetlands (McNabb and Batterson 1991). On the other hand, bare patches of road sand washed into ditches and wetlands may be of greater importance. Phragmites seeds are shed from November through January and so may be among the first propagules to reach these sites. If the seeds germinate and become established the young plants will usually persist for at least two years in a small, rather inconspicuous stage, resembling many other grasses. Later, perhaps after the input of nutrients, they may take off and assume the tall growth form that makes the species easily identifiable . Increases in soil nutrient concentrations, may come from runoff from farms and urban areas. It has also been suggested increases in nutrient concentrations, especially nitrates, are primarily responsible for increases in Phragmites populations. Ironically, eutrophication and increases in nitrate levels are sometimes blamed for the decline of Phragmites populations in Europe (Den Hartog et al. 1989).

Ecology:
Salinity and depth to the water table are among the factors which control the distribution and performance of Phragmites. Maximum salinity tolerances vary from population to population; reported maxima range from 12 ppt (1.2%) in Britain to 29 ppt in New York state to 40 ppt on the Red Sea coast (Hocking et al. 1983). Dense stands normally lose more water through evapotranspiration than is supplied by rain (Haslam 1970). However, rhizomes can reach down almost 2 meters below ground, their roots penetrating even deeper, allowing the plant to reach low lying ground water (Haslam 1970). Killing frosts may knock the plants back temporarily but can ultimately increase stand densities by stimulating bud development (Haslam 1968).

Phragmites has a low tolerance for wave and current action which can break its culms (vertical stems) and impede bud formation in the rhizomes (Haslam 1970). It can survive, and in fact thrive, in stagnant waters where the sediments are poorly aerated at best (Haslam 1970). Air spaces in the above-ground stems and in the rhizomes themselves assure the underground parts of the plant with a relatively fresh supply of air. This characteristic and the species' salinity tolerance allow it to grow where few others can survive (Haslam 1970). In addition the build up of litter from the aerial shoots within stands prevents or discourages other species from germinating and becoming established (Haslam 1971a). The rhizomes and adventitious roots themselves form dense mats that further discourage competitors. These characteristics are what enable Phragmites to spread, push other species out and form monotypic stands.

Such stands may alter the wetlands they colonize, eliminating habitat for valued animal species. On the other hand, the abundant cover of litter in Phragmites stands may provide habitat for some small mammals, insects and reptiles. The aerial stems provide nesting sites for several species of birds, and Song Sparrows have been seen eating Phragmites' seeds (Klockner, pers. comm. 1985). Muskrats (ONDATRA ZIBETHICUS) use Phragmites for emergency cover when low lying marshes are swept by storm tides and for food when better habitats are overpopulated (Lynch et al. 1947).

Studies conducted in Europe indicate that gall-forming and stem- boring insects may significantly reduce growth of Phragmites (Durska 1970; Pokorny 1971). Skuhravy (1978) estimated that roughly one-third of the stems in a stand may be damaged reducing stand productivity by 10-20%. Mook and van der Toorn (1982) found yields were reduced by 25 to 60% in stands heavily infested with lepidopteran stem- or rhizome-borers. Hayden (1947) suggested that aphids (HYALOPTERUS PRUNI) heavily damaged a Phragmites stand in Iowa. On the other hand work in Europe by Pintera (1971) indicated that although high densities of aphids may bring about reductions in Phragmites shoot height and leaf area they had little effect on shoot weight. Like other emergent macrophytes, Phragmites has tough leaves and appears to suffer little grazing by leaf-chewing insects (Penko 1985).

As mentioned above, there is great concern about recent declines in Phragmites in Europe where the species is still used for thatch. In fact, the journal Aquatic Botany devoted an entire issue (volume 35 no.1, September 1989) to this subject. Factors believed responsible for the declines include habitat destruction and manipulation of hydrologic regimes by humans, grazing, sedimentation and decreased water quality (eutrophication) (Ostendorp 1989).

Detailed reviews of the ecology and physiological ecology of Phragmites are provided by Haslam (1972; 1973) and Hocking et al. (1983) and an extensive bibliography is provided by van der Merff et al. (1987).

Reproduction:
Phragmites is typically the dominant species on areas that it occupies. It is capable of vigorous vegetative reproduction and often forms dense, virtually monospecific stands. Hara et al. (1993) classify sparse stands as those with densities of less than 100 culms m-2 and dense stands as those with densities of up to about 200 culms m-2 in wet areas or up to 300 culms m-2 in dry areas. Mammalian and avian numbers and diversity in the dense stands are typically low (Jones and Lehman 1987). Newly opened sites may be colonized by seed or by rhizome fragments carried to the area by humans in soils and on machinery during construction or naturally in floodwaters.

The plants generally flower and set seed between July and September and may produce great quantities of seed. In the northeast, seeds are dispersed between November and January. However, in some cases, most or all of the seed produced is not viable (Tucker 1990). The seeds are normally dispersed by wind but may be transported by birds such as red-winged blackbirds that nest among the reeds (Haslam 1972). Following seed set, nutrients are translocated down into the rhizomes and the above- ground portions of the plant die back for the season (Haslam 1968).

Temperature, salinity and water levels affect seed germination. Water depths of more than 5 cm and salinities above 20 ppt (2%) prevent germination (Kim et al. 1985; Tucker 1990). Germination is not affected by salinities below 10 ppt (1%) but declines at higher salinities. Percentage germination increases with increasing temperature from 16 to 25 oC while the time required to germinate decreases from 25 to 10 days over the same temperature range. Barry Truitt (pers. comm. 1992) has observed that areas covered by thick mats of wrack washed up during storms and high water events are frequently colonized by Phragmites on the Virginia Coast Reserve. It is not clear whether it establishes from rhizome pieces washed in with the wrack or from seed that blows in later.

Once a new stand of Phragmites takes hold it spreads, predominantly through vegetative reproduction. Individual rhizomes live for 3 to 6 years and buds develop at the base of the vertical type late in the summer each year. These buds mature and typically grow about 1 meter (up to 10 m in newly colonized, nutrient-rich areas) horizontally before terminating in an upward apex and going dormant until spring. The apex then grows upward into a vertical rhizome which in turn produces buds that will form more vertical rhizomes. Vertical rhizomes also produce horizontal rhizome buds, completing the vegetative cycle. These rhizomes provide the plant with a large absorbent surface that brings the plant nutrients from the aquatic medium (Chuchova and Arbuzoba 1970). The aerial shoots arise from the rhizomes. They are most vigorous at the periphery of a stand where they arise from horizontal rhizomes, as opposed to old verticals (Haslam 1972).

IV. CONDITION

Threats:

IMPACTS (THREATS POSED BY THIS SPECIES)
Phragmites can be regarded as a stable, natural component of a wetland community if the habitat is pristine and the population does not appear to be expanding. Many native populations of Phragmites are "benign" and pose little or no threat to other species and should be left intact. Examples of areas with stable, native populations include sea-level fens in Delaware and Virginia and along Mattagota Stream in Maine (Rawinski 1985, pers. comm. 1992). In Europe, a healthy reed belt is defined as a "homogeneous, dense or sparse stand with no gaps in its inner parts, with an evenly formed lakeside borderline without aisles, shaping a uniform fringe or large lobes, stalk length decreasing gradually at the lakeside border, but all stalks of one stand of similar height; at the landside edge the reeds are replaced by sedge or woodland communities or by unfertilized grasslands" (Ostendorp 1989).

Stable populations may be difficult to distinguish from invasive populations, but one should examine such factors as site disturbance and the earliest collection dates of the species to arrive at a determination. If available, old and recent aerial photos can be compared to determine whether stands in a given area are expanding or not (Klockner, pers. comm. 1985).

Phragmites is a problem when and where stands appear to be spreading while other species typical the of the community are diminishing. Disturbances or stresses such as pollution, alteration of the natural hydrologic regime, dredging, and increased sedimentation favor invasion and continued spread of Phragmites (Roman et al. 1984). Other factors that may have favored recent invasion and spread of Phragmites include increases in soil salinity (from fresh to brackish) and/or nutrient concentrations, especially nitrate, and the introduction of a more invasive genotype(s) from the Old World (McNabb and Batterson 1991; Metzler and Rosza 1987, see GLOBAL RANGE section for further discussion).

Michael Lefor asserts that one reason for the general spread of Phragmites has been the destabilization of the landscape (pers. comm. 1993). In urban landscapes water is apt to collect in larger volumes and pass through more quickly (flashily) than formerly. This tends to destabilize substrates leaving bare soil open for colonization. Watersheds throughout eastern North America are flashier due to the proliferation of paved surfaces, lawns and roofs and the fact that upstream wetlands are largely filled with post-settlement/post agricultural sediments from initial land-clearing operations.

Many Atlantic coast wetland systems have been invaded by Phragmites as a result of tidal restrictions imposed by roads, water impoundments, dikes and tide gates. Tide gates have been installed in order to drain marshes to harvest salt hay, to control mosquito breeding and, most recently, to protect coastal development from flooding during storms. This alteration of marsh systems may favor Phragmites invasion by reducing tidal action and soil water salinity and lowering water tables.

Phragmites invasions may threaten wildlife because they alter the structure and function (wildlife support) of relatively diverse Spartina marshes (Roman et al. 1984). This is a problem on many of the eastern coastal National Fish and Wildlife Refuges including: Brigantine in NJ; Prime Hook and Bombay Hook in DE; Tinicum in PA; Chincoteague in VA; and Trustom Pond in RI.

Plant species and communities threatened by Phragmites are listed in the Monitoring section. Some of these instances are described below:

1. Massachusetts, a brackish pondlet near Horseneck Beach supports the state rare plant MYRIOPHYLLUM PINNATUM (Walter) BSP, which Phragmites is threatening by reducing the available open water and shading aquatic vegetation (Sorrie, pers. comm. 1985).

2. Maryland, at Nassawango Creek, a rare coastal plain peatland community is threatened by Phragmites (Klockner, pers. comm. 1985).

3. Ohio, at the Arcola Creek wetland, Phragmites is threatening the state endangered plant CAREX AQUATILIS Wahlenb. (Young, pers. comm. 1985).

Phragmites invasions also increase the potential for marsh fires during the winter when the above ground portions of the plant die and dry out (Reimer 1973). Dense congregations of redwing blackbirds, which nest in Phragmites stands preferentially, increase chances of airplane accidents nearby. The monitoring and control of mosquito breeding is nearly impossible in dense Phragmites stands (Hellings and Gallagher 1992). In addition, Phragmites invasions can also have adverse

aesthetic impacts. In Boston's Back Bay Fens, dense stands have obscured vistas intended by the park's designer, Frederick Law Olmstead (Penko, pers. comm. 1993).

As noted above Phragmites is not considered a threat in the West or most areas in the Gulf states.

Restoration Potential:
Areas that have been invaded by Phragmites have excellent potential for recovery. Management programs have proven that Phragmites can be controlled, and natural vegetation will return. However, monitoring is imperative because Phragmites tends to reinvade and control techniques may need to be applied several times or, perhaps, in perpetuity. It is also important to note that some areas have been so heavily manipulated and degraded that it may be impossible to eliminate Phragmites from them. For example, it may be especially difficult to control Phragmites in freshwater impoundments that were previously salt marshes.

V. MANAGEMENT/MONITORING

Management Requirements:
Invasive populations of Phragmites must be managed in order to protect rare plants that it might outcompete, valued animals whose habitat it might dominate and degrade, and healthy ecosystems that it might greatly alter.

Management Programs:
Cultural, mechanical and/or chemical methods can be used to control Phragmites. The factors that are believed responsible for the alarming decreases of Phragmites beds in Europe and Texas include habitat destruction, increased soil nitrate levels, and eutrophication (Boar, Crook and Moss 1989, Ostendorp 1989, Sukopp and Markstein 1989) are not appropriate as management tools in natural areas.

BIOLOGICAL CONTROL: Biological control does not appear to be an option at this time. No organisms which significantly damage Phragmites australis but do not feed on other plant species have been identified. Naturally occurring parasites have not proven to be successful controls (Tscharntke 1988, Mook and van der Toorn 1982, van der Toorn and Mook 1982). In addition, some of the arthropods that feed on Phragmites are killed by winter fires and thus would likely be eliminated from the systems where prescribed fires are used. Coots, nutria, and muskrats may feed on Phragmites but appear to have limited impacts on its populations (Cross and Fleming 1989).

BURNING: Prescribed burning does not reduce the growing ability of Phragmites unless root burn occurs. Root burn seldom occurs, however, because the rhizomes are usually covered by a layer of soil, mud and/or water. Fires in Phragmites stands are dangerous because this species can cause spot-fires over 100 feet away (Beall 1984). Burning does remove accumulated Phragmites leaf litter, giving the seeds of other species area to germinate. Prescribed burning has been used with success after chemical treatment for this purpose at The Brigantine National Wildlife Refuge, NJ (Beall 1984) and in Delaware (Lehman, pers. comm. 1992). Occasional burning has been used in Delaware in conjunction with intensive spraying and water level management. This helps remove old canes and allows other vegetation to grow (Daly, pers. comm. 1991)

At Wallops Island, Virginia, a small (100' x 400') brackish to saline to dry wetland was burned November 1990 to control Phragmites (M. Ailes, pers. comm. 1992). A variety of other species appeared in the year following the burn but they appeared leggy while the Phragmites remained vigorous. A second winter burn is planned and monitoring of transects will continue (there are no pre-treatment data).

At Wertheim National Wildlife Refuge in New York, a 20-30 acre freshwater impoundment was drained in the fall of 1989, burned the following winter and then reflooded (Parris, pers. comm. 1991). Phragmites was eliminated from the half of the marsh that was treated and the area remained free of the grass through 1992.

According to Cross and Fleming (1989), late summer burns may be effective, but winter and spring burning may in fact increase the densities of spring crops. Thompson and Shay (1985) performed experimental burn treatments on Delta Marsh, Manitoba. They found that spring, summer and fall burns resulted in higher total shoot densities and lower mean shoot weights than on controls primarily as a result of greater densities of shorter, thinner vegetative shoots. Shoot biomass was greater in spring-burned and fall-burned plots than in control areas but less on summer- burned plots. They also found that below-ground production increased following spring and fall burns but not following summer burns. The increase in light availability following burns generally appears to benefit Phragmites. A variety of understory responses to these burns was noted. For example, summer burns increased species diversity, richness, and evenness, although certain species declined (Thompson and Shay 1985).

In Connecticut late spring burns followed by manual flooding with salt water was successful in reducing Phragmites height and density (Steinke, pers. comm. 1992). After three years, the fuel load was exhausted; the process was very expensive and self- regulating tide gates were installed instead (see MANIPULATION OF WATER LEVEL AND SALINITY).

In Europe, experimental removal of litter in winter resulted in doubling the above-ground biomass (Graneli 1989). Increased light availability at the soil surface and aeration of the soil around the rhizomes may have been responsible for this increase. Burning in the winter in an experimental field caused little damage, while burning during the emergence period led to the death of the majority of Phragmites shoots (van der Toorn and Mook 1982).

CHEMICAL: RodeoTM, a water solution of the isopropylamine salt of glyphosate is commonly used for Phragmites control. This herbicide is not, however, selective and will kill grasses and broadleaved plants alike. Toxicity tests indicate that it is virtually non-toxic to all aquatic animals tested. It should be noted that many of these tests were performed by or for Monsanto, the company which manufactures Rodeo. Bioconcentration values for glyphosate in fish tissues were insignificant. Glyphosate biodegrades quickly and completely in the environment into natural products including carbon dioxide, nitrogen, phosphate and water. Finally, since glyphosate does not volatilize, it will not vaporize from a treated site and move to a non-target area (Brandt 1983; Comes, Bruns and Kelly 1976; Folmar, Sanders and Julin 1979; Monsanto 1985).

Rodeo must be mixed with water and a surfactant which allows it to stick to and subsequently be absorbed by the plant (Beall 1984). Instructions for application, amounts needed per acre, the approved surfactants and ratios for mixing, are on the Rodeo label. Glyphosate must be mixed with clean or, if possible, distilled water because it binds tightly to sediments and is thus rendered non-toxic to plants (Lefor, pers. Comm. 1992). This limits its effectiveness but also may help prevent it from acting on plants that were not originally targeted. Rodeo should not by applied in windy conditions, as the spray will drift (I. Ailes, pers. comm. 1985). It also should not be applied if rain is forecast within 12 hours because it will wash away before it has a chance to act (Daly 1984). Application rates may vary but, as one example, effective control of Phragmites in a Delaware marsh was achieved with 4 pints/acre of concentrate (Lehman, pers. comm. 1992).

Application of Rodeo must take place after the tasseling stage when the plant is supplying nutrients to the rhizome. At this time, when Rodeo is sprayed onto the foliage of aquatic weeds, it translocates into the roots. Rodeo interferes with essential plant growth processes, causing gradual wilting, yellowing, browning and deterioration of the plant. Studies on tasseling at the Augustine Tidal area, in Port Penn Delaware, indicated that tasseling in a stand is never 100% but that it is possible to spray when 94% of the plants are tasseling. In dense stands, subdominant plants are protected by the thick canopy and thus may not receive adequate herbicide. For these reasons, touch up work will be necessary (Lehman 1984).

At Brigantine National Wildlife Refuge, Rodeo was applied aerially after the plants tasseled in late August. The application resulted in a 90% success. The following February, a fast moving prescribed burn was carried out to remove litter, exposing the seed bed for re-establishment of marsh vegetation. However funding was not available for several years and Phragmites has returned to 90% of the previously treated areas (Beall, pers. comm. 1991). Treatment was resumed in fall 1991.

In September, 1983, at the Prime Hook Wildlife Refuge in Delaware, 500 acres of freshwater impoundments were sprayed with Rodeo from a helicopter for Phragmites control. The plants yellowed within 10 days. The following May aerial and ground evaluations of the sprayed area revealed a 98% kill of Phragmites (Daly 1984). In addition to applying herbicide, Prime Hook manipulates water levels with a stop log to stress Phragmites; winter water levels are held at an elevation of 2.8' msl until June, when water would otherwise be held at 2.2 msl. The combined spraying and water management approach was successful and many aquatic plants returned. A regime of spraying in August-September for two years followed by flooding has been used through 1991 (Daly, pers. comm. 1991). Annual costs of Phragmites control are $20K annual at Prime Hook (1,000 acres) and $3K at Bombay Hook (20-60 acres); monitoring costs, which include reading vegetation transects for species presence and density each September are not included in the cost.

Aerial spraying has been used since 1983 in many Delaware state wildlife refuges (Lehman, pers. comm. 1992). Using Rodeo, the state sprays freshwater and brackish impoundments, brackish marshes, and salt marshes from early September to early October; this is combined with winter burns between the first and second year of spraying. Areas will be spot-treated whenever needed after that. The herbicide treatments consist of 4 pints/acre the first year and 2 pints/acre the second, with an average cost of $65/acre. The state is involved with cost-sharing programs with private landowners where the state pays half the spraying cost with a willing owner. Desirable native vegetation usually returns after spraying; no revegetation is done. Occasionally become open mud flats that are eventually repopulated by Phragmites.

At Chincoteague National Wildlife refuge, an aerial spraying program initiated in 1986 in an 18-mile long freshwater impoundment was terminated due to budget cuts. Phragmites quickly reclaimed the area, estimated to be 100-150 acres total in small scattered stands (I. Ailes, pers. comm. 1991). In September 1991, spraying with Rodeo began again; it is expected that the entire area will be sprayed again in 1992, and that small areas of re-growth will be sprayed in 1993. Because the area is impounded, the water level usually is lower in the spring, which helps prevent Phragmites regrowth.

Herbicides are used at Tinicum Environmental Center, because other control options are limited. Unplanned burns do occur, but prescribed burns are not allowed due to the proximity to the highway and airport. Tinicum was recently granted $2M to restore a 18-acre site. Here they will be altering the elevation of the marsh, seeding with native plants, and monitoring the results (Nugent, pers. comm. 1991).

At Parker National Wildlife Refuge, an aerial spraying program (annual budget $5K) for 50 acres of a 100-acre freshwater impoundment began in mid-August 1991. A winter burn is anticipated and a second year of spraying planned. Results will be monitored by using aerial photos to delineate the boundaries of the Phragmites clones. A nearby tower also provides a suitable viewing point to observe progress (Healey, pers. comm. 1992).

In more fragile situations where Phragmites is threatening a rare plant or community, aerial spray techniques are inappropriate because such large-scale application could kill the community that the entire operation was designed to protect. Glyphosate can be applied to specific plants and areas by hand with a backpack sprayer. Wayne Klockner of The Nature Conservancy's Maryland Field Office has been successful in eliminating most Phragmites at the Nassawango preserve by applying glyphosate by hand with a backpack sprayer (Klockner, pers. comm. 1985). The control program there began in 1983; actual spraying is conducted along the power line ROW by Delmarva Power (Droege, pers. comm. 1991). Delmarva Power generally sprays with trucks, backpacks or helicopter, depending on the accessibility of the area and presence of rare plants nearby (Johnstone, pers. comm. 1991). They use Rodeo in tidal areas, and AccordTM (another glyphosate product) in non-tidal areas from mid-August to mid-October, when the plants are going to seed. They spray intensively the first year, and conduct touch-up spraying the second year which eliminates 90-95% of the plants. They then return every three years to eliminate any new plants. They do not spray if the plants are not tasselling and are short.

Rodeo was used at Cape May Meadows in 1989, 1990, and 1991. It was applied with a 30 gallon gas-powered tank with spray nozzle mounted on a truck, Indian pump sprayers, 2.5 gallon hand-held sprayers, and wick applicators (Johnson, pers. comm. 1991). This appeared to kill most, if not all, of the treated Phragmites in this 20-acre area; plants found in the area following treatment were shorter and the stand was less dense (determined visually). However the dead stalks remained and blocked views from the trail.

In Connecticut a 5m x 23 m patch of Phragmites has been treated with a hand-held spray of Rodeo (1988 and 1989) and Roundup (1990 and 1991) for four years in late August-early September. The Phragmites is shorter and less dense at the site but it is still present (Lapin pers. obs.). Actions to supplement and enhance herbicide applications including the removal of tassels (1991) and removal of dead stalks (planned 1992), have been and will be taken.

Other chemicals have been used on Phragmites and are described in Cross and Fleming (1989).

Also see CUTTING at Constitution Marsh for another method of application.

CUTTING: Cutting has been used successfully to control Phragmites. Since it is a grass, cutting several times during a season, at the wrong times, may increase stand density (Osterbrock 1984). However, if cut just before the end of July, most of the food reserves produced that season are removed with the aerial portion of the plant, reducing the plant's vigor. This regime may eliminate a colony if carried out annually for several years. Care must be taken to remove cut shoots to prevent their sprouting and forming stolons (Osterbrock 1984). In the Arcola Creek Preserve in Ohio, cutting reduced the vigor of the Phragmites colony. Also in Ohio, at Morgan Swamp, cutting began in mid to end of July (before tassel set) in 1989 around a gas well in a freshwater wetland (Seidel, pers. comm. 1991). The preferred tool was an old-fashioned hedge trimmer with an 8" flat blade with serrations manufactured by Union Fork and Hoe. The trimmers worked better than loppers and were safer than sickles; a circular blade on a weed whacker was also used and proved to be faster and good for staff but it was more dangerous for volunteers and detracted from the atmosphere of the work-day (Huffman, pers. comm. 1992).

Small patches (10' x 50') in a New York freshwater system were cut at the end of July or the beginning of August for two successive years with positive results (Schneider, pers. comm. 1990). The hand-cut material was removed from the site and thrown on a brush pile (unfortunately it was located too close to the water and returned to the system).
Massachusetts Audubon staff have cut the perimeter around a 0.25 acre Phragmites patch at the end of July since 1986 in a freshwater wetland at Daniel Webster Preserve in Marshfield, Massachussetts (Anderson, pers. comm. 1992). They have monitored their success in keeping it from spreading by using a map and hand compass.

Stands of Phragmites of less than 1 acre in extent that block views in Everglades National Park are cut just before the onset of the rainy season. The rise in water elevation from the rains that follow stresses the roots of the plant. This works to a degree but Phragmites returns (Dowlen, pers. comm. 1985).

In Quincy, Mass., the town used small Bobcats with lawnmower clippers mounted on the buckets with a flexible cable to cut an area with 75% cover of Phragmites and 20-25' of muck (Wheelwright, pers. comm. 1991; Dobberteen pers. comm. 1991). Cutting this 10-acre plot three times during the summer (April, June, August) cost $150K. The cut material was stockpiled nearby where it was to be burned in the winter when it was washed away in a severe storm. In winter 1992, the town plans to open the tide gate and allow flushing to prevent further return of Phragmites. Results are not yet known.

Cutting culms to 6" followed by addition of rock salt on a 10' x 10' patch appeared to have reduced the height and density of Phragmites in a salt marsh in Greenwich, CT (Jontos and Allan 1984). Continued observations indicated that this trend appeared to continue (Jontos, pers. comm. 1992).

Cutting an area 25' x 25' to waist height with a hedge clippers and the applying one drop of Roundup with a syringe with a large needle (horse size) into the top of the plant in a brackish- freshwater marsh was begun in Constitution Marsh in New York in 1991 (Keene, pers. comm. 1991). Initial results indicate 90% eradication.

In Connecticut, cutting below the first leaf at the end of July in 1986, 1989, 1990, 1991, and 1992 in a freshwater tidal wetland around the perimeter of a one-acre patch has prevented subsequent expansion of the patch. Monitoring using aerial photos taken at five-year intervals indicated the control success. Cutting was done with hand-held cutters and gas-powered hedge trimmers, which were very efficient. Cut material was removed from the site and allowed to decompose on upland areas. In a second area, similar efforts in a calcareous wetland 1990-1992 were monitored by placing red survey wires around the perimeter of the patch. Preliminary observations indicate a cessation of Phragmites expansion.

In Europe, Weisner and Graneli (1989) found that oxygen transport was reduced by cutting the culms above and below the water surface;cutting below the water in June almost totally inhibited regrowth of shoots the following summer, while cutting above water reduced regrowth of shoots. Cutting in August did not reduce growth the following summer. Cutting in sandy substrates was minimally effective, while cutting on calcareous muds caused decreases in oxygen levels.

Also see MANIPULATION OF WATER LEVEL AND SALINITY.

GRAZING, DREDGING, AND DRAINING: Grazing, dredging, and draining are other methods that have often been used to reduce stand vigor (Howard, Rhodes and Simmers 1978). However, draining and dredging are not appropriate for use on most preserves (Osterbrock, 1984).

Grazing may trample the rhizomes and reduce vigor but the results are limited (Cross and Fleming 1989). Van Deursen and Drost (1990) found that cattle consumed 67-98% of above-ground biomass; in a four year study, they found that reed populations may reach new equilibria under grazing regimes.

MANIPULATION OF WATER LEVEL AND SALINITY: A self-regulating tide gate which reintroduced saltwater tidal action was used to help restore a diked marsh in Fairfield, Connecticut (Thomas Steinke pers. comm. 1992; Bongiorno et al. 1984). A 1-3 foot reduction in stem height resulted over each of three years . In addition to reduced height, plant density declined dramatically from 11.3 plants m-2 in 1980 to 3.3 plants/ m-2 the following year. In following years, Phragmites continued to decline, although less dramatically. In addition to the decreased height and density of the Phragmites stands, typical marsh flora including SALICORNIA, DISTICHILIS, SPARTINA ALTERNIFLORA Loisel. and S. PATENS (Aiton) Muhl. returned. Depending on topography and elevation, Phragmites was eliminated in large areas and continues to remain short and sparse in other areas through 1992. Hence, reintroduced tidal action and salinity can reduce Phragmites vigor and restore the community's integrity. This has been implemented successfully in other degraded former salt marshes in Connecticut (Rozsa, pers. comm. 1992).

Flooding can be used to control Phragmites when 3 feet of water covers the rhizome for an extended period during the growing season, usually four months (Beall 1984). However, many areas can not be flooded to such depths. Furthermore, flooding could destroy the communities or plants targeted for protection.

Open Marsh Water Management (OMWM) has been used as a method to control Phragmites. Plugging of ditches and addition of culverts to raise the soil salinities appears to have caused Phragmites die-back over the last four growing seasons at Fireplace Neck, New York (Niniviaggi, pers. comm. 1991; Rozsa, pers. comm. 1992).

Hellings and Gallagher (1992) found that Phragmites was negatively impacted by increasing salinity and increased flooding. They also found that cutting and subsequent flooding also reduced growth and survival in outdoor experiments. They suggest that Phragmites may be controlled by increasing flooding and salinity levels. Matoh, Matsushita and Takahashi (1988) also found reduction in vigor with increased salinity. However death apparently occurred only when cutting was combined with brackish flooding (Hellings and Gallagher 1992).

In Europe, episodic freshwater flooding occurring early in the growing season has been suggested as one of the reasons for reed population declines (Ostendorp 1991). McKee et al. (1989) investigated root metabolic changes due to freshwater flooding and labelled Phragmites as a flood-tolerant species.

Also see Chincoteague NWR under CHEMICALS, Wertheim NWR under BURNING, and Town of Quincy under CUTTING for additional references.

MOWING, DISKING, AND PULLING: Beall (1984) discourages mowing and disking. Mowing only affects the above ground portion of the plant, so mowing would have to occur annually. To remove the rhizome, disking could be employed. However, discing could potentially result in an increase of Phragmites since pieces of the rhizome can produce new plants. Cross and Fleming (1989) describe successful mowing regimes of several year duration during the summer (August and September) and discing in summer or fall.

In Cape May Meadows, New Jersey, a brackish to freshwater non- tidal sandy area, an attempt was made to remove rhizomes by pulling to a depth of three feet (Johnson, pers. comm. 1991). This resulted in a very sparse Phragmites stand the following year. However it was very labor-intensive (using 130 people- hours to cover a 50 ft2 patch) and could be applied best to sandy soils.

In a private yard, Phragmites was mowed and a thin layer of soil and grass seed were added. This was mowed weekly over the course of the summer. In the second summer shoots of Phragmites occurred around the edges. The rhizomes were decomposing after this treatment (M. Ailes, pers. comm. 1992).

PLASTIC: Clear plastic six-mil thick, 12 x 17 m, weighing 51.8 kg, was carried into a North Carolina marsh by air and held in place by sandbags (Boone et al. 1987, 1988). Plants were initially cut to 6-8" with a hand-pushed bush hog (Boone, pers. comm. 1991) or a weedeater with blade, with an area of 20 x 20 m taking several days to cut. The cut material was left and the plastic put over the area. The high temperatures under the plastic caused die-off of Phragmites in 3-4 days. After 8-10 weeks, the plastic deteriorated. The rhizomes appeared to have died back, but the project was of short duration and the results were not monitored the following year (Boone, pers. comm. 1991). Turner (pers. comm. 1992) noted that follow-ups in subsequent years indicated Phragmites returned but not as densely. Plastic management in each 12 x 12 m plot took an average of 53 hours, compared with 17 hours to cut and three hours to burn (Boone et al. 1987).

Clear plastic in two narrow swaths (70 m x 20 m) was placed along the edge of a tidal brackish pond after hand-cutting the Phragmites at the end of July 1991 (Anderson, pers. comm. 1992). One plot, in total sun, had a complete kill of Phragmites in 10 days, while the plot in partial shade had a partial kill. It is unknown how the plastic was kept in place or what was done with the cut material.

Clear and black plastic were used on 50' circular areas at Constitution Marsh in New York in 1990 and 1991 (Keene, pers. comm. 1991). Although there was difficulty due to tidal influence, the plastic was weighted down with rocks and appeared to kill what is under it. Runners along the edge were treated with a syringe application of Roundup in August. In November 1991, a hole cut in the middle of the black plastic provided the opportunity for cattail shoots to germinate. After the first year there was viable Phragmites in the areas covered. It appeared that the black plastic was more effective, due to the higher heat levels attained (Rod, pers. comm. 1992).

Monitoring Requirements:
Phragmites populations require close monitoring in order to determine whether they are increasing in area or not. Populations that are growing may quickly threaten or even eliminate rare elements. Monitoring provides the data needed in order to decide if control measures are necessary. If and when a control program is begun it is important to monitor targeted populations so that the program's effectiveness can be determined. If it is possible to leave untreated control areas without jeopardizing the success of the control program these should be monitored as well for comparison. It is imperative to continue monitoring even if a control program succeeds initially because Phragmites may reinvade and the sooner this is detected the easier it will be to combat.

To assess if a Phragmites colony is spreading, quantitative measurements should be made of percentage of aerial cover, stem density and culm height, especially at the periphery of the stand. Annual data should be compared to detect if the colony is expanding and the stand gaining vigor. Inventories of the vegetation in and near the colony should also be carried out in order to determine whether declines in species diversity are occurring.

In Europe, reed declines have been documented by comparing areas covered by Phragmites colonies on up-to-date maps or aerial photographs with older sources, monitoring permanent quadrats within

or at the border of the reed belt and mapping the stubble fields left after die-back (Ostendorp 1989). In lakes (Stark and Dienst 1989), wooden poles 5 m apart were connected with string and the numbers of reed stalks directly below the strings were counted each year in the spring.

Monitoring Programs:
The programs listed below used various methods to control Phragmites populations and are monitoring the success of these actions including the degree of recovery of native species and the longevity of the control.

CONNECTICUT Monitoring Phragmites reduction and replacement vegetation after reintroducing tidal flow, using transects and line intercept. Contact: Charles T. Roman, William Niering, Scott Warren Dept of Botany Connecticut College New London, CT 06320

Monitoring Phragmites reaction to reintroduction of tidal flow and salinity. Contact: Tom Steinke Fairfield Conservation Commission, Independence Hall 725 Old Post Road Fairfield, CT 06430 203-256-3071

Addition of rock salt and casual observation of reduction of Phragmites height and density; also potential impact of inadvertent spill of used fryerlator oil. Contact: Robert Jontos, Jr. Land-Tech Consultants, Inc. Playhouse Corner Suite 205 Southbury, CT 06488 203-264-8300

Reintroduction of salt water into degraded former salt marshes, removal of dredge material and restoration of tidal creek in several sites in CT with transect and line intercept monitoring of results. Contact: Ron Rozsa Long Island Sound Program Department of Environmental Protection 165 Capitol Avenue Hartford, Ct 06106 203-566-7404

Annual cutting of perimeter of one-acre stand and monitoring with aerial photos on five-year basis; herbicide application on small patch at edge of salt marsh. Contact: Beth Lapin The Nature Conservancy 55 High Street Middletown, CT 06457 203-344-0716

DELAWARE Aerial spraying of RodeoTM (glyphosate) and water management plan using stoplogs and vegetation analyses (using transects that measure density and species of plants) of replacement species. Contact: Paul Daly Bombay Hook National Wildlife Refuge RD #1 Box 147 Smyrna, DE 19977 302-653-9345

Monitoring the ecological factors (water table level, PH, salinity) governing the growth of Phragmites in 4 habitats; 1) open high salt marsh, 2) open low salt marsh, 3) brackish water impoundment, 4) freshwater impoundment. Investigating Phragmites control with glyphosate. Contact: Wayne Lehman and Bill Jones Delaware Division of Fish and Wildlife P.O. Box 1401 Dover, DE 19903 302-653-2079

LOUISIANA See RESEARCH PROGRAMS section below.

MASSACHUSETTS Cutting three times in one season, followed by opening of tidal flood gate to restore natural water regime, with initial 1 m random quadrats to measure stem density and plant height Contact: Mike Wheelwright Department of Public Works Town of Quincy Quincy, MA 02169 617-773-1380 x210 Contact: Ross Dobberteen Lelito Environmental Consultants 2 Bourbon St. #102 Peabody, MA 01960 508-535-7861

Aerial spray of RodeoTM (glyphosate) two years in a row, with winter burning; aerial photos to determine decrease in affected boundaries. Contact: Joann Healey Parker National Wildlife Refuge Northern Blvd. Plum Island Newburyport, MA 01950 508-465-5753

Clear plastic over cut bands along edge of tidal pond and cutting around perimeter of 0.25 acre stand. Contact: Jeanne Anderson Massachusetts Audubon Society South Great Road Lincoln, MA 01773 617-259-9500

Plastic mulch experiments Contact: Edward Stashko Brookline Massachusetts Conservation Commission 617-730-2088

Restoration of saltmarshes now dominated by Phragmites Contact: Larry Oliver U.S. Army Corps of Engineers New England Division 424 Trapelo Road Waltham, MA 02254 617-647-8347

MARYLAND Nassawango Creek, A Nature Conservancy Preserve RodeoTM (glyphosate) applied with backpack sprayer. Monitoring site to determine both reaction of natural plant community and evidence of Phragmites re-invasion. Contact: Wayne Klockner The Nature Conservancy Chevy Chase Center Office Building 35 Wisconsin Circle, Suite 304 Chevy Chase Maryland 20815 301-656-8073

Spraying with RodeoTM (glyphosate), burning; monitoring vegetation and invertebrates, annual expansion of Phragmites in untreated areas. Contact: Steve Ailstock Environmental Center Anne Arundel Community College Arnold, MD

NEW JERSEY Aerial spraying with RodeoTM (glyphosate), prescribed burn to remove litter, evaluating success. Contact: David Beall Edwin B. Forsythe National Wildlife Refuge Brigantine Division PO Box 72, Great Creek RD Oceanville, NJ 08231 609-652-1665

Pulling rhizomes, chemical spray; visual monitoring of presence/absence, sense of height and density. Contact: Liz Johnson The Nature Conservancy 17 Fairmont Road Pottersville, NJ 07979 908-439-3007

NEW YORK Cutting (herbicide use would require a permit), using visual assessment for success. Contact: Kathy Schneider Department of Environmental Conservation 700 Troy-Schenectady Road Lathan, NY 12110-2400 518-783-3932

Cutting and covering with plastic (black and clear); dripping herbicide in cut stems with syringe at Constitution Marsh, New York. Contact: Chuck Keene Museum of Hudson Highlands The Boulevard P.O. Box 181 Cornwall-on-Hudson, NY 12520 914-534-7781 Contact: Jim Rod National Audubon Society RFD 2, Route 9D Garrison, NY 10524 914-265-2601

Open Marsh Water Management with GIS infrared aerial photos and black and white photos (1986 & 1990) to monitor success Contact: Dominick Niniviaggi New York DEC Building 40 SUNY Stony Brook, NY 11790-2356 516-751-7900 x379 516-751-2719

Using water level manipulation and burning and visual monitoring Contact: Bob Parris Wertheim NWR P.O. Box 21 Smith Road Shirley, NY 11967 516-286-0485

PENNSYLVANIA Tinicum National Environmental Center Chemical application, 18 acre restoration with seeding Contact: Dick Nugent Tinicum Environmental Center Scott Plaza 2 Philadelphia, PA 19113 215-521-0663

OHIO Arcola Creek Wetland, Morgan Marsh Controlling Phragmites by cutting when reserves are in the aerial portion of the plant (before nutrients are translocated into the rhizomes); using aerial photos to map extent of areas, small (1 x 1 m plots) to measure stem density. Contact: Terry Seidel The Nature Conservancy Ohio Field Office 1504 West 1st Ave. Columbus, Ohio 43212 614-486-6789

VIRGINIA RodeoTM (glyphosate) application and monitoring program, with transects (mainly used for changes in vegetation and not in Phragmites) and vegetation maps on "topo" scale. Contact: Irvin Ailes Chincoteague National Wildlife Refuge Chincoteague, VA 23336 804-336-6122

Winter burns, checking progress in summer with six 400 m transects perpendicular to the shore that measure % cover and list species in 0.1 m2 plots every ten meters; success marginal. Contact: Marilyn Ailes Public Works Office Building Q29 Aegis Combat System Center Wallops Island, VA 23337 804-824-2082

VI. RESEARCH

Management Research Programs:
LOUISIANA Aerial photographs of the Mississippi River Delta indicated that different stands of Phragmites had different infrared signatures. Isozyme analyses were performed on samples from these stands in order to determine whether they differed genetically and constituted different clones. Two distinct clones were found and both differed from stands elsewhere on the Gulf coast. Additional isozymal work is planned on populations from elsewhere on the Gulf coast and, if time allows, from populations in the eastern and Great Lakes states as well

For research on population biology and control methods refer to BIOLOGICAL MONITORING PROGRAMS section.

Research Needs (General):
What are the genetics of natural populations and how do stable and invasive populations differ?

Management Research Needs:
Research on the following facets of Phragmites invasions and basic biology are needed: 1. what types and levels of disturbance and stress induce Phragmites to invade and/or dominate an area?; 2. how effective are various control programs and what conditions promote or allow Phragmites to reinvade areas from which it has been removed?; 3. if Phragmites does reinvade how long does this process take?; 4. are there ways to alleviate or mitigate for the stresses that induce the spread of Phragmites?; 5. can the use of competitive plantings of TYPHA or other desirable species be used to control Phragmites.

VII. ADDITIONAL TOPICS

VIII. INFORMATION SOURCES

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IX. DOCUMENT PREPARATION & MAINTENANCE
Edition Date: 93-05-12
Contributing Author(s): Marianne Marks (original version), Beth Lapin & John Randall

(1993 update)

White-tailed deer and Virginia Natural Area Preserves: a discussion
Mike Leahy (July 2003)

Background
A large body of research (Russell et al. 2001) presents evidence that dense populations of white-tailed deer (*Odocoileus virginianus*) in many eastern U.S. ecosystems can negatively impact tree regeneration, recruitment and composition (Alverson and Waller 1997, Horsley et al. 2003), alter natural community composition (Rooney and Dress 1997), eliminate certain plant species from areas (Augustine and Frelich 1998), and disrupt bird populations (McShea and Rappole 1997). Deer also avoid browsing on the invasive, exotic plants stilt grass (*Microstegium vimineum*; Tu 2000) and garlic mustard (*Alliaria petiolata*; Nuzzo 1991), further exacerbating the nefarious effects of these weeds on our native flora. Of particular concern for natural areas management are the negative effects of high deer densities on herbaceous plants (Anderson 1994, Balgooyen and Waller 1995, Augustine and Frelich 1998) and rare plants (Miller et al. 1992).

It is estimated that the presettlement deer density of the eastern U.S. was around 8-11 deer/mi^2 (McCabe and McCabe 1997). At the end of the 19th century deer were over hunted to the point of near extirpation from Virginia. Since then the implementation of strict game laws, the elimination of natural predators and the changing landscape of the state with more edge habitats has given rise to a burgeoning deer population today that in most areas of the state exceeds the estimated presettlement deer densities (Knox 1997). A number of studies have demonstrated that deer densities >20 deer/mi^2 can have negative impacts on tree regeneration, recruitment and composition (Tilghman 1989, Healy 1997, Horsley et al. 2003). Deer densities of 8-15 deer/mi^2 have well-stocked and diverse woody understories (Healy 1997) and abundant and flowering herbaceous populations of such deer sensitive species as *Trillium grandiflorum* (Anderson 1994) and *Laportea canadensis* (Augustine et al. 1998). It should be noted that the effects of deer on forest ecosystems depends on the landscape context in which they occur (Horsley et al. 2003). Forest stands in landscapes with a significant amount of agricultural row-crop land are less impacted by the same density of deer than a forest stand in a primarily forested landscape.

Deer on NAPs
The results of field observations from DNH biologists coupled with deer density data from DGIF (Table 1) in light of cited research above indicates that there are currently too many deer on many of our NAPs if the goal of managing the preserves is to sustain and restore natural communities and rare plants.

Detailed and replicated, labor-intensive exclosure studies are not practical for DNH at this time to prove that deer are a problem on NAPs. I recommend that small exclosures on the scale of 5-10m^2 plots could be used that are easily constructed and monitored. Research studies have effectively used plots of this size (Alverson and Waller 1997, Healy 1997). The goal would be to monitor trends in vegetation that should track trends in deer densities. Preserves in counties or landscapes where deer densities exceed > 20 deer/mi^2 are likely negatively influenced by deer herbivory.
Deer are a problem for many of our NAPs and a deer management program via regulated hunting needs to be enacted to reduce the local herd to a density that does not negatively impact the ecological communities on a preserve. Deer hunting is the most practical method of deer control currently available (DGIF 1999). Utilizing deer birth control, trapping and moving; or erecting a deer-proof fence around a preserve would be extremely costly. DNH needs to work with wildlife biologists from the Virginia Department of Game and Inland Fisheries through the deer management assistance program (DMAP) and or the deer damage control assistance program (DCAP) to develop a deer management plan for either each preserve and or a state-wide deer hunting plan for NAPs. These DGIF programs consist of:

- DMAP is a site-specific deer management program that increases a landowner's or hunt club's management options by allowing a more liberal harvest of antlerless deer than could be obtained under the current system of county regulations. DMAP tags can only be used to harvest antlerless deer (does and male fawns) and are not valid for antlered bucks. The primary goal of DMAP is to allow landowners and hunt clubs to work together on a local level to manage their deer herds. Secondary objectives are to increase the Department's biological database and to improve communication between deer hunters, landowners, and the Department.
- Like DMAP, DCAP was started in 1988. DCAP is a site-specific deer damage management program that increases a landowner's management options by allowing a more liberal harvest of antlerless deer than could be obtained under the existing system of county regulations. DCAP permit tags can only be used to harvest antlerless deer (does and male fawns) and are not valid for antlered bucks. The primary objective of DCAP is to provide site-specific assistance in the control of crop depredation by deer or other property damage. Secondary objectives are to maximize hunter participation in the control effort and to shift closed-season kill permit deer harvest(s) into the open deer season.

More harvest of female deer (does) will undoubtedly be a needed step towards reducing the herds using the preserves. Hunting efforts should concentrate on thinning the herd in those ecological communities most negatively impacted by excessive deer herbivory. One solution to deer overpopulation on NAPs would be to open preserves in counties with deer densities greater than a certain threshold to hunting of antler-less deer only (mainly does). In addition to obtaining the ecological benefits of a reduced deer herd on the preserves, we will be allowing greater public use of the NAPs during a time of year (fall, winter) when human impacts on the biota will be minimized.

Depending on the state other state programs vary in their approach to hunting on state natural areas. Natural areas in Missouri and Wisconsin are generally open to hunting while other programs such as Minnesota, Michigan, Illinois, Indiana and Ohio have a mix of open and closed to hunting natural areas.

Deer population pressures can be measured in terms of deer densities and or deer impacts (Horsley et al. 2003). Deer density can be assessed via a number of techniques including deer harvest data (DGIF 1999), counts at dusk (Storm et al. 1992), the drive method (deCalesta 1994), pellet counts (Neff 1968, White 1992, Alverson and Waller 1997), winter aerial surveys (Augustine and Frelich 1998) and line-transect sampling (Burnham et al. 1980, Healy and Welsh 1992). Population data on sensitive or "indicator" herbaceous plants have been used as a relatively crude but quick method of gauging the impact of deer populations on natural communities (Anderson 1994, Balgooyen and Waller 1995, Augustine and Frelich 1998, Augustine et al. 1998, Webster and Parker 2000). It is recommended that a monitoring program to track deer population densities and deer impact be utilized to assess the success of a deer management (hunting) program. Monitoring trends of deer impact on exclosure plots and measurements of sensitive herbaceous ground flora plants is recommended.

Recommendations

- Establish simple exclosure plots in NAPs with evidence of excessive deer herbivory to track trends in ground flora and the understory.
- Work with DGIF to establish some efficient system of hunting on NAPs that effectively reduces the deer impacts to preserves.

- NAPs in counties with deer population densities > 20 deer/mi^2 need to incorporate a deer management plan into the overall resource management plan.

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Impacts and Economic Costs of Deer In Suburban Landscapes

by Paul D. Curtis

The past quarter-century has witnessed a period of major growth and spread of people, automobiles, suburban living, and ownership of nonfarm rural lands. At the same time, white-tailed deer (*Odocoileus virginianus*) numbers have increased to unprecedented levels, and populations have expanded into areas with suburban development (Flyger et al. 1983). Deer in suburban landscapes cause significant economic losses to residential landowners, present safety hazards to motorists, and are perceived as agents in the transmission of Lyme disease (Connelly et al. 1987, Decker and Gavin 1987). The purpose of this paper is to provide an overview of the economic impacts caused by deer in suburban landscapes. Much of the information was obtained from several studies conducted in New York State by the Human Dimensions Research Unit at Cornell University. However, trends in other northeastern states with growing deer populations and rapid urbanization are similar. The major economic losses caused by deer are divided into three sections: deer-related vehicle accidents, Lyme disease, and plant damage.

DEER-RELATED VEHICLE ACCIDENTS

Most states keep records of deer-related vehicle accidents (DRVAs) and/or dead deer found along state highways. Romin (1994) reported that 538,000 deer collided with vehicles during 1991 in 35 states. Conover et al. (1995) estimated that the total number of reported DRVAs nationwide would be approximately 726,000 if all states were included. These estimates exclude deer that die away from the highway, and unreported DRVAs (Romin 1994). The reported number of DRVAs ranges from approximately 20 percent (Decker and Loconti 1989, Decker et al. 1990) to 50 percent (Romin 1994) of the actual number of collisions. Consequently, a conservative estimate of the total number of DRVAs nationwide would be 1.5 million annually.

Vehicle repair bills following a DRVA (in 1993 dollars) ranged from $1,200 to $2,200 in several states, with an average value of $1,577 (Conover et al. 1995). Accounting for just the 726,000 reported accidents, total annual cost for DRVAs in the United States would be about $1.1 billion. Current estimates for the cost of DRVAs in New York State alone are $50 to $70 million each year (J.R. Palmateer, New York State Department of Environment Conservation, Delmar, unpublished report).

Stout et al. (1993) examined the relationship between the perceived risk of being involved in a DRVA and public preference for local deer densities. Managing deer with consideration of public perceptions of risk from DRVAs differs from managing deer based on the actual incidence of DRVAs. Lowering the actual number of DRVAs can be accomplished with barrier fencing or reducing the size of the deer herd. However, this approach ignores the many positive recreational, aesthetic, and economic benefits people derive from higher deer densities. Risk perception is a complex process that involves more than assessing the number of DRVAs, and provides wildlife managers with an understanding of how the public balances the benefits and costs in the preference of a specific density for a local deer herd.

Respondents to a mail survey ($\underline{n}$ = 397, 66 percent response rate) indicated their most frequent deer-related concerns were DRVAs (83 percent) and Lyme disease (57 percent) (Stout et al. 1993). Most residents (88 percent) in Tompkins County, New York, were aware of at least one DRVA in the county, usually by first-hand experience of witnessing DRVAs involving other people (22 percent), or

seeing car-killed deer along the highway (76 percent). Also, many respondents (69 percent) knew someone who had been involved in a DRVA in the county. However, most people (63 percent) still believed their chances of being personally involved in a deer-car accident during the next 12 months was low. A relationship existed between perceptions of higher risk and preferences for a decrease in herd size. In addition, perceptions of social benefits from deer, probability of DRVA occurrence, tolerance of other deer-related problems, and personal involvement with a DRVA, also influenced respondents' attitude towards decreasing the size of the deer herd.

LYME DISEASE

Lyme disease was first recognized in the United States in 1975, after an unusual outbreak of arthritis near Lyme, Connecticut. Lyme disease is spread by ticks in the genus *Ixodes* that are infected with the bacterial spirochete *Borrelia burgdorferi*. *Ixodes* ticks may also spread the disease human babesiosis (*Babesia microti*), which is caused by a malaria-like parasite (Spielman et al. 1985). A public information guide from the Center for Disease Control indicated that between 12,000 and 14,000 cases of Lyme disease have been reported annually in the United States since 1994.

Larval and nymphal black-legged ticks (*I. scapularis*) commonly feed on white-footed mice (*Peromyscus leucopus*) and white-tailed deer in the northeast, but can be found on many other mammals and birds. Adult ticks, however, feed primarily upon deer (Watson and Anderson 1976, Piesman et al. 1979, Anderson and Magnarelli 1980). Although adult ticks are occasionally found on medium-sized mammals, deer densities may be a primary factor determining tick abundance (Wilson et al. 1985). *I. scapularis* is not found in regions where deer are absent, and tick abundance is greatest in areas where deer exhibit their highest densities (Piesman and Spielman 1979).

For 13 islands off the coast of Massachusetts, the abundance of larval ticks on white-footed mice was associated with deer density (Wilson et al. 1985). However, this relationship was not apparent for nymphal ticks, and it was speculated that transport of nymphs by birds confounded the relationship. On Long Island, New York, the frequency of deer use of 0.25-ha quadrats in fall was positively correlated with immature tick numbers found on white-footed mice the following summer (Wilson et al. 1990). Consequently, it has been suggested that the risk of contracting tick-borne diseases may be decreased by reducing local deer densities (Wilson et al. 1990). This may be difficult to achieve given the lack of support for hunting in many suburban landscapes.

Control of ticks on deer has been attempted mostly by deer exclusion or population reductions (Wilson and Deblinger 1993). Both methods have reduced populations of *I. scapularis* from selected experimental areas (Wilson et al. 1988, Daniels et al. 1993, Deblinger et al. 1993, Stafford 1993). However, these techniques are expensive, may be incompatible with recreational uses, and may result in opposition from animal-welfare activists.

Consequently, self-treatment of deer with acaricides is being investigated. Food-baited tubes have successfully delivered acaricides to mice and voles (Sonenshine and Haines 1985). "Damminix" tubes containing cotton have been used to treat mice with acaricides (Mather et al. 1987, Spielman 1988). A self-medicating applicator for killing ticks on deer and goats (*Capra hircus*) has been field tested in Virginia and North Carolina (Sonenshine et al. 1996). A 1 percent permethrin solution was used on a ceramic column to treat deer feeding from a circular polyethylene bin (Norval et al. 1994). Both penned and free-ranging deer readily used the applicators. Hunter-killed deer from a treated site were infested with fewer black-legged ticks (= 3.4) than those from a control site (= 10.8). Chromatographic analyses of hair samples revealed traces of permethrin on 3 of 4 deer tested. Additional large-scale field studies with similar self-application devices are currently under way.

PLANT DAMAGE

Deer damage to ornamental plants is widespread in the Northeast, but is not evenly distributed across the landscape. Impacts are often most intense near the suburban-rural fringes of large metropolitan areas (Curtis and Richmond 1992). Conover (1997a) surveyed a random sample of 100 homeowners in 10 of the 100 largest metropolitan areas in the United States, and determined that most respondents (61 percent) had experienced wildlife-related problems during the previous year. When results were extrapolated to the 60 million households in these metropolitan areas, wildlife damage was estimated to cost $3.8 billion annually. Only 4 percent of respondents reported problems with deer (2.4 million households), indicating that deer damage may cost homeowners approximately $251 million each year (Conover 1997b).

More detailed mail surveys of nursery producers and homeowners in suburban areas of southeastern New York State indicated higher levels of deer damage to landscape plants. Approximately two-thirds of producers and one-third of homeowners reported deer browsing. Nursery producers ($\underline{n} = 24$) reported total losses of $519,000 in a 5-county area during 1988, with a median loss per producer of $3,000 (Sayre et al. 1992). However, 3 producers reported more than $150,000 in deer damage, and the average loss for all growers exceeded $20,000.

Homeowners with deer impacts ($\underline{n} = 26$) reported a median loss of $200 per household in southeastern New York, and about three-fourths of these respondents classified the damage as light to moderate. The average replacement costs for trees and shrubs was nearly $500 for households with deer damage, so losses were not evenly distributed across the landscape (Sayre and Decker 1990).

Results from a self-administered mail survey of 1,002 households (70 percent response rate) in Westchester County, New York, indicated 95 percent of residents had seen a deer in the past 5 years, and 49 percent perceived an increasing trend in deer numbers (Connelly et al. 1987). More than 40 percent of respondents reported plant damage caused by deer. Average cost of plant replacement for households with deer damage averaged $94 for vegetables, $102 for flowers, $156 for fruit trees, and $635 for shrubbery. Estimated total plant replacement costs for northern Westchester County ranged from $6.4 to $9.5 million in 1987.

Despite significant plant damage in southeastern New York, two-thirds of all respondents believed that prevention of deer-car collisions should be the most important consideration of deer managers (Sayre and Decker 1990). Also, three-fourths of homeowners supported regulated hunting as a tool to manage deer populations. Even in highly suburban Westchester County, 72 percent of respondents recognized the need for deer management, and 44 percent supported the use of firearms during a regulated hunting season (Connelly et al. 1987). Two to three times more respondents expressed concerns about DRVAs and Lyme disease than about plant damage in Westchester County. It is obvious that human health and safety concerns related to deer should be the highest priority for wildlife managers.

FUTURE TRENDS

Overabundant deer populations currently cause substantial economic losses in many parts of the United States. The problems are particularly severe in the northeastern states, where expanding metropolitan areas continue to encroach on high-quality agricultural and forest lands. The forage and cover available near exclusive wooded home sites, and protection from hunting in many residential areas, have provided an ideal situation for deer populations to rapidly expand. Deer numbers in local parks and suburban landscapes may continue to double every two to three years, as long as forage is

available, unless some form of mortality or fertility control is implemented. Densities in some parks now exceed 100 deer per square mile, a level that would have been beyond the belief of most wildlife managers two decades ago.

I expect the situation will get worse in the near future. Deer numbers continue to grow at the fringes of several metropolitan areas in the northeast, and elected officials are receiving more calls concerning damage to ornamentals, deer-car collisions, and Lyme disease. The greatest difficulty will be managing the social or human-dimensions aspects of these problems, as a proposal to reduce deer numbers can become a very controversial issue for a community. People hold a wide range of attitudes and beliefs concerning human-wildlife relationships, and a variety of stakeholders groups now demand a voice in wildlife management decisions. Although many different stakeholders will agree that high deer densities in suburban areas can pose significant human health and safety risks, it can be difficult to achieve consensus on an appropriate deer density for a local area, and acceptable methods for removing deer. Wildlife managers with traditional biology training may be poorly equipped to facilitate meetings and handle the competing demands of these different interest groups.

The specialized management required for suburban deer herds may be quite different from traditional programs. Although hunting will continue to be a valuable management tool for many herds, experimental methods to reduce deer fertility will continue to be tested and refined. Several recent surveys have indicated strong public support for non-lethal control of problem wildlife species. However, these high-technology approaches are very expensive, and it is unclear how many communities will be willing to pay the long-term costs for developing alternative deer management techniques. Many policy and regulatory hurdles also need to be resolved before fertility control methods will become widely available for deer managers.

In summary, suburban deer herds will continue to pose a tremendous challenge for wildlife managers. There is no quick-fix or simple solution that will resolve deer-human conflicts. Deer will utilize the habitat created by residential development, and exhibit sustained high reproductive output. Rapid population growth will continue as long as communities limit mortality factors (i.e., hunting and/or predation), and suitable forage is available. If people choose not to take action early in the process as problems start to develop, then communities often must remove many more deer at much greater expense at some point in the future.

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Appendix E. 2004 Phragmites Survey for Goodwin Islands

Description of 2004 Survey for *Phragmites australis* at Goodwin Islands Reserve:

Ground and aerial surveys were conducted during September. Populations were mapped using GPS and were combined into a single data layer in ArcView 3.3.

Aerial Survey Methods: Aircraft. The aerial survey was conducted using a Schweitzer 300 CBi two-seat helicopter. Small, stable in flight, and highly fuel-efficient, the Schweitzer allowed the pilot and one passenger (the observer) up to three hours of flight time between fueling stops. The cockpit provided an excellent view as most construction material is clear Plexiglas. Most flights were conducted with the door removed on the passenger side, further enhancing the view.

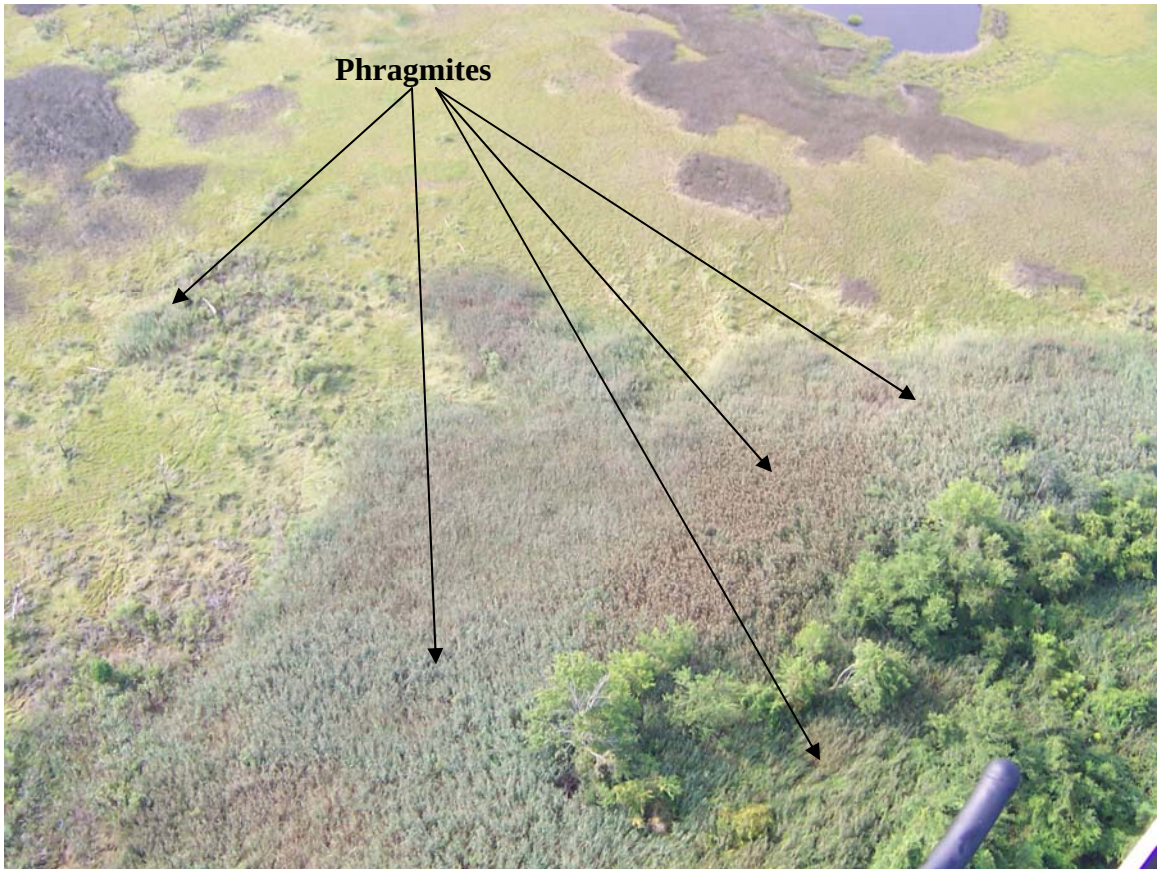
GPS equipment. The observer carried and operated a handheld GPS receiver (Trimble GeoExplorer 3) for collecting position data. A data dictionary was developed to support the census goals and provide some flexibility to meet a variety of field conditions. The following GPS rover unit settings were used during all census flights:

PDOP mask	4.0	Minimum satellites	4
SNR mask	6.0	Recording interval	1 second
Elevation mask	15 degrees		

Identification of vegetation. *Phragmites* was easily identified from the air during the survey period (Figure A1). The following characteristic features of *Phragmites* all contributed to a highly distinct search image: tall stature, bluish green leaves, purple-red inflorescence, and dense stand formation. Even under tree canopy or mixed with shrub species, *Phragmites* occurrences stood out clearly. Cat-tail (*Typha latifolia)* and tall cordgrass (*Spartina cynosuroides)* were occasionally mistaken for *Phragmites* from a distance. However, upon closer approach, the coloration and structure of these species readily distinguished them from *Phragmites*.

Ground Survey Methods. DCR-DNH field biologists verified aerial observations of *Phragmites* populations and mapped forest interior extent of some populations. Trimble Geo3 handheld units were used for collecting GPS data. Settings were the same as those used for the aerial survey.

Findings. On Goodwin Islands, 21 *Phragmites* patches comprising a total of 37 acres were mapped (Table A1). Two patches comprise 27 acres, or 73%, of the *Phragmites* on the island. The other ten acres is found in patches ranging in size from 3 acres to less than a tenth of an acre. Seventeen patches are less than 1 acre. Most *Phragmites* is found in open habitat, usually in a zone between low marsh and drier scrub and forest communities. However, some *Phragmites* is found in forested areas. At Goodwin Islands, as elsewhere, Hurricane Isabel appears to have increased *Phragmites* habitat through canopy gaps in pine forest along or near the forest-marsh edge. High waters and winds also appear to have cleared away dead standing stems and resulted in a lush growing season for *Phragmites*.



Phragmites is readily discernible from above.

Figure A1 – Goodwin Islands: *Phragmites australis*.

Table A1. Goodwin Islands *Phragmites* stands (2004) Arranged and numbered by size, largest to smallest.

Stand number	**Acres**	**Stand number**	**Acres**
1	15.5	13	0.1
2	11.7	14	0.1
3	3.0	15	0.1
4	1.3	16	0.1
5	1.1	17	0.1
6	0.9	18	0.1
7	0.7	19	0.1
8	0.7	20	0.1
9	0.6	21	0.1
10	0.6	22	0.1
11	0.3		
12	0.1	**Total acres =**	**37.3**

Appendix F. Waterfowl and Deer Hunting: Goodwin Islands

Special Managed Waterfowl Hunt: KEY IDEAS

WHY CONDUCT A WATERFOWL HUNT ON A NATURAL AREA?

- Historical use: prior to acquisition and/or management by the state as a natural area; private interests hunted ducks and geese here regularly.

- VIMS is now responsible for regulating and managing the use of portions of the property by the public. These uses must be compatible with the objectives for which the property was acquired by the state in the first place.

- Virginia law provides that anyone can hunt waterfowl in public waters during established seasons and using legal methods so long as they are not within 500 yards of an existing licensed waterfowl blind. Therefore, if VIMS does not license, establish, and use (for the purpose of hunting) waterfowl blinds along the shoreline at Goodwin Islands Reserve, then any member of the public has the opportunity to obtain a license and build a stationary hunting blind in the public waters surrounding the Reserve. Where stationary blinds are not built, anyone could legally hunt from licensed floating blinds (boats) in the waters adjacent to the Reserve.

- The result of VIMS not establishing and managing the use of shore blinds at portions of Goodwin Islands Reserve is expected to be the rapid licensing and construction of blinds, and the frequent use of these blinds in the public waters surrounding the Reserve, making it a *de facto* waterfowl hunting area from November through January of every year. This unregulated use would not be in the interest of VIMS and visitor/researcher safety would be of high concern.

The Department of Conservation and Recreation, Division of Natural Heritage allows managed waterfowl and deer hunting at selected Natural Area Preserves. The information that follows are examples of information that DCR-DNH distributes to potential and/or registered hunters participating in these hunts.

2005 Managed Waterfowl Hunt at Dameron Marsh and Hughlett Point Natural Area Preserves

Lottery Information and Application

This is an opportunity to hunt **WATERFOWL** at Dameron Marsh Natural Area Preserve and Hughlett Point Natural Area Preserve, both in Northumberland County, VA. Half-day hunting will be available for each Tuesday during the last segments of the general duck season.

Hunt Dates: November 22 and 29; December 13, 20, and 27; January (2006) 3, 10, 17, and 24.

- To hunt waterfowl at Dameron Marsh and Hughlett Point, hunters must apply and be chosen by lottery. Application deadline is 5:00 PM, Oct. 7, 2005 and a $5.00 non-refundable application fee is required. A random drawing will be held on Oct. 10 at 1:00 PM at the Richmond Office of DCR's Division of Natural Heritage located at 217 Governor Street and will be available for public inspection. Hunters must be 16 years of age or older to apply for this hunt.
- Successful applicants will have the option of purchasing from one (1) up to a total of three (3) permits @ $10.00 each for their hunt day, allowing each hunter to form a party consisting of themselves and up to two (2) other hunters. The applicant (Chief-of-Party) will be responsible for payment to DCR and distributing permits to each party member. Permits are non–transferable.
- **AS WITH ALL DCR HUNTING OPPORTUNITIES, PROOF OF COMPLETION OF A HUNTER SAFETY COURSE IS REQUIRED FOR EACH HUNTER.** Hunter Safety Certificates must be in possession and presented along with licenses if checked during the hunt.
- Maximum of four hunting parties per hunt day. No stand-by hunting is available.
- One blind per hunt party is land accessible ("walk-in"). All other blinds are accessible by water ONLY. No boat launching is permitted at either Preserve.
- It is strongly recommended that permit holders scout the area in advance to find boat ramp and blind locations, and to become familiar with navigating the waters of these exposed and potentially hazardous Chesapeake Bay hunting locations. **YOU MUST BE FAMILIAR WITH THE AREA TO LOCATE BLIND SITES IN THE DARK BEFORE SHOOTING TIME.**
- Specific navigation hazards include but are not limited to large waves, shoals, wooden pilings, pound nets, stationary blinds, and other structures. Water depth and

boating conditions can vary drastically with wind direction, wind speed, tidal changes, fog, and other factors.

- Hunting is permitted **ONLY** from: (1) assigned shore blind sites; or, licensed floating blinds positioned at a distance no greater than 100 feet from the assigned shore blind site.
- Only one floating blind per hunt day may occupy a blind site and may not be left unattended.
- Hunting hours are ½ hour before sunrise to 1:00 PM. All hunters are required to stop hunting at 1:00 PM, have all decoys retrieved, and be away from the blind site by 2:00 PM.
- The use of dogs for retrieving waterfowl is strongly recommended.
- Only U.S. Fish & Wildlife Service approved non-toxic shot is allowed for this hunt. Each hunter is limited to 25 rounds of ammunition in possession per hunt day.
- All State and Federal migratory bird regulations and laws apply during hunt. **HUNTERS MUST POSSESS: a VA state hunting license, both state and federal migratory waterfowl stamps, a hunter safety course certificate, and a 2005 – 2006 HIP registration number.** A HIP number may be obtained by calling 1-888-788-9772 or registering on-line at **www.dgif.virginia.gov.**

HOW TO APPLY:

1.Complete and mail the following application along with your $5.00 application fee (check only) payable to NAPF (Natural Area Preservation Fund) to:

Attention: Waterfowl Hunt
Virginia Department of Conservation and Recreation
Division of Natural Heritage
217 Governor Street
Richmond, VA 23219

2.Applications will be accepted until the close of business (5:00 PM) on October 7, 2005.

3.Only successful applicants will be notified – within two weeks of the drawing. **Selected hunters must return the $10 per hunter Natural Area Preserve permit fee (maximum $30) by 5:00 PM on Friday, October 28, 2005 to the above address.** No stand-by hunting is available.

4.Your name can only appear one time in the drawing.
ALL DUPLICATE ENTRIES WILL BE DISQUALIFIED.

DAMERON MARSH and HUGHLETT POINT NATURAL AREA PRESERVES
WATERFOWL HUNT APPLICATION

****** ALL INCOMPLETE APPLICATIONS WILL BE DISCARDED ******

PLEASE PRINT

Name_____

Address_____
City_____

State_____ **Zip Code**_____

Telephone No. ( ) _____ - _____ Date of Birth_____

2005-06 Hunting License #_____ **Expiration Date**_____

Hunt dates (Tuesdays): November 22 and 29; December 13, 20, and 27; January (2006) 3, 10, 17, and 24.

If desired, indicate your preferred hunt date:_____

Do you wish to be considered for dates other than your indicated date of preference? YES NO

The Department of Conservation and Recreation reserves the right to manage hunter access and hunter use on Department owned lands as deemed appropriate.

HUNTER SAFETY CERTIFICATION IS REQUIRED FOR PARTICIPATION ON THIS AND ALL HUNTS ON DEPARTMENT LANDS.

---------- Natural Area Preserve
Managed Deer Hunt Rules and Regulations

1. All hunters must sign in at the check-in kiosk when arriving at the Preserve and sign out when leaving.

2. All hunters in the party must possess a valid DCR hunting permit. Each permit will bear the name of the Chief-of-Party, who will be responsible for providing the name and Virginia Hunting License number of each party member on their hunting permit.

3. Each hunter must have on his/her person proof of successfully completing a Hunter Education Course (certificate or copy of certificate).

4. Hunters hunting alone must be 16 years of age by the date of the hunt. Youth hunters aged 12-15 must be accompanied by an adult at all times. Both the youth and the adult must possess a DCR hunting permit and proof of completing a Hunter Education Course.

5. Hunters must have all necessary state licenses and abide by all state and DCR regulations.

6. Allowable weapons are shotguns with rifled slugs or buckshot.

7. All deer targeted must be within the Preserve boundaries, which are marked by conspicuous white signs and yellow boundary paint.

8. A limit of two (2) deer per hunter, per day, one of which must be antlerless, may be harvested. **The objective of the hunt is to reduce the size of the deer herd. Therefore, the harvesting of antlerless deer is strongly encouraged.**

9. All deer harvested should be tagged immediately at the point of kill.

10. Hunters are asked to voluntarily provide the following data for harvested deer:
    - sex
    - weight (dressed)
    - number of points (bucks), lactation status, pregnancy & number of young (does)
    - general health and condition

Additional notes:
Data sheets will be available at the check-in kiosk. Scales for weighing deer will not be provided. It is requested that hunters bring their own scales to provide this key harvest statistic. If necessary and only if scales are unavailable, hunters should estimate the field dressed weights of harvested deer in order to complete the data sheet.

Hunter Information Summary Sheet
2004 Lottery Deer Hunt
---------- Natural Area Preserve

Dates: December 6-11, 2004 (Monday - Saturday)
December 13-18, 2004 (Monday - Saturday)

Type of Hunt:
●This is a **lottery** hunt.
●A non-refundable $5.00 State Park Reservation fee will be required at the time of application in order to enter the lottery. Applications and payment must be received by **5:00 PM on Friday, October 8, 2004**. Make checks payable to *Treasurer of Virginia*. Telephone applications and payment by credit card is also acceptable.
●Each selected applicant will be assigned one (1) hunt day during the 2-week hunting period. Selected applicants will be notified within two (2) weeks of the random drawing.
●Each selected applicant may request up to five (5) permits for their assigned hunt day, for a party of up to five hunters. For each member of the hunting party, a $10.00 Natural Area Preserve hunting permit fee must be remitted.
●Hunting permit fee payments must be received by Friday, November 5, 2004. Hunting permit fees must be made by personal check, payable to *Natural Area Preservation Fund*, and mailed to the Department of Conservation and Recreation, 217 Governor Street, Richmond, VA, 23219 – Attention: ---------- Deer Hunt

Participation Requirements:
All members of the hunting party:
1. Must possess all necessary state licenses.
2. Must possess issued hunt permit from DCR.
3. **Must show proof of having completed a Hunter Education Course**.
4. Must be 16 years of age or older to hunt alone. Hunters 12-15 years of age may hunt as a member of the party, but must be under the direct supervision of a hunting adult.
5. Must abide by and meet all rules and regulations, including but not limited to, weapons and ammunition restrictions/specifications and blaze orange requirements (vest and hat).

How to Participate:
●By filling out a lottery application and returning it to the State Parks Reservation Center – along with a non-refundable $5.00 application fee. Applications may also be made by telephone with application fees paid by credit card (call 1-800-933-PARK). **Applications must be received by 5:00 PM on October 8, 2004.**
●Selected hunters will be notified by October 22, 2004. Each hunter must render payment of the Natural Area Preserve fee ($10.00 per hunter) to: DCR-Division of Natural Heritage, 217 Governor Street, Richmond, Virginia 23219. Payment must be received by November 5, 2004 or the hunt date will be forfeited and offered to hunters on a stand-by list. Payment should be by personal check made out to *Natural Area Preservation Fund*. Please specify -------- Deer Hunt on the memo line.
●The selected applicant will be considered the Chief-of-Party and will be responsible for all payment to DCR and distributing permits to hunt party members.

●Once payment is made, the Chief-of-Party will be sent an information packet, including maps and hunting permits.

Allowable Weapons:
Allowable weapons are shotguns with rifled slugs or buckshot.
Hunters may ground hunt or use portable tree stands with approved safety belts.

Hunt Zones:
Hunters may hunt anywhere within the preserve boundaries (299 acres). All deer targeted must be within the preserve boundaries. There will only be 1 hunting party on any given day (the hunting party consisting of the successful applicant and up to four other hunters if the applicant chooses).

Allowable Harvest:
A limit of two (2) deer per hunter, one of which must be antlerless, may be harvested. The objective of the hunt is to reduce the size of the herd. Therefore, the harvesting of does is strongly encouraged.

Additional Harvest Information:
All deer harvested must be tagged immediately. Field dressing of deer should occur at the point of kill.

Hunter's will be required to provide the following information for harvested deer:
●sex
●weight **(either live or dressed; hunter's must provide scale)**
●number of antler points, lactation status, pregnancy (as applicable)
●general health and condition.
Data sheets will be available at the Hunter Check-in Kiosk.

Disabled Hunters:
Hunting at ------- NAP requires traversing rough terrain (thick underbrush, sand dunes, drainage ditches, wetlands).

Scouting and Additional Information:
To arrange a scouting date or for additional information, call: -----

Appendix G. Federal and State Natural Resource Laws

Federal and State Natural Resource Laws

LEGISLATION	CITATION	RESPONSIBLE AGENCY
Presidential Order on Introduction of Exotic Species	Executive Order # 11987	Office of the President
U.S. Noxious Weed Law	7 USC 2802-2814	U.S. Department of Agriculture (USDA)
U.S. Clean Water Act	33 USC 1344	U.S. Army Corps of Engineers (ACOE), U.S. Environmental Protection Agency (EPA)
U.S. Anadromous Fish Conservation Act	16 USC 757a-757g	National Marine Fisheries Service (NMFS)
U.S. Clean Air Act	42 USC 7401-7671q	EPA
National Environmental Policy Act	42 USC 4321-4307d	all Federal agencies
Lacey Act (exotics)	18 USC 42	U.S. Department of Interior (DOI)
U.S. Endangered Species Act	16 USC 1531-1544	U.S. Fish & Wildlife Service (FWS), NMFS
U.S. Fish & Wildlife Coordination Act	16 USC 661-668s	many
U.S. Migratory Bird Treaty Act	16 USC 701-712	FWS
U.S. Aquatic Nuisance Prevention & Control Act	16 USC 4701-4751	FWS, NMFS
VA Commercial Fishing Law / Recreational Fishing Law	VA Code 28.2-100 – 1001	VA Marine Resources Comm. (VMRC)
VA Wetlands Act	VA Code 28.2-1300 – 1320	VMRC
VA Historic Resources Law	VA Code 10.1-2200 – 2216	VA Department of Historic Resources (VDHR)
VA Antiquities Act	VA C ode 10.1-2300 – 2306	VDHR
VA Endangered Species Act	VA Code 29.1-563 – 570	VA Department of Game & Inland Fisheries (VDGIF)
VA Fish & Wildlife Law	VA Code 29.1-100 et seq.	VDGIF
VA Endangered Plant & Insect Species Act	VA Code 3.1-1020 – 1030	VA Department of Agriculture and Consumer Services (VDACS)
VA Noxious Weed Law	VA Code 3.1-296.11 - 296.21	VDACS

Federal and State Natural Resource Laws (continued)

LEGISLATION	CITATION	RESPONSIBLE AGENCY
VA Chesapeake Bay Preservation Act	VA Code 10.1-2100 - 2115	Chesapeake Bay Local Assistance Dept. (CBLAD)
VA Water Quality Improvement Act of 1997	VA Code 10.1-2118 – 2128.B.	VDCR
VA Water Control Law	VA Code 62.1-44.2 - 44.34	VA Department of Environmental Quality (VDEQ)
VA Ground-water Management Act	VA Code 62.1-44.84 - 44.104	VDEQ
VA Environmental Quality Act	VA Code 10.1-1200 - 1221	VDEQ
VA Waste Management Act	VA Code 10.1-1400 - 1457	VDEQ
VA Open Space Land Act	VA Code 10.1-1700 - 1705	VA Outdoors Foundation (VOF)
VA Erosion & Sediment Act	VA Code 10.1-560 - 571	VDCR
VA Natural Area Preserves Act	VA Code 10.1-202 - 217	VDCR
VA Conservation Easement Act	VA Code 10.1-1009 - 1016	VDCR

Appendix H. Glossary Of Technical Terms And Abbreviations

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ac – acre(s).
acidic – having a pH value < 7.0, often indicating moderate or low fertility.
alluvial – of or pertaining to deposition of sediment by a stream.
alluvium – unconsolidated sand, silt, clay, or gravel deposited by running water.
asl – above sea level
aspect – the direction a slope faces (e.g., a north aspect).
basal area – the cross-sectional area of a tree at breast height; extrapolated to a larger area, basal area is an estimated measure of how much of a site is occupied by trees.
basic – as applied to soils, having high levels of base cation (e.g., calcium and magnesium) saturation, typically indicating high fertility; as applied to rocks, having high concentrations of iron, magnesium, and calcium.
biological resource management – those components of natural areas stewardship pertaining to or impinging on vegetation, natural communities, or habitat for rare species. Examples of biological resource management include invasive species control, habitat restoration, and monitoring of species population status.
biomass – the total weight of all living organisms in a biological community; in vegetation science, usually the total weight of all above-ground plant parts.
bryophyte – a non-vascular green plant; includes mosses, hornworts, and liverworts
colluvial – of or pertaining to colluvium.
colluvium – unconsolidated earth materials deposited on steep slopes by direct gravitational action and local unconcentrated run-off.
community – as applied to plants, any unit of vegetation regardless of rank or development; an aggregation of plants on the landscape; in broader terms, any assemblage of organisms that co-occur and interact.
cover – the percentage of the ground covered by the vertical projection of above-ground plant parts.
DCR – Virginia Department of Conservation and Recreation.
dbh – diameter at breast height (4.6 ft above the ground); the standard position at which woody stems are measured in forestry procedures.
dedication – dedication of a natural area is the strongest form of protection that can be afforded a natural area in Virginia and involves recording a legally binding Deed of Dedication with the property deed. The Deed of Dedication states the preservation purpose of the property, designates the property as Open-Space Land, restricts land uses which are incompatible, and formally places the site in Virginia's Natural Area Preserve System. Dedication is perpetual, and although ownership of the property can be transferred, the dedication will remain in effect.
density – the number of plants per unit area; used more specifically in this study as a measure of the number of woody stems ≥ 1in in diameter at breast height per hectare.
DGIF – Virginia Department of Game & Inland Fisheries.
dip slope – a side slope determined by and approximately aligned with the angle of the underlying bedrock plane.
DNH –Virginia Department of Conservation & Recreation, Division of Natural Heritage.

DOF – Virginia Department of Forestry.
dominant – of or pertaining to an organism or taxon that by its size, abundance, or coverage exerts considerable influence on a community's biotic and abiotic conditions.
dry-mesic – intermediate between dry and moist but well drained; submesic to subxeric.
duff – the matted, partly decomposed organic surface layer of forest soils.
EO – element occurrence. A site that supports a population of a rare plant or animal or an exemplary stand of an ecological community. EOs are sites tracked in the natural heritage database by the Division of Natural Heritage.
EO rank – the viability of a particular EO, graded from A to D.
ecological community - an assemblage of co-existing, interacting species, considered together with the physical environment and associated ecological processes, that usually recurs on the landscape.
ecological community group – a level in the hierarchical ecological community classification used by DNH (Fleming et al. 2001). An ecological community group consists of ecological communities with similar topographic, edaphic, physiognomic, and gross floristic traits. This level is comparable to the level at which many natural community classifications define their basic units, *e.g*., Basic Oak-Hickory Forests. Ecological community groups are not defined at a single, standard scale. Because community groups differ in their extent on the landscape, some are very broadly defined and have large geographic coverage (*e.g*., Chestnut Oak Forests), while others are very narrow in concept and distribution (*e.g*., Granitic Flatrocks). Ecological community types are nested within an ecological community group.
ecological community type – an abstract unit of vegetation representing concrete plant communities sharing a similar structure and floristic composition, and occurring under similar environmental conditions; more or less equivalent to the "association" used in traditional vegetation studies and the U.S. National Vegetation Classification. Ecological community types are the next finest level in the community classification hierarchy after ecological community groups.
ecotone – a transitional area where characteristics of adjacent communities or environments intermingle or intergrade.
ecosystem – a complete interacting system of organisms and their environment, applicable at any spatial scale.
edaphic – of or pertaining to the influence of soils on living organisms, particularly plants.
endemic – geographically restricted; a species or taxonomic group restricted to a particular geographic region.
environmental gradient - a spatially varying aspect of the environment (*e.g*., elevation, slope position, soil pH) that is expected to be related to species composition.
ericaceous – of the Heath Family (*Ericaceae*).
ericad – a plant of the Heath Family (*Ericaceae*); for example, blueberries (*Vaccinium* spp.), rhododendrons (*Rhododendron* spp.), and mountain-laurel (*Kalmia latifolia*).
exotic – an introduced, non-native species.
fire management – all activities associated with the management of fire-prone land, including the use of fire to meet land management goals and objectives - a unique and distinct component of natural areas stewardship combining elements of both biological and operations management. Fire management activities include both prescribed fire implementation and wildfire management.

fire management plan – statement, for a specific area, of fire policy, objectives, and prescribed action.
flora – all the vascular plants that make up the vegetation of a specified area.
floristic – of or pertaining to the flora of an area and the geographic patterns of distribution represented by its taxa.
floristics – the study of a flora and the geographic distributions of its taxa.
floodplain – a nearly level alluvial plain that borders a stream and is subject to inundation (non-tidal) under flood-stage conditions.
foliose lichen - a lichen typically lying flush to its substrate, but removable such that the lower surface is visible; foliose lichens are often attached to rocks and other substrates by numerous fine structures called rhizines.
forb – a broad-leaved herbaceous plant.
forest – an ecosystem dominated by trees (≥ 20ft tall) producing a more or less closed canopy, typically with 60-100% cover; some forests may temporarily have < 60% canopy cover following disturbances such as windthrow, disease, etc.
fruticose lichen – a lichen that grows erect or pendent, with thalli that have no clearly distinguishable upper and lower surfaces; includes species that are branched and shrubby, as well as those that form unbranched stalks.
ft – foot (feet).
geomorphic – of or pertaining to processes that change the form of the earth (e.g., volcanic activity, running waters, glaciers).
graminoid – grasses and grass-like plants (e.g., sedges and rushes).
groundwater – water occurring below the earth's surface in bedrock and soil.
heath - a plant of the Heath Family (*Ericaceae*); an Ericad; for example, blueberries (*Vaccinium* spp.), rhododendrons (*Rhododendron* spp.), and mountain-laurel (*Kalmia latifolia*).
herb – a vascular plant lacking woody tissue at or above ground level.
herbivory – the consumption of plants by animals.
hibernacula – over-wintering den sites used by animals such as bats, snakes, and insects.
humus – decomposed organic matter that has lost all trace of the structure and composition of the vegetable or animal matter from which it was derived.
hydric –wet and poorly drained.
hydrology – the science that deals with the circulation, distribution, movement, and chemistry of the waters of the earth.
in – inch(es).
invasive species – any species of plant, animal, or other organism (e.g. microbes) that is both non-native (exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.
integrated pest management – is the maintenance of destructive agents, including insects, at tolerable levels by the planned use of a variety of preventative, suppressive, or regulatory tactics and strategies that are ecologically and economically efficient and socially acceptable. The methods used in pest management must be ecologically based, involve a combination of tactics from insecticides to “doing nothing” appropriate to the situation and the biota and be a part of an overall management plan for the ecosystem being considered.
interstice – an intervening space or crevice.
interstitial – of or pertaining to interstices.

Jurassic – the second period of the Mesozoic era (following the Triassic), from approximately 190 to 135 million years ago.
liana – a woody vine.
lichen – a symbiotic association between a fungus and one or more species of algae and/or blue-green algae; although not based on genetic relationships, lichen species, for the aid of identification, are divided into foliose, fruticose, crustose, and umbilicate groups based on their growth strategies.
lithologic – of or pertaining to the physical characteristics of a rock.
lithology – the description of rocks on the basis of physical characteristics such as color, mineralogical composition, and grain size.
liverwort - a nonvascular, chlorophyll-containing plant closely related to mosses and hornworts, but differing in reproductive structures; liverworts have two dominant growth forms, one which resembles moss with overlapping leaves, the other forming prostrate leafless bodies.
m – meter(s).
macroinvertebrate – an animal lacking a backbone (invertebrate) and visible without the aid of magnification.
mafic – geologically, containing large amounts of dark-colored silicate minerals rich in magnesium and iron, e.g., pyroxene, amphibole, and biotite mica; examples include igneous and metamorphic rocks such as amphibolite, basalt, diabase, gabbro, and greenstone; also applied to soils with high levels of magnesium and iron that are derived from these formations.
mesic – of intermediate moisture conditions (i.e., moist and well-drained).
mesophyte – a plant characteristic of mesic environments.
mesophytic – of or pertaining to plants or vegetation adapted to environments of moist, well-drained sites.
Mesozoic – an Era of geologic time, from the end of the Paleozoic to the beginning of the Cenozoic, or about 225 to 65 million years ago; includes the Triassic, Jurassic, and Cretaceous periods.
metabasalt – metamorphosed basalt, a fine-grained igneous rock composed largely of plagioclase feldspar, pyroxene, and volcanic glass.
metamorphic – altered in mineral composition, chemical composition, and structure by heat, pressure, and hot fluids at some depth below the earth's surface; applied to rocks of igneous and sedimentary origin.
metasedimentary – consisting of sedimentary rock that shows evidence of having been subject to metamorphism; examples include quartzite (= metasandstone) and metasiltstone.
mi – mile(s).
microclimate – the local climate of a small site; this may vary from the climate of the larger, surrounding area due to aspect, tree cover, elevation, wind exposure, and other local factors.
microhabitat – within a habitat, a subdivision or precise location that has distinctive environmental characteristics; e.g., a tree-base hummock in a flooded swamp.
microtopography – the fine-scale variation in topography within a habitat; e.g., the pattern of vertical rock faces, shelves, and crevices on a cliff.
monospecific – consisting wholly or largely of a single species.
moss - a nonvascular chlorophyll-containing plant closely related to liverworts and hornworts, but differing in reproductive structures.

muscovite – a mineral of the mica group that is common in gneisses and schists; also known as "white mica."
natural community - those ecological communities which have experienced only minimal human alteration or have recovered from anthropogenic disturbance under mostly natural regimes of species interaction and disturbance. No portion of Virginia's landscape, however, has altogether escaped modern human impacts – direct or indirect – and only a few small, isolated habitats support communities essentially unchanged from their condition before European settlement.
natural heritage resources – as defined in the Virginia Natural Area Preserves Act these are "…the habitat of rare, threatened, or endangered plant and animal species, rare or state significant natural communities or geologic sites, and similar features of scientific interest." (Code of Virginia, section 10.1-209, et seq.).
non-vascular – lacking a structural system of tissue (xylem and phloem) that conducts water and soluble nutrients; non-vascular plants include mosses, lichens, and liverworts.
oligotrophic – infertile; nutrient-poor.
operations management – those components of natural areas stewardship pertaining to or impinging on non-biological features of natural area preserves. Examples of operations management activities include public access facilities development and maintenance, boundary line marking, sign installation, law and regulation enforcement, and ensuring visitor safety.
overstory – the uppermost layer of trees forming the canopy of a forest or woodland.
Paleozoic – the era of geologic time from 600 to 230 million years ago.
patch-dominant – a species that exerts dominance by forming dense but spatially discrete colonies; such a species typically varies from abundant to completely absent within a given habitat.
pathogen – an organism that causes disease in another organism.
pH – a value on the scale 0 to 14 that gives a measure of the acidity or alkalinity of a medium.
physiognomic – of or pertaining to vegetative form and structure.
physiognomy – the form and structure of vegetation.
phytogeography – the study of the geographic distribution of plants and vegetation , with an emphasis on environmental determinants of distribution.
Pleistocene – the first Epoch of the Quaternary Period of geologic time, from approximately two million to ten thousand years ago.
prescribed burn plan – a written statement defining the objectives to be attained as well as the conditions of temperature, humidity, wind direction and speed, fuel moisture, and soil moisture, under which a fire will be allowed to burn. A prescription is generally expressed as acceptable ranges of the prescription elements, and the limit of the geographic area to be covered.
prescribed fire – a management ignited wildland fire that burns under specified conditions where the fire is confined to a predetermined area and produces the fire behavior and fire characteristics required to attain planned fire treatment and resource management objectives.
pyrophytic – of or pertaining to plants or vegetation adapted to environments in which fire is an important ecological process.
quartzite –metamorphosed sandstone.

rare species – species believed to be sufficiently rare or threatened in Virginia to merit an inventory of their status and locations by DNH.
recruitment – generally, the trees involved in natural supplementation of a forest stand; more specifically, trees that have entered a particular category (age or size class) during a given period.
refugia – sites where plants or vegetation that formerly had much wider distributions have survived locally through periods of unfavorable conditions in a region.
regolith – all unconsolidated earth materials above solid bedrock.
rhizomatous – having a horizontal, creeping, perennial rootstock that produces smaller roots and vegetative shoots.
riparian – of the area beside a stream, especially a river.
rill – a small streamlet or rivulet.
ruderal vegetation – vegetation resulting from succession following anthropogenic disturbance of an area; generally characterized by unnatural combinations of species (primarily native though including small to substantial numbers of exotics) and relatively short persistence in the absence of additional disturbance.
sandstone – a medium-grained sedimentary rock composed of rounded sand grains cemented together by silica, iron oxide, or calcium carbonate.
saturated – wet for extended periods during the growing season, but never or rarely flooded by surface water; usually applied to wetlands maintained by seepage inputs or perched water tables.
schist – a metamorphic rock containing abundant, visible platy minerals (*e.g.*, mica), giving it a pronounced foliation and cleavage.
sedimentary – formed from the deposition and compression of mineral and rock particles, and sometimes material of organic origin; examples of sedimentary rocks include sandstone, shale, and limestone.
seep – a small area of groundwater discharge, either non-forested or shaded by trees rooted in adjacent, upland habitats; seeps generally support characteristic herbaceous wetland species but are too small or narrow to support hydrophytic woody vegetation.
seepage swamp – a large area of groundwater discharge supporting wetland forest or shrubland vegetation.
seral – of or pertaining to an intermediate or transitional stage in plant succession.
serotinous cone – the cone of a pine that remains closed for a period of time, sometimes years, following maturation; the opening of such cones are often triggered by the heat of fires; a reproductive adaptation that ensures seed dispersal under optimal conditions.
site operations – in the context of natural areas management, those activities that deal with boundaries, facilities, access, signage, public safety, and other human use issues.
smoke management – application of fire intensities and meteorological processes to minimize degradation of air quality during prescribed fires.
snag – a standing dead tree.
sp. – a species.
spp. - species (plural).
spring ephemeral – a plant that completes its reproductive cycle early in the growing season, typically before or during the period in which trees leaf out; such species usually die back and become dormant during unfavorable summer months when habitats are characterized by high temperatures and deep shade.

ssp. – subspecies, a taxonomic rank below species.
stewardship – in the context of natural areas management, the combination of three primary components – biological resource management, site operations, and fire management – with the objective of perpetuating occurrences of natural heritage resources and preserving inherent biological diversity.
stratigraphy – the arrangement of bedrock strata, particularly their geographic position and chronological order of sequence.
stratum – a distinct vertical layer of vegetation defined by relative height (e.g., overstory, understory) and/or by a specific range of heights.
sub-canopy – the understory tree layer immediately below the overstory.
submesic – somewhat moist but well drained, or intermediate between dry and moist; dry-mesic.
subxeric – somewhat dry and drought-prone; intermediate between submesic and xeric.
succession – natural change in the composition and structure of a plant community over time in the absence of disturbance.
successional – of or pertaining to the process of succession.
surface substrate – a collective term for the abiotic materials (e.g., leaf litter, rocks, dead wood) that constitute the ground cover of a site.
terrestrial – of or pertaining to upland (non-wetland) environments.
Triassic – the earliest period of the Mesozoic Era, from approximately 225 million to 190 million years ago.
umbilicate lichen - a leaf-like lichen attached to rocks by a single cord; umbilicate lichens, especially those of the genus *Umbilicaria*, are often referred to as "rock tripes."
understory – collective term for the small trees and shrubs growing beneath the canopy in a forest or woodland.
var. – variety, a taxonomic rank below species.
vascular – having a structural system of tissue (xylem and phloem) that conducts water and soluble nutrients; vascular plants include ferns and flowering plants.
vegetation – the plant life of an area, including its floristic composition, structure, biomass, and phenology.
watch-list species – species of uncommon or uncertain status in Virginia. More information is needed on these species, which may or may not be of high conservation concern at this time; these species are monitored for general population trends.
woodland – vegetation dominated by trees (≥ 20 ft tall) producing an open canopy, typically with 5-60% cover; such vegetation with canopy cover from 5 to 25% is referred to as a sparse woodland; some woodlands may have > 60% canopy cover following elimination or reduction of natural disturbances (e.g., fire).