

INVASIVE SPECIES IN THE CHESAPEAKE BAY WATERSHED

***A WORKSHOP TO DEVELOP REGIONAL INVASIVE SPECIES MANAGEMENT
STRATEGIES***

HELD MAY 7 –8, 2002 BALTIMORE, MARYLAND

**FINAL REPORT TO THE CHESAPEAKE BAY PROGRAM, INVASIVE SPECIES
WORKING GROUP**

edited by

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WORKSHOP SUMMARY

Introduction

The U.S. EPA Chesapeake Bay Program and Maryland Sea Grant College Program jointly sponsored a workshop May 7 – 8, 2002, in Baltimore, Maryland to discuss management strategy frameworks for six species identified as causing, or having the potential to cause, significant degradation of the Chesapeake Bay aquatic ecosystem. Ninety individuals representing government, private, academic and non-governmental organizations participated in the two-day workshop. The workshop provided an opportunity for participants to discuss in plenary and breakout sessions the necessary components of an invasive species management plan. Through these interactions, six species-specific draft management strategy frameworks were completed by the close of the workshop. Included were: Phragmites (*Phragmites australis*); purple loosestrife (*Lythrum salicaria*); water chestnut (*Trapa natans*); mute swan (*Cygnus olor*); nutria (*Myocastor coypus*); and zebra mussel (*Dreissena polymorpha*).

By design the workshop did not address issues specific to the introduction of species through the uptake and discharge of ship's ballast water. Instead, the focus was on species considered to be of highest priority for active management in the Chesapeake Bay watershed by the Chesapeake Bay Program's Invasive Species Workgroup (ISW). This broad range of species were introduced through diverse pathways, have differing levels of population success (from well established populations, such as phragmites and purple loosestrife to limited populations such as zebra mussel), and present varying degrees of economic and ecological risks. Indeed, this diversity in selected invasive species proved beneficial for several reasons. First, it allowed participants to think expansively about the problem, rather than taking a more narrow approach that a single species discussion would have evoked. Second, it brought together specialists from different fields, thereby providing an exciting opportunity for new ideas and solutions to be proposed. Third, it addressed serious invasive species issues for specific areas of the Bay watershed. By developing management strategies for a broad spectrum of species the Chesapeake Bay watershed produced model species management plans that may serve as frameworks for managing invasive species of aquatic plants, invertebrates and vertebrates that emerge in the future.

A unique aspect of this workshop was that it brought together representatives from a range of jurisdictions and interests within the Chesapeake Bay watershed to discuss management of multiple aquatic invasive species. Although numerous management plans exist for individual species, this workshop may have been the first in the United States to take a regional watershed approach to developing management strategies for six invasive aquatic species concurrently. This structure provided an important opportunity for the Chesapeake Bay jurisdictions to take a national leadership role in addressing a pressing environmental and economic problem. The success of this workshop is noteworthy. Six draft invasive species management strategy frameworks now exist for the Chesapeake Bay watershed. Continued efforts by the jurisdictions, the Chesapeake Bay Program, other interested groups and the public will allow these plans to be finalized and implemented by the jurisdictions.

Highlights from the Draft Invasive Species Management Plans

Each breakout group identified critical issues fundamental to the success of any management plan for that specific species. These key issues from each of the management plans are highlighted below.

Phragmites (Phragmites australis)

- Achieve no net gain in phragmites acreage with a long-term goal of restoration of natural communities by a 75 percent or more sustained reduction of phragmites acreage in treated sites.
- Create a lead contact person and coordinator for phragmites in each state within the region.

Purple loosestrife (Lythrum salicaria)

- Achieve no net gain of purple loosestrife and maintain native diversity.
- Conduct a risk assessment for purple loosestrife in the region, then develop protocols for limiting purple loosestrife spread and rank the most important sites for control.
- Develop a regional coordination framework for purple loosestrife that includes a region wide clearinghouse for outreach, mapping, and control, thereby reducing unnecessary duplication.

Water chestnut (Trapa natans)

- Commit to eradication of water chestnut outbreaks.
- Encourage strong public participation and increase public awareness of the problem.
- Designate water chestnut as a noxious weed.

Mute swan (Cygnus olor)

- Increase public education and outreach concerning mute swan management.
- Strengthen regional coordination on management strategies and implementation plans.
- Support research to increase understanding of mute swan migration, population dynamics and their effect on Bay ecosystem dynamics.

Nutria (Myocastor coypus)

- Base Chesapeake Bay regional nutria management on the *Nutria Control/Marsh Restoration Partnership* program.
- Develop regional coordination.
- Monitor species occurrence with special attention to expansion of the range of the Blackwater and/or Virginia populations.
- Develop an outreach program to explain risks from nutria and enfranchise relevant stakeholders in the control effort.

Zebra mussel (Dreissena polymorpha)

- Eradicate zebra mussel population in Eaton Brook Reservoir, New York.
- Develop and apply a rapid response model to control the zebra mussel population in Eaton Brook Reservoir.
- Establish zebra mussel monitoring stations in the Bay watershed.
- Develop website reporting for zebra mussel sightings.

While each management plan may be unique, the breakout groups identified recurring issues fundamental to the effective management of invasive species within the Chesapeake Bay watershed. Of particular note were the following:

- Improve agency communication about invasive species in the Bay, particularly between the states.
- Improve public education and outreach on invasive species.
- Expand invasive species monitoring efforts and encourage broad participation by numerous interested parties in a monitoring network.
- Expand individual species management to include multiple species approaches as a mechanism to improve coordination, effectiveness and wise use of resources.

The participants strongly supported the need for better communication across jurisdictions and further engagement of the public in the problem of invasive species. The workshop consensus was that coupling regional cooperation and coordination with a multiple invasive species approach would be the most effective approach to cost-effectively manage these species. Participants agreed that raising public awareness, building consensus, reexamining existing regulations, and furthering participation with industry were key to minimizing the effects of invasive species on the Bay.

The six draft invasive species management frameworks detailed in this report capitalized on the existing regional management structure guiding restoration of the Chesapeake Bay. Using this effective structure, the Chesapeake Bay community created yet another opportunity to take a national leadership role by concurrently addressing multiple invasive species while developing regional management strategies. The frameworks developed at this workshop provide the foundation on which to construct workable invasive species management plans that can be realistically implemented by each jurisdiction. The ultimate success of this workshop will be measured by the ability of the Chesapeake Bay region to effectively manage these six priority species and, in a broader context, to use the findings from this workshop as a model for organizing proactive responses when new invasive species emerge in the future.

WORKSHOP BACKGROUND

Introduction

Determining when a species is “invasive” to a particular ecosystem is a challenge for both scientists and managers because plants and animals move across the globe as part of a natural dispersal process. Often the designation of a species as invasive is linked to the emergence of economic and ecological problems associated with that species. In the Chesapeake Bay region, a number of invasive species are thought to cause serious problems.

The Chesapeake 2000 Agreement calls for the identification of such problem invasives in the Bay and the development of control plans for these species. The Agreement also calls for the development and implementation of management plans for species deemed problematic to the restoration and integrity of the Bay’s ecosystem. In September 2001, the Invasive Species Workgroup of the Chesapeake Bay Program (ISW), in coordination with jurisdictions in the watershed and others with interests in the Chesapeake Bay region, identified six key species that are causing, or have the potential to cause, significant degradation to the Bay’s aquatic ecosystem and may be economically costly. The six species are:

- Phragmites (*Phragmites australis*)
- Purple loosestrife (*Lythrum salicaria*)
- Water chestnut (*Trapa natans*)
- Mute swan (*Cygnus olor*)
- Nutria (*Myocastor coypus*)
- Zebra mussel (*Dreissena polymorpha*)

In order to further the goals of the Chesapeake 2000 Agreement, the ISW sought to provide a forum where diverse stakeholder interests could come together and develop regional management strategies for each species. This workshop, which was held in Baltimore, Maryland, May 7 - 8, 2002 provided a forum to produce consensus frameworks for advancing the implementation of regional management plans for the six priority species. Six breakout groups, each of which included participants from state and federal agencies, universities and private organizations, identified key issues and potential strategies for each species. The workshop provided an important opportunity to move forward toward meeting the invasive species goal of the Chesapeake 2000 Agreement.

Basis for Selection of the Six Workshop Target Species

In Spring 2001 the Chesapeake Bay Program’s Invasive Species Workgroup began work to meet the *Chesapeake 2000 goal of identifying and ranking non-native, aquatic and terrestrial species which are causing or have the potential to cause significant negative impacts to the Bay’s aquatic ecosystem*. The workgroup developed a questionnaire that was to elicit from the Chesapeake Bay Program partners, the U.S. Fish and Wildlife, National Park Service and U.S. Geological Survey, a consensus list of the top five aquatic nuisance species presently affecting their jurisdiction and the top five nuisance species expected to enter and adversely affect their jurisdiction.

The criteria requires that each species should have the potential to:

- Have an ecological or economic impact on the health of the Bay by impacting rare habitats or “natural areas,” or native species’ habitat such as marsh or other wetland or riparian habitats AND commercial fisheries, industries, outdoor recreation, or other revenue generating activities that support your state.
- Have political significance, with management of the species impacting vocal and/or conflicting constituency groups like commercial seed producers or plant nurseries, the pet or fish bait industry, animal welfare, sportsmen, outdoor recreationers, commercial fishermen, farmers, or other constituents who may oppose or support certain management approaches.
- Have human health significance by being vectors of disease organisms affecting humans.

Upon receiving and tabulating the species from the survey, the workgroup further discussed each one in the context of its potential or documented impacts on the Chesapeake Bay ecosystem and the level of support that each jurisdiction was willing and able to provide toward joint management plans or risk analyses. A further consideration was whether a given species was having a negative impact on specific Chesapeake 2000 Agreement goals, such as restoration of fisheries and submerged aquatic vegetation or out-competing native or protected species. With these considerations in mind, the ISW categorized the species into four groups. Table 1 summarizes the results of the survey and the species groupings. Genus and species names for these species are listed in Appendix II of this report.

Table 1. Priority Invasive Species*

Current Invasive Species	Signatory Jurisdictions				Non-Signatory Jurisdictions				Federal Agencies			Group
	DC	MD	PA	VA	CBC	DE	NY	WV	USFWS	USGS	NPS	
Asian Long-Horn Beetle	-	3	-	-	-	-	-	-	-	-	-	c
Asian Swamp Eel	-	-	-	3	-	-	-	-	-	-	-	d
Asiatic Clam, <i>Corbicula</i>	1	-	1	1	1	1	-	-	-	-	-	b
Blue Catfish	-	2	-	1	-	-	-	-	-	-	-	b
Brazilian Elodea	-	-	-	-	-	-	3	-	-	-	-	d
Cabomba	-	-	-	-	-	1	-	-	-	-	-	d
Canada Goose	2	-	-	2	-	-	-	-	-	-	-	-
Chinese Mitten Crab	-	-	-	-	-	-	-	-	-	-	-	d
Eurasian River Ruffe	-	-	3	-	-	-	3	-	-	-	-	d
Eurasian Watermilfoil	-	-	-	-	-	-	1	-	-	-	-	d
European Starling	-	-	2	-	-	-	-	-	-	-	-	-
Flathead Catfish	-	-	-	2	-	-	-	-	-	-	-	d
Garlic Mustard	-	-	-	-	-	-	-	-	-	1	-	-
Giant Salvinia	-	-	-	3	-	-	-	-	-	-	-	d
Grass Carp	-	3	-	3	-	-	-	-	-	1	-	d
Green Crab	-	1	-	-	-	-	-	-	1	-	-	b
Gypsy Moth	-	-	2	-	-	-	-	-	-	-	-	c
House Mouse	-	-	2	-	-	-	-	-	-	-	-	-
House Sparrow	-	-	2	-	-	-	-	-	-	-	-	-
Hydrilla	1	-	3	1	-	1	3	-	-	-	-	b
Japanese Honeysuckle	-	-	2	-	-	-	-	-	-	-	-	c
Japanese Knotweed	-	-	2	-	-	-	-	-	-	-	-	c
Japanese Shore Crab	-	3	-	-	-	2	-	-	1	-	-	b

Japanese Stiltgrass	-	-	-	-	-	-	-	-	-	1	-	c
<i>Microstegium</i>	-	-	-	-	-	-	-	-	-	-	-	c
Mile-a-Minute Weed	-	-	2	-	-	-	-	-	-	-	-	c
Morrow's Honeysuckle	-	-	2	-	-	-	-	-	-	-	-	c
Multiflora Rose	-	-	2	-	-	-	-	-	-	-	-	c
Mute Swan	-	1	2	3	1	-	-	-	1	-	-	a
Norway Rat	-	-	2	-	-	-	-	-	-	-	-	-
Nutria	-	1	-	2	-	1	-	-	1	1	-	a
Oriental Bittersweet	-	-	2	-	-	-	-	-	-	-	-	c
Phragmites	1	1	2	1	1	2	-	-	1	1	-	a
Purple Loosestrife	1	2	1	1	1	1	1	-	1	-	-	a
Quagga Mussel	-	-	3	-	-	-	-	-	-	-	-	d
Rapa Whelk	3	-	3	-	3	-	-	-	2	-	-	b
Round Goby	-	-	3	-	-	-	-	-	-	-	-	d
Sea Lamprey	-	-	-	-	-	-	1	-	-	-	-	-
Suminoe Oyster, <i>Crassostrea ariakensis</i>	-	3	-	-	-	-	-	-	-	-	-	b
Tree-of-Heaven	-	-	1	-	-	-	-	-	-	-	-	c
Water Chestnut	-	1	-	-	-	3	1	-	-	-	-	a
West Nile Virus and Tiger Mosquito	3	-	-	3	1	-	-	-	-	-	-	-
Woolly Adelgid	-	-	2	-	-	-	-	-	-	-	-	c
Zebra Mussel	-	3	1	3	-	3	1	-	-	-	-	a

This table is adapted from the ISW list developed September 10, 2001

*Priority Invasive Species are species that have been documented or are believed to have the greatest ecological or economic impact on the water quality or environmental health of the Bay or tributary and have the greatest political significance, i.e., management of the species impacted by vocal and/or conflicting constituency groups. (As of September 2001 West Virginia and the National Park Service had not yet completed the survey.)

Table Key:

Jurisdiction Ranking

1 - Ranked in the top 5 by the jurisdiction or federal agency.

2 - Identified as a priority by the jurisdiction or state agency, but was not in the top 5.

3 - Identified as a potential threat.

ISW Groups

a-Species for which management plans will be written.

b-Species for which risk assessments will be conducted.

c-Species for which gap analysis will be conducted.

d-Species for which status and management will be assessed.

Those species identified as a top priority by two or more signatory jurisdictions were selected for management plans; one exception is Asian clam (*Corbicula*), which the ISW agreed to place on a risk assessment list (low priority) as it is established in the Bay and management or removal may be unrealistic.

After completing this ranking exercise, the Chesapeake Bay Program, through the ISW joined Maryland Sea Grant College to sponsor a workshop aimed at developing regional invasive species management strategies. The six species selected for this workshop cover an important spectrum of invasive problems for the region. The species range from intentional to unintentional introductions and from highly established to intermittent populations. Management objectives could vary from eradication to control to prevention, depending on the species selected. By choosing a diverse set of plant and animal species, the ISW hoped to explore the broad range of management options that might be called on to deal with other invasive species in the future.

WORKSHOP PROGRAM

Design

The two-day workshop consisted of a series of plenary talks on policy, science and management strategies, species-specific presentations and facilitated breakout sessions that were designed to engage participants and build consensus on target issues. The plenary talks, species presentations, and a draft guidance on developing management frameworks provided a starting point for the breakout sessions whose task was to produce draft frameworks and timelines for the six species management strategies. All participants received a comprehensive workbook at the meeting, which provided an extensive background on each species, as well as, information about the workshop and strategies for developing draft management plans in the breakout sessions. The species explanations from the briefing book are provided in this report as species summaries in each draft management plan. The workshop briefing book is available on the Maryland Sea Grant web site at: www.mdsg.umd.edu/exotics/workshop/.

The first day's presentations provided participants with a common foundation of knowledge on ecological, management and economic aspects of non-native species; the aim was to further the participants' understanding of the complexities of developing regionally-based, management strategies for non-indigenous species in the Bay. Specifically, workshop plenary speakers discussed important components of invasive species management strategies, including economics, regulatory and legislative mandates, public participation, bioinvasion complexity, and scientific uncertainty. In addition, there were presentations about the occurrence, problems and existing management actions for the six invasive species of concern. Table 2 provides a list of plenary speakers, their affiliations and the titles of their talks.

Table 2. Workshop speakers, topic of their talk and affiliation.

PLENARY SPEAKERS		
SPEAKER	TOPIC	AFFILIATION
Jason Shogren	Integrating economics and invasive species management	University of Wyoming
Bill Matuszeski	Lessons learned about developing management plans for the Chesapeake Bay	Former Director EPA CB Program
Katherine Glassner-Shwayder	A model for consensus building to advance regional policy on invasive species	Great Lakes Commission
David Lodge	Risks, uncertainties and values in prevention and management of nonindigenous species	University of Notre Dame
Bernd Blossey	Developing control strategies for invasive plants	Cornell University
SPECIES SPECIFIC SPEAKERS		
Curtis Hutto	Phragmites (<i>Phragmites australis</i>)	VA Dept Conser. Rec.
Steve Capel	Purple loosestrife (<i>Lythrum salicaria</i>)	VA Dept Game Inland Fish
Mike Naylor	Water chestnut (<i>Trapa natans</i>)	MD Dept Nat. Resources
Larry Hindman	Mute swan (<i>Cygnus olor</i>)	MD Dept Nat. Resources
Steve Kendrot	Nutria (<i>Myocastor coypus</i>)	USDA-APHIS-WS
Tom Horvath	Zebra mussel (<i>Dreissena polymorpha</i>)	SUNY at Oneonta

Breakout sessions were held on both days of the workshop. The breakout sessions met at the end of the first day for preliminary discussions on key issues and goals of a management plan for their particular species and to plan their work for the next day.

The second day was spent developing draft invasive species management strategies through a combination of breakout and plenary sessions. Each breakout sessions had a facilitator, a rapporteur and 6 to 13 participants. All breakout sessions attempted to reach consensus on the goals and key issues for their species and, where possible, to develop a draft implementation table for a management strategy. The participants from all breakout groups reconvened in plenary sessions twice during the second day. These proved to be highly successful venues because it provided opportunities for exchange of ideas and a comparison of the directions the different groups were going.

Plenary Discussion: Key Issues

Five issues were identified as critical components in the development of draft invasive species management plans. These issues are summarized below. The remainder of this report discusses the process used to develop the six draft species-specific management plans and presents the draft plans.

Prevention, early detection and rapid response

Although the emphasis of the workshop was on management of invasive species currently causing problems within the Bay watershed, the participants agreed that a successful invasive species strategy must emphasize prevention, detection and rapid response. Participants noted that many of the current problems might have been avoided had pathways of introduction or the ability to quickly eradicate newly detected invasions been a policy priority in the past. The recent introduction of zebra mussels into a reservoir in New York State, which falls within the Chesapeake Bay watershed, became a major topic of discussion by participants who were interested in using this invasion as a “test case” for prevention and rapid response to new invasions to the watershed.

Economics

Because invasive species are often defined by the economic damage they cause, there was considerable discussion about the importance of including economic interests in the development of management strategies. One speaker emphasized that cost-benefit analyses and economic “feedback” must integrate with the costs associated with “human dimension values”. Coupled to the economic issues were legal issues, concerns associated with public-private land issues and compatible legislation and regulation across jurisdictions within the Bay region.

Cooperation and coordination

Considerable discussion focused on organizational framework and covered issues ranging from increased cooperation and coordination with national invasive species process, such as the Aquatic Nuisance Species Task Force, to local concerns about defining a clear process for distributing information and receiving input from all concerned parties. Many participants felt that coordination and improved communication across local, regional and national programs were critical to implementing effective regional invasive species management plans. In general, participants felt that the Chesapeake Bay program had a critical role to play in this, but that individual jurisdictions must provide leadership.

Education and outreach

Throughout the workshop, participants encouraged an emphasis on education and outreach. There was a consensus that the public was not as well informed on this issue and that invasive species management would only be effective if the public's awareness of invasive species was increased. Participants discussed mechanisms to improve outreach to user groups, such as gardeners, aquarists, and pet owners who deal with live plants and animals, to increase awareness about invasive species. Workshop attendees encouraged the development of a strong communication component within any management strategy.

Research and scientific uncertainty

The issue of scientific uncertainty was raised repeatedly during the workshop. It was noted that a poor understanding of an invasive species could lead to mismanagement of the species. Participants supported an active role for both monitoring and research in invasive species in the development of management plans. In particular, one speaker advocated adapting ecological models in order to forecast possible risks of invasion from species not yet introduced. Participants consider it important for management to emphasize prevention and opportunities for eradication of species beyond just those six species discussed at the workshop.

DRAFT MANAGEMENT PLANS

Introduction

On Day 1, all workshop attendees received a regional species management strategy framework, a mock management strategy implementation table and a list of the participants in their breakout session developed by the workshop steering committee. These materials were consistent with other recent invasive species management plan frameworks and were intended to provide guidance, if needed, to the participants in developing their management strategies. A copy of the guidance document is attached in Appendix III.

On Day 2, participants divided into the six breakout sessions, with a goal to develop a regional management strategy for each of the six species. Each group was encouraged to discuss and identify species-specific goals and problems. Day 2 included a morning breakout session, a plenary for presentations by each group on progress thus far, afternoon breakout session and a plenary for final reporting on each species. The progress reports in the first plenary were valuable in that they helped catalyze ideas and approaches for the afternoon breakouts.

Adhering to the mandate of developing a consensus framework for a species-specific invasive species management strategy, each breakout session completed a list of actions needed for developing and implementing a species management plan and a draft implementation timetable. In addition, each breakout session reported on specific goals and key issues that were central to their discussions during the day.

The draft management plans that emerged from each breakout session are summarized below. Each plan opens with background information on the species. It is followed by an explanatory text for the management action items in the implementation timetable that follows. The final section describes key goals or issues considered fundamental to developing and implementing species-specific, regional management strategies. Some key issues were a recurring theme across breakout sessions; these are discussed and highlighted at the beginning of this report.

DRAFT MANAGEMENT PLAN

PHRAGMITES AUSTRALIS **(COMMON REED)**

BREAKOUT SESSION PARTICIPANTS

Facilitator

Kirk Havens

Virginia Institute of Marine Science

Rapporteur

Dick Hammerschlag

USGS Patuxent Wildlife Research Center

Participants

Chris Firestone

DCNR, Bureau of Forestry

Curtis Hutto

Virginia Department of Conservation and Recreation

Lisa Jameson

National Park Service

John Miele

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David Norris

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Donald Webster

Maryland Department of Natural Resources

Kirk Mantay

RKK Engineers

Don Robbins

Maryland Department of Agriculture

DRAFT MANAGEMENT PLAN

PHRAGMITES AUSTRALIS **(COMMON REED)**

SPECIES SUMMARY

Description

Phragmites australis, (Cav.) Trin. Ex Steudel (Poaceae) or Common Reed, is a perennial, coarse wetland plant that can be described as having erect culms 2-4 m tall, occasionally up to 6 m; stout, creeping rhizomes, often also with stolons (length: <1m to ≥ 10 m); leaf-blades broad, flat, 1.5-6 dm long, 1-6 cm broad, glabrous, green or glaucous, the sheaths overlapping; panicle tawny or purplish, 15-40 cm long, the branches ascending, rather densely flowered; spikelets 10-17 mm long, the florets exceeded by the hairs of the rachilla; first glume 2.5–5 mm long; second glume 5.7 mm long; lemmas glabrous, sharp-pointed, not bifid, with long hairs confined to rachilla joints; lowest floret staminate” (Purdue 1998 after Duke 1983).

Its feathery and drooping inflorescences (clusters of tiny flowers) are purplish when flowering and turn whitish, grayish or brownish in fruit. Flowering occurs from July to October. The stalks are characteristically tough.

Recent work (Saltonstall 2002) has begun to distinguish the presence in North America of both native North American haplotypes and European haplotypes of *P. australis*. Blossey (2002a) suggests the possibility that these native and introduced *P. australis* may have distinctive morphologic characteristics; these issues are discussed in more detail below. *P. australis* is commonly referred to as phragmites.

Ecology

Phragmites is a cosmopolitan plant, occurring throughout temperate North America. Duke (1978; 1979) describes suitable phragmites habitat as

Ranging from Cool Temperate Steppe to Wet through Tropical Desert to Moist Forest Life Zones, reed is reported to tolerate annual precipitation of 3.1 to 24.1 dm (mean of 16 cases = 9.8) annual temperature of 6.6 to 26.6°C (mean of 16 cases = 14.8) and pH of 4.8 to 8.2 (mean of 12 cases = 6.2).

The common reed occurs in and near fresh to brackish wetlands, tolerates and even thrives in alkaline and acidic wetlands, with some populations tolerating salinities as high as 40 ppt (Marks et al. 1994). Phragmites is a highly successful colonizer in that it propagates in several ways, by seed dispersion and rhizomes and stolon fragments. Marks et al. (1994) suggest that established stands of phragmites propagate primarily through vegetative reproduction.

Individual rhizomes live for 3 to 6 years and buds develop at the base of the vertical rhizome 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 that in turn produces buds that will form more vertical rhizomes. Vertical rhizomes also produce horizontal rhizome buds, completing the vegetative cycle (Marks et al. 1994).

Temperature, salinity and water levels affect seed germination. Marks et al. (1994) report that water depths of more than 5 cm and salinities above 20 ppt prevent germination and germination improves as salinity decreases. Germination is unaffected by salinities below 10 ppt. Germination success increases with increasing temperature from 16 to 25°C, while the time required for germination decreases from 25 to 10 days over the same temperature range.

Phragmites colonization is commonly associated with disturbed marsh areas, which usually means areas where plant communities, hydrology and topography have been altered through natural events (e.g., storms, lightning strike fires) or anthropogenic events (e.g., logging, mining, waste disposal, intentional flooding, dredge spoils disposal). The plant can tolerate standing water, low oxygen levels and acidic sediments, which allow it to thrive in disturbed habitats often unsuitable for other plants (Marks et al. 1994; Bart and Hartman 2000). Numerous studies report on changes in disturbed marsh hydrology with the development of phragmites stands (see Marks et al. 1994; Chambers et al. 2002). Other researchers (Ailstock 2001; Bart and Hartman 2000; Burdick and Konisky 2002) suggest that phragmites has been successful in establishing itself, in part, because of an ability to modify disturbed habitats into conditions highly conducive to its further propagation and establishment.

Introduction History

Paleoecology studies of peat samples show that phragmites has grown in New England tidal wetlands for at least the last 3,000 years (Orson 1987). Many researchers (Blossey 2002a; Norris et al. 2002; Rice et al. 2000) note that during the 1900s in parts of North America, phragmites rapidly expanded its range and successfully invaded fresh and brackish wetlands, substantially altering the landscape of the coupled marsh-estuary system (Lathrop et al. 2002). Although there is ongoing debate and research to understand the apparently recent invasiveness of this species, many concur with the view of Marks et al. (1994) and Roman et al. (1984) that this population expansion may be partially driven by human activities that have led to habitat destruction, sedimentation, eutrophication, and decreased oxygen levels in water and sediments in marsh areas. Recently, concern has also been growing that the use of constructed wetlands to replace natural wetlands (lost to development) may compromise the function and value of the wetland ecosystem because constructed wetlands are susceptible to invasion by phragmites (Havens 2000; Havens 2002).

Concurrent with the observed expansion of phragmites, there has been discussion that the invasiveness of phragmites in North America over the last century may be attributable to the introduction of more aggressive European genotypes (Blossey 2002b; NJMSC 2002). Questions over this issue prompted genomic research to determine whether there were differences in genotype among stands of North American phragmites. Saltonstall (2002) recently reported the present-day existence of native North American haplotypes (lineages) and of introduced

European haplotypes in North American stands of phragmites. These findings are summarized by Blossey (2002a) and reported here.

A total of 27 haplotypes were identified of which 11 (A-H, S, Z, AA) are native to North America (Saltonstall 2001). Within the North American populations, a continuum of geographic substructuring exists for the native haplotypes. Types AA, F, Z and S are known historically from the Northeast; types E, G, and H are found throughout the Midwest and types A-D are found in the South and Intermountain West only. Two haplotypes show worldwide distribution with M as the most common type in North America, Europe and Asia. Type I is found along the Gulf Coast and also occurs in South America and Asia (for more details see Saltonstall 2001). Comparing the genetic structuring of present-day populations with those available in herbarium specimens collected prior to 1910 reveals significant changes in haplotype frequencies in North America. While the herbarium samples show a widespread distribution of native haplotypes across North America, modern populations show a striking range expansion of the M haplotype (for more details see Saltonstall 2001b). Type M has entirely replaced native types in New England and expanded to the southeast where no historic phragmites populations were known to occur. Type M (which is most closely related to other European types) has spread to the West and is also becoming prevalent in the Midwest. It is likely that the introduction of type M material has occurred sometime in the early part of the 19th century, probably at several Atlantic coast ports. Over the last 150 years, among-population variation in North America has declined significantly and today the genetic structure of North American populations resembles that of Europe.

Current research (Blossey per. comm.) is investigating whether the native and non-native genotypes are morphologically distinctive. These findings may further our understanding of the occurrence, colonization and expansion of phragmites in North America and the broader issue of what role genomic differences within species may play in species invasiveness.

Distribution in the Chesapeake Bay Watershed

Appendix I includes a distribution map of reported occurrences of phragmites in the Chesapeake Bay watershed, though there has not been a comprehensive mapping of the entire watershed for the presence of phragmites.

Maryland

Phragmites is now the dominant macrophyte in a wide variety of intertidal environments in the Chesapeake Bay (Stevenson and Rooth 2002) and in freshwater nontidal wetlands (Ailstock et al. 2001). The species is not on the Maryland noxious weed list (Bean pers. comm.). U. S. Fish and Wildlife Service (USFWS) aerial surveys over tidal marshes in Maryland and Virginia from 1995 to 1997 detected 8,500 acres of phragmites in 4,138 sightings in Maryland's wetlands along the Chesapeake Bay. The largest patches of phragmites occur in dredge spoil areas. The greatest extent of phragmites in natural marshes was in the lower Eastern Shore from the Nanticoke River south to the Pocomoke River, the northern Eastern Bay and Chester River area, Baltimore Harbor, C&D Canal, and Aberdeen Proving Grounds (Forsell and Gerlich 2000).

Pennsylvania

The distribution map indicates areas where phragmites is reported in Pennsylvania (Appendix I). Highest concentrations occur in the southeast corner of the state along the Delaware estuary system.

Virginia

Occurrence of phragmites is widespread in eastern Virginia and in some areas of western Virginia. A 1995 to 1997 aerial survey found over 1,700 acres of phragmites in more than 1,500 sightings in Virginia's wetlands along the Chesapeake Bay (Forsell and Gerlich 2000). These data show the largest patches of phragmites are located in or near dredge spoil areas and highly disturbed marshes. Areas with the greatest extent of phragmites in natural marshes were the upper Eastern Shore south of the Pocomoke River, on the lower James River, marshes near Tappahannock and the lower Pamunkey River (Forsell and Gerlich 2000). In 1995, the Nature Conservancy and the (USFWS) conducted an aerial survey to map phragmites in the interior of the barrier islands and along the mainland upland/salt marsh ecozone from Assawoman Creek south to the mouth of the Chesapeake Bay (Truitt 1996).

Overview of Management Efforts

Many jurisdictions in the United States are concerned about the rapid invasion of phragmites and the threat it may pose to biodiversity and ecosystem function. The reed can be considered a noxious weed and management of it is often aggressive. Several studies (Warren et al. 2001; Meyerson et al. 2000; Chambers et al 1999) report that stands of phragmites are not conducive to the establishment of other plant species and that colonization of disturbed wetland areas by phragmites usually ensures the development of a phragmites monoculture stand. Beyond this common lack of plant species diversity in phragmites-dominated wetlands, other aspects of ecological change are less clear, which suggest considerable differences may exist between phragmites colonies throughout the U.S. eastern seaboard.

Some researchers (Chambers et al. 1999; Osgood et al. 2002) report that phragmites invasion of tidal freshwater wetlands results in a reduction in insect, avian and other animal assemblages; however, other researchers found little or no difference in macroinvertebrate populations and mummichog foraging between phragmites marsh and nearby marsh not invaded by this reed (Fell et al. 1998). In addition, Parsons (2002) found that phragmites provided critical habitat for nesting wading birds in Delaware Bay. Able and Turner (2002) suggest any future faunal work should consider the status (variables such as spatial variation, tidal range, elevation, history of disturbance, etc.) and chronology of the phragmites invasion and control for these variables in studies and when making management decisions. Because of differences in scientific findings, some researchers (e.g., Campana and Perry 2000; Rooth and Stevenson 2002) argue that phragmites can be critical for armoring shoreline against erosion and may increase freshwater marsh accretion; their argument suggests the potential importance of these needs for management of marsh landscapes.

Given these scientific uncertainties, valuable research efforts could focus on the ecological benefits and losses associated with phragmites and the appropriate criteria to use when developing management strategies for phragmites wetlands. Two recent symposia focused on science and management strategies for phragmites (VDCR 2000; NJMSC 2002). Presentations and discussions at these meetings suggest the importance of considering adaptive management

strategies for phragmites. At NJMSC (2002), the recent identification of native and non-native genotypes and the potential for differences in their invasiveness (Blossey 2002a, 2002b; Saltonstall 2002) was discussed with regard to phragmites management. It was noted at the meeting that management options might vary depending on the lineage of a particular stand of phragmites as well as its setting and invasion history. Morphologic differences (if confirmed) and invasive behavior differences between genotypes could be further important factors to consider when developing phragmites management decision strategies.

Control and Eradication of *Phragmites*

A technical report “*A summary of methods for controlling Phragmites australis*” by Norris et al. (2002) provides a review of current control methods for phragmites. This report is available from the Wetlands Program, School of Marine Science, Virginia Institute of Marine Science.. Additional control methods are discussed at the web site www.invasiveplants.net.

Management Efforts within the Chesapeake Bay Watershed

Maryland

Maryland initiated a phragmites chemical (Rodeo) control program in 1995 with state landowners. As part of a legislatively mandated program, landowners who have substantial stands of phragmites that are deemed to significantly threaten the preservation of valuable wildlife habitat are allowed to control phragmites on their own property (Maryland General Assembly, SB65 1996). Maryland offers landowners a 50 percent cost share and coordinates the program through the Department of Natural Resources in cooperation with the Maryland Department of the Environment. In 1999, over 200 landowners participated in the program. Landowners cannot receive more than \$12,000/year and DNR cannot spend more than \$60/acre on control (Maryland General Assembly, SB65, HB 535). The mandating legislation, SB65, has no appropriation so, in 2001, funds were provided by MDE (\$10,000) and the Governor’s Office (\$25,000 allocated to be spent over two years). These funds provided support for control of about 400 acres of phragmites on private lands in Dorchester, Worcester, Somerset and Wicomico Counties (Hindman pers. comm.; MDDNR 2002). A Landowner’s Guide is distributed by the Maryland DNR to encourage participation in the program (www.dnr.state.me.us/wildlife/phrag.html).

Maryland DNR also applied herbicide (Rodeo) by helicopter to 400 acres of phragmites on state-owned Wildlife Management Areas on the Eastern Shore during 2001 (Maryland DNR 2002). Phragmites management on public lands is supported by the Maryland Waterfowl Stamp Fund, about \$30,000 was spent on treatment in 2001.

Other work in Maryland on management of phragmites included a five-year study of the effects of chemical controls on phragmites and the abilities of the reed to propagate in disturbed and vegetated soils (Ailstock et al. 2001). The sites were located in Cecil County (upper Chesapeake Bay) and Dorchester County (lower eastern shore). The former site received chemical and burn treatments in 1987 and 1988. At the Dorchester County location, three sites — vegetated, burned and bare soil (with seeds added)—were studied. As with the studies discussed above, the effectiveness of the control program was ambiguous, leading the researchers to conclude, in part, that “control programs must be evaluated on an individual basis to achieve the goals of enhancing biodiversity” (Ailstock et al. 2002).

Maryland also has a demonstration area near Grasonville, Maryland, where phragmites is controlled and a wetland is being restored. The Department of Agriculture also does some phragmites control through a ditch spraying program (L. Hindman pers. comm.).

Pennsylvania

Efforts to control phragmites in Pennsylvania include work by the Pennsylvania State Parks to treat limited acreage with herbicide. On Presque Isle State Park in the Lake Erie area the State Parks department has an ongoing applied research program on control management strategies (John Miele pers. comm.). Phragmites is not on the Pennsylvania noxious weed list and thus not managed by the state's Department of Agriculture (Leo Dunn pers. comm.).

Virginia

In Virginia, phragmites is considered an invasive species and is on the Virginia Department of Conservation and Recreation's advisory list, which is a non-regulatory list. Phragmites received the highest "invasiveness" ranking on the list (VDCR 2001). Cooperative efforts through partnerships between the state agencies, federal agencies, academia, private landowners and non-governmental organizations have resulted in a number of phragmites control and management efforts in the coastal bay areas, including Parramore and Hog Island (Curtis Hutto pers. comm.). A control and restoration demonstration project on 600 acres of the Hog Island Wildlife Management Area by the Virginia Department of Game and Inland Fisheries reported phragmites reduction after two years of treatment; however, cessation of treatment resulted in phragmites recolonization within a year (Askins 2000).

Efforts primarily driven by the Rappahannock Phragmites Action Committee, a public-private coalition to raise awareness about phragmites, started a small, coordinated herbicide control spraying effort for private landowners in the Rappahannock area (Wellford 2000). This ongoing program is currently supported by the U.S. Fish and Wildlife Service (Curtis Hutto pers. comm.). Other efforts include a monitoring and control research program covering about 11 acres at the Dameron Marsh Natural Area Preserve in Northumberland County, Virginia. This program, started in 2000, is planned to run until 2004 and is funded through the Wetland Trust Fund (Curtis Hutto pers. comm.).

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Web Resources

The Nature Conservancy Elemental Stewardship Abstract for *Phragmites australis* Common Reed.

<http://tncweeds.ucdavis.edu/esadocs/documents/phraaus.html>

Phragmites australis (Cav.) Trin. ex Steud

http://www.hort.purdue.edu/newcrop/duke_energy/phragmites_australis.html

Phragmites: Common Reed

<http://www.invasiveplants.net/phragmites/work/natint.html>

PHRAGMITES AUSTRALIS **(COMMON REED)**

EXPLANATORY TEXT FOR THE IMPLEMENTATION TABLE

Goal

No net gain in phragmites acreage with a long-term goal of restoration of natural communities by a 75 percent or more sustained reduction of phragmites acreage in treated sites.

Leadership, Coordination and Regulatory Authority

Phragmites “Coordinator” and National-Regional-State-Local Coordination

The participants were most concerned that there was a lack of general coordination with regard to management and understanding of phragmites locally, statewide, regionally and nationally. The group agreed that creating a single phragmites “Coordinator” for each state would improve management of phragmites. This “Coordinator” would be a focal point within a state for all action taken that might be relevant to the management of phragmites. This could include reviewing permits from numerous agencies concerning wetland construction, coordinating state control actions and coordinating with citizen groups. A phragmites “Coordinator” would also coordinate with other phragmites specialists within the region and nationally. It was not clear what statutory or regulatory authority this person might have, but it was agreed that simply having someone coordinate and disseminate information would be an improvement over the existing system which has little to no coordination across agencies and with other stakeholders. There was general agreement that the phragmites “Coordinator” position should be at the Secretary of Natural Resource level.

Heritage Ranking

Participants encouraged State and regional action to support the Virginia Heritage Program’s placement of native phragmites in its rare plant ranking system. In doing so, the Heritage program would have the mandate to conduct yearly surveys for native phragmites.

Prevention

Monitoring

The participants felt that monitoring existing stands for extent and rate of expansion of phragmites and documenting newly disturbed sites that could be susceptible to invasions by phragmites was a critical management component. This would also cover monitoring of constructed wetland sites to see if restoration sites as well as the construction sites themselves were invaded and responsible parties engaged to reestablish native communities on these wetland sites. The monitoring of these sites would help address the goal of no new phragmites sites.

Permitting Process

The participants encouraged all permitting processes to be linked to a phragmites “Coordinator” review and establish accountability across agencies to prevent the invasion of phragmites into new wetland areas. It was noted that across the region Transportation Departments and the Army Corps of Engineers are involved in permitting activities in wetlands that include earth moving, dredge disposal, and road construction. This breakout session thought the wetland permitting process should be reviewed and strengthened to ensure that mitigators were responsible for maintaining “phrag-free” areas after a project ended. Action such as this might considerably strengthen the region’s ability to limit areas of new phragmites growth.

Early Detection and Rapid Response

Early detection and rapid response were closely linked with monitoring and mapping. It was recognized that early detection, through a monitoring program, followed by prompt management action were critical in preventing phragmites spread into environmentally sensitive areas.

Control and Management

This component is the most important for phragmites and participants spent considerable time discussing different actions and how to prioritize actions.

Control strategies – biological, chemical, burn, checklist

Participants discussed in detail the different existing mechanisms for controlling phragmites spread. Chemical treatment dominated the preferred treatment approach, but the group recognized the need for research and monitoring over 5 – 10 years to determine the usefulness of these techniques in removing phragmites and to determine better control mechanisms. Burning was also a recommended technique, but only in conjunction with chemical treatment. It was noted that in many areas it is not logistically possible to burn, thus limiting the usefulness of this control strategy. Further research to investigate biological control mechanisms was encouraged. Recognizing the uncertainty surrounding effective control of phragmites, the participants thought a phragmites “Coordinator” could develop a “control checklist” and a ‘phragmites best management checklist’. The ‘control checklist’ would outline various control options and a ranking mechanism for determining what sites and what control measures would be considered. The phragmites ‘best management checklist’ would outline ‘best management practices’ for land disturbing activities to help prevent invasion of new areas by phragmites.

Also important to the participants was the recent work on genotyping of phragmites. The group strongly recommended that control efforts initially look to address areas where non-native haplotypes of phragmites occur, as a reasonable “first cut” for ranking phragmites stands to control. It was also noted in the discussions concerning control that perhaps some highly disturbed sites might best, at least temporarily, be left populated with phragmites.

Monitoring, research, mapping and inventory

Monitoring, research, mapping and inventory were the action items that the participants felt were seriously lacking from existing state and national actions. The need to monitor sites currently invaded and sites likely to be invaded was discussed under other components of the management plan and are relevant here also. Monitoring is an essential component to understanding this species and identifying key areas for prevention and control.

The participants noted that research was improving, citing, for example, several recent workshops on phragmites and publications. However, the group suggested more research would improve a manager's ability to understand issues critical to developing good adaptive management strategies for phragmites. Possible research efforts could include understanding the habitat value of phragmites stands, the role of phragmites for erosion protection, understanding dispersal mechanisms, new control mechanisms, investigating commercial uses, and determining areas where phragmites presence was advantageous.

Taking an inventory and mapping of phragmites sites was another dominant theme throughout this component. It was felt that an effective regional strategy would need to include a mapping program and a detailed inventory of the location and description of phragmites stands in the region. This could be accomplished through approaches such as, aerial and ground surveys, and multispectral, hyperspectral, and satellite imagery. It seemed possible that this effort could be coupled with other efforts in the States to develop detailed land cover and land use maps.

Communication and Information Access

Raise public awareness

The participants encouraged informing the public about the distinction between native and non-native phragmites and suggested public participation, through education and outreach, to help map and inventory these different genotypes. This could be developed into a school program and applied in particular in schools with access to wetlands. The participants also encouraged the Heritage program to rank native phragmites as a "species of concern" so that more attention might be directed at the differences between these two haplotypes.

Best Management Practices

Participants suggested developing a best management practices document for phragmites that could be web accessible for managers and the public.

***PHRAGMITES AUSTRALIS* (COMMON REED)**
IMPLEMENTATION TABLE: LEADERSHIP, COORDINATION AND REGULATORY AUTHORITY

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Phragmites Coordinator	On-going	\$100K/year/State	States, Chesapeake Bay Commission, Chesapeake Bay Program Executive Committee	State agencies, MD-DNR wetlands, Ag. Depts.	CBP
State Phragmites Coordinator Committee	On-going	Travel support for State Coordinators to meet	States, Chesapeake Bay Commission, Chesapeake Bay Program	State agencies Mid-Atlantic Invasive Species Council, CBC, CBP Executive Committee	CBP
National Coordination	Need to formalize over next 1-3 years		Federal agencies	CBP	Federal Agencies, ANSTF, Regional Panel, other states, NGOs.
Heritage Ranking	1 year	\$15K/year/State	State	Heritage Program	
Local Authority				County wetland board	

***PHRAGMITES AUSTRALIS* (COMMON REED)
IMPLEMENTATION TABLE: PREVENTION**

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Monitoring	On going	Low	State/Local	State/Local	
Permitting Process	On going	Low	State/Local	State/Local	DOT, US Army Corps.

***PHRAGMITES AUSTRALIS* (COMMON REED)
IMPLEMENTATION TABLE: EARLY DETECTION AND RESPONSE**

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
No action items were identified for this component					

***PHRAGMITES AUSTRALIS* (COMMON REED)**
IMPLEMENTATION TABLE: CONTROL AND MANAGEMENT

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Chemical	Yearly	\$100/acre	State	MD-DNR, Ag Dept. Other state agencies?	Private citizens
Biological	5 years	\$500K	Federal	Cornell, other academics	
Burn					
Control Checklist					
Monitor					
Research				Universities	
Inventory and Mapping					

***PHRAGMITES AUSTRALIS* (COMMON REED)**
IMPLEMENTATION TABLE: COMMUNICATION & INFORMATION ACCESS

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Raise public awareness	On-going	Low	Fed/State/Local	State/CBP	NGO's, extension agents, TNC, private citizens
Best Management Practices		Low		States	NGO's, academia

PHRAGMITES AUSTRALIS **(COMMON REED)**

KEY ISSUES

Key Issues

No Net Gain

No net gain in phragmites acreage with a long-term goal of restoration of natural communities by a 75 percent or more sustained reduction of phragmites acreage in treated sites.

Phragmites Coordinator

The participants agreed that for an effective management strategy to be implemented the Chesapeake Bay Program and the States should seriously consider creating a lead contact person and coordinator for phragmites in each state within the region. Such a person (phragmites “Coordinator”) could develop a priority list of problems, control triggers and actions to be taken by the implementing agencies. This person would work to ensure communication and coordination among the implementing agencies for a phragmites regional management strategy and should be at the Secretary of Natural Resource administrative level. It was emphatically noted that site restoration is an extremely important component of phragmites management coupled with treatment.

Other Discussion Points

Threats and Problems posed by Phragmites

The participants spent a considerable amount of time discussing what the problems with phragmites were and why control strategies might be determined necessary. The group developed a table of problems and threats that they felt were key to driving the need for a management strategy.

Threats	Problems
Monoculture – decreases biodiversity at different scales	Loss of habitat for waterfowl
Plugs drainage ways	Changes in community structure can modify initial habitat
Impact on RTE species diverse flora communities (freshwater ecozones), and conservation areas	Lack of good scientific data on wildlife use of phragmites stands
Can invade and dominate wetland sites constructed to offset losses through regulatory process. Potentially loss of overall wetland acreage and function	May become a fire hazard
	Alters viewsapes
	Alters roadway visibility – driving hazard
	Traps sediment, alters marsh elevation
	Alter local hydrology, such as tidal movement and flood flow

Control Triggers

Once the issues presented above were identified as the major reasons for considering phragmites as an unwanted invasive species, the participants considered under what conditions might a specific area of phragmites require control action to be taken. The group called these “Control Triggers” and developed a list of situations that might currently drive State agencies to take control action.

- Request by private landowner to remove species.
- Request by public agency (federal, state or local) to remove species.
- Political interests responding to constituencies may result in funds for control cost share or develop mandating legislation (though sometimes without an appropriation).
- Size and location of stand.
- Potential for expansion, seed source, “good neighbor” to prevent spread.
- Access and capacity to follow with a burn after spraying.
- May be an area for re-treatment.
- Potential for success, look for areas where likely that control will work and ecosystem will benefit.

By developing lists of threats, problems and control triggers participants were able to develop the key issues for a phragmites regional management strategy noted above.

PURPLE LOOSESTRIPE

DRAFT MANAGEMENT PLAN

LYTHRUM SALICARIA **(PURPLE LOOSESTRIFE)**

BREAKOUT SESSION PARTICIPANTS

Facilitator

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Participants

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Steve Capel	Virginia Department of Game and Inland Fisheries
Leo Dunn	Pennsylvania Department of Agriculture
Frank Fulgham	Virginia Invasive Species Council
Kevin Hefferman	Virginia Department of Conservation and Recreation
John Martin	Delaware Valley College
Will Mountain	Pennsylvania Department of Agriculture
Bob Trumbule	Maryland Department of Agriculture

DRAFT MANAGEMENT PLAN

LYTHRUM SALICARIA **(PURPLE LOOSESTRIFE)**

SPECIES SUMMARY

Description

Lythrum salicaria is an erect herbaceous perennial with a strong taproot. Height ranges from 0.5 to 2.5 m. Stems vary from glabrous (smooth, hairless) to pubescent (covered with fine hairs). Each root crown supports 30 to 50 stems. Leaves, arranged opposite or in whorls of 3, are lanceolate to oblong with cordate bases. The spike-like inflorescence is 10 to 40 cm in length; each flower has 5 to 7 petals. Floral masses are typically magenta, but white or pink flowers may also be observed. Flowering occurs from late June to early September in most areas (Thompson et al. 1987, Balogh 1985, Rawinski 1982, Gleason 1957, Fernald 1950).

Native to Europe, purple loosestrife is distributed in the temperate northern hemisphere (below 65°N), some subtropical climates and Australia. Populations of purple loosestrife have not been confirmed in South Africa or South America (Thompson et al. 1987).

Ecology

At maturity, seed production is estimated to be 2.7 million seeds per plant (Thompson et al. 1987). Weighing 0.05 to 0.06 g each, seeds are viable within 3 weeks of flowering. (McCaughey and Stephenson 2000, Shamsi and Whitehead 1974). Wind, mud, wildlife and human-associated transport are vectors of seed dispersal (Thompson et al. 1987, Shamsi and Whitehead 1974). However, wind probably plays a limited role in seed transport. Thompson et al. (1987) observed declines in seedling density within 10 m of the parent plant, and a tendency towards down slope versus downwind transport.

Optimal germination occurs between pH 4.0 to 9.1 at temperatures between 15 to 20°C. Moisture is considered to be the most important determinant of growth and reproduction, but germination occurs across a variety of substrate conditions (Thompson et al. 1987, Balogh 1985, Shamsi and Whitehead 1974). In a study of seedling recruitment of wetland plant species, water level gradients between -5 to 10 cm yielded no significant differences among the percent of seedling germination (Keddy and Ellis 1985). Established seedlings are also capable of surviving shallow (30 to 45 cm depth) flooding (Thompson and Stuckey 1980). Seedling densities may approach 10,000 to 20,000 plants/m²; growth rates may exceed 1cm/day (Thompson et al. 1987, Rawinski 1982). The duration between germination and flowering is 8 to 10 weeks (Rawinski 1982). Growth and development are nitrogen-limited; decreases in nitrogen increase shoot to root ratios (Shamsi and Whitehead 1977).

Purple loosestrife colonizes both brackish and freshwater habitats, spreading reproductively and vegetatively from lateral shoot meristems (Stevens et al. 1997,

Thompson et al. 1987). It commonly occurs with *Typha* sp., reed canary grass, sedges and rushes (Thompson et al. 1987). Although purple loosestrife primarily invades disturbed wetlands, it also becomes established among natural wetlands, wet meadows, swamps, riverbanks and edges of ponds and reservoirs (Rawinski 1982). While mammalian herbivores may prevent production of terminal inflorescence, formation of monospecific stands often occurs, due to a lack of native herbivores and host-specific pathogens (Rachich and Reader 1999, Hight 1990). Monospecific stands in the Northeast are capable of self-replacement for at least 20 years (Thompson et al. 1987).

Introduction History

A contaminant of European ship ballast, purple loosestrife was well established along New England coasts by the 1830s. *Lythrum salicaria* was also imported as a medicinal herb for the treatment of diarrhea, dysentery, bleeding, wounds, ulcers and sores (Malecki et al. 1993). Conversion of wetlands to agricultural lands and construction of canals for waterborne commerce facilitated the inland spread of *L. salicaria* (Thompson et al. 1987). Intentional introductions have also enabled purple loosestrife to achieve a broad distribution across the U.S. It was commonly planted in Virginia's English style gardens, and naturalization by beekeepers may have contributed to its westward spread (Thompson et al. 1987). The rate of distribution has increased exponentially since the 1880s, with a marked acceleration around 1940. In a survey of four northeastern and Midwest states, Thompson et al. (1987) estimated the rate of expansion in natural habitats to be 1,157 km²/yr between 1940 and 1980.

Seed mixes and commercial cultivars are another source of North American introductions. In a survey of commercial wildflower and native prairie seed mixes, 10% of the 25% of seed mixes containing non-native seed species also contained *L. salicaria* (Wade, as cited in Thompson et al. 1987). Pollen and seed from sterile cultivars may also contribute to the spread of purple loosestrife. When *L. virgatum*, commercially sold as "Morden Pink," was transplanted into wild stands of *L. salicaria*, Lindgren and Clay (1993) found evidence of cross-pollination. Using a tetrazolium test, 83% of the seeds collected from Morden Pink transplants were viable. Anderson and Ascher (1993) found similar evidence of cross-pollination among male and female loosestrife cultivars crossed with *L. salicaria*. Seed germination rates ranged from 30 to 100%.

Local nursery associations such as the Virginia Landscape and Nursery Association and the Maryland Nurserymen's Association do not advocate loosestrife varieties in their buyer's guides; however hybrids, cultivars and seeds continue to be commercially available on the Internet. Although European companies primarily advertise seeds, seedlings are available from nurseries outside the Chesapeake Bay region. (Surprisingly, one Virginia nursery recommended Morden Pink as a choice perennial for Washington gardens.)

Wetland disturbance increases susceptibility to purple loosestrife invasions. In a comparison of *L. salicaria* seedling germination among disturbed and undisturbed plots of *Phalaris arundinaceae*, Rachich et al. (1999) observed >50% establishment in disturbed plots. Seedlings did not become established in undisturbed plots of *P. arundinaceae*. Mixing of genotypes may also be a factor in the invasiveness of loosestrife across North America. Repeated ballast introductions originating from multiple European

ports combined with the cross-pollination of cultivars and wild species may have increased the adaptability of *L. salicaria* to differing climate and hydrologic regimes (Thompson et al. 1987).

In contrast to environmental disturbance and gene flow resulting from cross-pollination, flood tolerance is not a significant predictor of invasion. In a comparison of six *Lythraceae* species, increased plant height and development of an aerenchymatous phellem were consistent across all six species (Lempe et al. 2001). Morphological adaptations to flooding were not species-specific, which suggest that invasiveness is not attributed solely to flood tolerance in *L. salicaria*.

Distribution in the Chesapeake Bay Watershed

See Appendix I for a purple loosestrife distribution map.

Maryland

L. salicaria has been reported from 15 Maryland counties; 19 individual sites have been confirmed by the Department of Agriculture. In counties where purple loosestrife has been detected but sites not identified, reports were received from reliable sources, though they have not been verified with GPS or mapping (Dick Bean pers. comm.).

Pennsylvania

Purple loosestrife occurs throughout Pennsylvania, particularly in the Susquehanna River Basin and south central counties. Total acreage in Pennsylvania is unknown; however biological control has been implemented at 35 sites in 21 counties since 1991 (Will Mountain pers. comm.).

Virginia

Based on state herbarium records and field surveys, purple loosestrife has been identified at 25 sites statewide. Although present along Virginia's coastal plain, purple loosestrife is most abundant in Northern Virginia. While existing infestations appear to be expanding, few new introductions are occurring (Steve Capel pers. comm.). Purple loosestrife has not been recorded from National Wildlife Refuges in Virginia and Maryland (Jan Taylor pers. comm.).

Washington, D.C.

Purple loosestrife is present in freshwater tidal marshes along the Anacostia River watershed. While percent coverage has remained minimal (~5%) in Kenilworth Marsh, purple loosestrife is a dominant plant in a newly reconstructed wetland at Kingman Lake. Dominance at Kingman Lake may be due to the fact that resident geese foraging on marsh plantings do not target *L. salicaria* (Dick Hammerschlag pers. comm.).

Management Efforts within the Chesapeake Bay Watershed

Purple loosestrife, hybrids and cultivars are regulated as noxious weeds in Virginia (§3.1-296.11 et seq.) and Pennsylvania (3 P.S. 255.1 et seq.), but are not listed in Maryland (Dick Bean pers. comm.). The Virginia law declares it illegal to move, transport, deliver, ship or offer for shipment into the state. The Pennsylvania law prohibits sale, transport, planting and propagation. Although it is legal to sell *L. salicaria* in Maryland, individual

nurseries have voluntarily discontinued its sale as a potted plant (Dick Bean pers. comm.).

Maryland

Since 1999, the Maryland Department of Agriculture has been releasing and monitoring *Galerucella* species at several locations in Howard, Prince Georges and Caroline counties. The Department's nursery inspectors continue to educate industry members about potential impacts of the non-native plant (Dick Bean pers. comm.).

Pennsylvania

Since 1995, the Pennsylvania Dept of Agriculture and USDA/APHIS have released *Galerucella*, *Hylobius* and *Nanophyes* for biological control of purple loosestrife. Success is monitored each fall via a leaf damage survey. Between 1995-2001, USDA's biological control program in Pennsylvania cost approximately \$50,000 (Gary Clement pers. comm.). In a cooperative effort, the Pennsylvania Game Commission and Department of Agriculture are managing purple loosestrife infestations at Middle Creek Wildlife Management Area (Lancaster County). While *Galerucella* have been released, biological control has not been successful in eradication. Manual control was effective short-term, but too labor intensive. In contrast, herbicide application was successful on a small scale, and may be used more extensively in the future (Ian Gregg, pers. comm.) The Nature Conservancy is also managing for purple loosestrife at Valley Creek, Chester County (Betsy Lyman pers. comm.).

Virginia

The Virginia Native Plants Society and Department of Conservation and Recreation have sponsored educational programs and workshops. The education of nursery wholesalers was largely ineffective because of turnover in management/personnel (Steve Capel pers. comm.). Virginia has also implemented a *Galerucella* biological control program through the Virginia Polytechnic Institute's Entomology Department and USDA/APHIS. However, their program has not been as extensive as other states due to concern over host-specificity of non-native beetles/weevils on *Lythrum* species. Informally, float fishermen have voluntarily removed purple loosestrife from fishable rivers during its flowering season (Steve Capel pers. comm.).

Washington, D.C.

The National Park Service used a combination of biological and chemical control to treat two acres of purple loosestrife at Kenilworth Marsh, a freshwater tidal wetland in the Anacostia River watershed. *Galerucella* were released in 1996 and 1997, but did not overwinter successfully. Using the Blossey monitoring protocol, none of the beetles were observed the following spring. *Hylobius* inoculated plants were transplanted in Kenilworth Marsh in 1997, but again weevil populations did not become established. Rodeo applications were also ineffective. The estimated cost for treatment was \$40,000, about \$10,000 of which was supplies and materials. Despite the lack of success with biological and chemical control, percent cover has not increased significantly during the past eight years. The percent of purple loosestrife coverage remains about 5% (Dick Hammerschlag pers. comm.).

Current Research and Control Efforts

Prior to the discovery of biological control agents, existing control technologies (manual removal, water-level manipulation, burning and herbicide application) were ineffective in eradicating large areas of purple loosestrife infestation (Malecki et al. 1993). The cost, long-term maintenance, and non-target effects of these methods prompted the investigation of plant-herbivore interactions for weed control (Blossey, webpage). Bernd Blossey coordinates the biological control program for purple loosestrife at Cornell University. The goal is to achieve long-term control of *L. salicaria* infestations through the use of natural enemies. Four species of host-specific herbivores have been approved by USDA/APHIS for release in the U.S. to control purple loosestrife.

Two native European beetle species, *Galerucella californiensis* and *Galerucella pusilla*, were approved for release in 1992. Prior to their release, susceptibility of 50 native North American plants was examined. Only winged loosestrife (*Lythrum alatum*) and swamp loosestrife (*Decodon verticillatus*) were identified as potential hosts, and field experiments in Europe indicated preference for *L. salicaria* when available. Feeding on leaf, stem and bud tissues, *Galerucella* are host-specific herbivores for *L. salicaria* (Blossey et al. 1994). Leaf defoliation reduces aboveground biomass, and does not deplete carbohydrate reserves in root or crown tissue severely enough to yield plant mortality short-term (Katovich et al. 1999). However, leaf defoliation may decrease future seedbank replenishment. Plant defoliation as low as 10% reduces inflorescence length, number of flower buds and seed capsules (Katovich et al. 2001). Preferred release sites include areas where purple loosestrife is continuously distributed, and relatively free of standing water and shade. However, Landis and Klepinger (2000) observed slower rates of *Galerucella* colony establishment where water resources are scarce throughout the growing season.

Galerucella may provide a long-term solution upon establishment of beetle colonies. In a 5 to 10 acre site, colony establishment is expected to take 7 to 10 years (Weeden et al. webpage). Landis and Klepinger (2000) report 100% establishment at 23 sites within 2 to 6 years of *Galerucella* releases. However, *G. californiensis* was found to be more effective in establishing persistent populations than *G. pusilla*. Long-term monitoring at 5 sites between 1994 and 2000 indicated *L. salicaria* stem height was reduced 15 to 27%, percent coverage decreased 5 to 39%, and non-target species richness increased significantly. Although significant impacts were observed during the initial release phase, a period of 3 to 5 years was required to yield significant vegetation impacts (Landis and Klepinger 2000).

Recent research by Lindgren et al. (1999) indicates the potential for combining biological control with herbicide application to manage purple loosestrife infestations on short- and long-time scales. *Galerucella* exposure to 2 to 4% glyphosate ("Roundup") concentrations did not affect larval pupation, oviposition or adult survival.

The root-mining weevil *Hylobius transversovittatus* has also been approved as a biological control agent for purple loosestrife. Comparing the effects of root herbivory and plant competition during two growing seasons, Noetzold et al. (1998) found root herbivory to be more effective than plant competition at reducing height, biomass and inflorescence in established *L. salicaria* plants. As with *Galerucella*, *Hylobius*

transversovittatus will not be effective in shaded areas or standing water (Weeden et al. webpage).

A flower-feeding weevil, *Nanophyes marmoratus* has also been approved for introduction. This species was released in Pennsylvania in 1999 (Will Mountain pers. comm.). Although a related seed-feeding weevil, *N. brevis*, has been approved for introduction, it has not been introduced because of nematode infestations in Europe (Blossey webpage).

In addition, Nyvall and Hu (1997) identified three species of North American fungi as potential biocontrol agents in laboratory experiments. Spores of *Alternaria alternata*, *Botrytis cinerea* and *Phoma sorghina* applied to *L. salicaria* foliage via a carrier matrix were pathogenic to 6-week old plants. Farr and Rossman (2001) have identified another potential pathogenic fungus, *Harknessia lythri*.

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<http://www.miseagrant.org/pp/>
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http://www.dnr.state.mn.us/ecological_services/exotics/plprog.html
Virginia Department of Conservation and Recreation, Natural Heritage Program
<http://www.state.va.us/~dcr/vaher.html>
Virginia Native Plant Society
<http://www.vnps.org>
Virginia Nursery and Landscape Association
<http://www.vnla.org/default.htm>
Wisconsin DNR. Purple Loosestrife Fact Sheet
<http://www.dnr.state.wi.us/org/land/er/invasive/factsheets/loose.htm>

**LYTHRUM SALICARIA
(PURPLE LOOSESTRIFE)**

EXPLANATORY TEXT FOR THE IMPLEMENTATION TABLE

Leadership, Coordination and Regulatory Authority

Develop Coordination Framework Across Jurisdictions

All participants in the breakout group were in agreement that regional or watershed-wide coordination on purple loosestrife control measures would significantly improve efforts to achieve the goals of no net gain of this invasive plant. Such a framework would reduce the duplication of materials and promote increased public awareness. Such a framework could lead to reduced costs, particularly in the production of print and related outreach materials. With these considerations in mind, participants proposed that a regional coordinating group with representatives from state invasive species councils should develop a framework for promoting effective coordination across jurisdictions on controlling the spread of purple loosestrife. Such a coordinating group, which would meet periodically, would interact with the proposed Regional Communications Coordinator (see Communications and Information Access) and provide advice for improving region wide communications. The participants felt that it was important to bring representatives together at the beginning and recognized that regional meetings would be an ongoing process. The costs were not estimated, though it was generally assumed that they would be relatively low and borne by each state.

Early Detection and Response

State Monitoring: Activate Field Staff to Monitor for New Infestations and Pioneering Plants

As part of their monitoring for invasive plants, state and local agencies and Cooperative Extension services in each state should monitor for pioneering plants of purple loosestrife that could potentially serve as the source of new infestations; these efforts should be coordinated with volunteer monitoring programs and have a standardized reporting system (see below). This activity would be ongoing and supported by current funding, primarily by state agencies.

Volunteer Monitoring and Reporting, e.g., Hotline and Email

Awareness of non-native species infestations has been growing among local and regional organizations such as horticultural clubs and nature organizations — many undertake regular forays to identify and remove invasive plant species. Such volunteer monitoring and reporting could play a valuable role in better controlling harmful invasive species, while educating the broader public about environmental and invasive issues. The group estimated that \$10,000 would be needed to set up and maintain a system such as a hotline and email reporting. With the state coordinators for purple loosestrife working with the regional coordinator, email and web-based reporting could be standardized and data (with GPS coordinates) placed on a website so that it would make it easier for volunteer teams

to return to the same sites each year and to be able to assess the impact of their control measures.

Interagency Coordination for Rapid Response

Rapid response to control new stands of purple loosestrife would be enhanced by more efficient reporting, through email and/or hotline, to natural resource agencies in each state, which could act more effectively with regularly updated databases.

Prevention

Long-Term Monitoring and Assessment of Control Areas and Assessment of Control Areas

Statewide monitoring of the impact of control efforts on purple loosestrife is critical if there is to be any long-term success at meeting the goals of no net gain and maintenance of biodiversity. While monitoring can be labor intensive, there is a great opportunity for state agencies to partner with garden clubs, nursery associations, and other organizations to help undertake regular monitoring. Analogous efforts are ongoing in the Bay watershed with submerged aquatic vegetation monitoring, bird counts and water quality monitoring. By integrating these efforts with web-based reporting, it should be possible to assess the effectiveness of control strategies and better determine successes and failures.

Volunteer Projects to Identify and Monitor Sites for Control

Many organizations in the Bay region such as sportsmen's associations, garden clubs, nursery associations and other water users are involved in projects to remove non-native plants. These efforts would be more effective than they currently are and provide essential information by encouraging these organizations to monitor and report in standardized web-based forms. (See, for example, the University of Connecticut's website for reporting on Purple Loosestrife:

www.hort.uconn.edu/ipm/general/forms/lstrifrm.htm)

Control and Management

Identify Threats Using Existing Risk Assessments

The group agreed strongly that we must first be able to clarify the various threats that purple loosestrife poses to the environment in order to justify the costs for controlling its spread. Such threats can be identified by risk assessments, which a number of participants thought that the USDA has probably done already. However, if no risk assessment is available, then it should be undertaken as the first order of business — the estimated cost is \$15,000 and is estimated to take six months.

Develop Regional Map of Infestations, Collecting Standardized, Size-Specific Data from Each State

Based on maps available to the group, there was a lack of detailed information about purple loosestrife infestations in Maryland, Virginia and Pennsylvania, e.g., location, site conditions, type of water body, areal coverage, abundances and densities. In order to develop priority sites for actions, it is necessary to map purple loosestrife infestations in each watershed state. Participants believed that funding should come from state agencies.

Develop Protocol to Prioritize Sites for Control

The group agreed that once purple loosestrife stands were clearly identified and mapped, the next step would be to develop protocols for classifying sites that pose the greatest threats to natural habitats. A multi-state panel of plant experts would like to work together with USDA-APHIS in developing such protocols.

Develop Site-specific IPM Guidelines for Control

These newly developed protocols would help state agencies identify purple loosestrife sites that represent threats to biodiversity or related problems, the panel of state representatives could then develop integrated pest management guidelines for control — this could mean herbicides, biological controls, mechanical removal or a combination of these and other methods. It would be up to each state to identify priority areas for control and to implement control beginning with top priority sites. By maintaining a database of maps, actions and findings (see Monitoring below), it could then be possible to compare the effectiveness of actions for specific habitats.

Recommend that States Identify Priority Areas for Control

With the availability of protocols for identifying priority sites, the breakout group recommended that states rank those areas that posed the greatest threat. Then, every state would also know where control efforts were undertaken.

Recommend that States Implement Control in Priority Sites

With the ranking of sites, states should then begin implementing control strategies, beginning, of course, with those that are expected to have the most impact on biodiversity or other environmental threats.

Evaluate Potential for Obtaining a Regional Permit for Application of Garlon

A number of group members agreed that the potential for obtaining a regional permit for Garlon, an herbicide for controlling broadleaf weeds on pastures and in non-crop areas, should be investigated. They expected this to be a three to six month project that an intern or fellow could do under the auspices of the Chesapeake Bay Program.

Communication and Information Access

Development and Implementation of Public Knowledge and Attitude Survey

The breakout group agreed that in order to develop outcome-based education and outreach programs, we must first have a clear understanding of public knowledge and attitudes about invasive species and purple loosestrife, in particular. The survey, that could cover several major invasive species, would then serve as a springboard for more effective development of state and region wide outreach strategies. The group estimated the survey costs at \$10,000-15,000 and that funding could be sought from NGOs such as the League of Women Voters and the American Horticultural Society.

Hire Regional Coordinator, Part-time

A strategic approach to watershed-wide control of purple loosestrife programs, must have a specialist who will be a point-of-contact within the region, will be responsible for developing a clearinghouse for available information, and will work with representatives from state invasive species councils to identify information needs. The participants all agreed that hiring such a coordinator is a priority (January 2003) and should be among

the first goals of a commitment to reducing the negative impacts of purple loosestrife and ensuring no net gain of purple loosestrife. The anticipated cost of \$40,000 includes salary and operating expenses.

Regional Coordinator Develops Clearinghouse for Publications and GIS Maps

Based on web searches and print materials, information about purple loosestrife does not appear to be in short supply — what is lacking, however, in the Chesapeake Bay region is any coordination in terms of publications and other outreach materials. Participants in the breakout group felt strongly that a clearinghouse was needed for print, electronic and other media that would be especially applicable to the Chesapeake Bay watershed. Setting up a clearinghouse, which would include mailing lists, email lists and listservs for promoting new publications and related material, should be among the first objectives of the new coordinator.

Develop Targeted Education Programs for Private and Public Landowners

Based on the outcomes of the public knowledge and attitudes survey, the consolidation of information about current public and private programs for controlling purple loosestrife (e.g., state agency, horticultural clubs, nature and environmental groups) and the findings of the risk assessment [see Prevention, Control and Management], the regional coordinator will oversee outcomes-based education programs by coordinating with representatives from state invasive species councils. Such education programs should be underway by the end of the first year of the regional coordinator's appointment.

Develop and Distribute IPM Publications

Integrated pest management materials (print and web-based) for preventing the spread of purple loosestrife and other invasive species are a valuable way for reaching citizen groups, gardeners, nursery operators and others. An effective communications program would develop and make these materials widely known. (See, for example, Penn State's IPM website at www.cas.psu.edu/docs/CASDEPT/IPM/ and the University of Connecticut Cooperative Extension Service's website at www.hort.uconn.edu/ipm/.)

LYTHRUM SALICARIA (PURPLE LOOSESTRIFE)
IMPLEMENTATION TABLE: LEADERSHIP, COORDINATION AND REGULATORY AUTHORITY

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Coordination Framework	On-going	Low	Each state	Reps from state invasive species councils	CBP, USFWS, USDA, NPS, NGOs

LYTHRUM SALICARIA (PURPLE LOOSESTRIFE)
IMPLEMENTATION TABLE: EARLY DETECTION AND RESPONSE

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
State monitoring	Ongoing	Low — in-kind	State agencies		Natural resource agencies, agriculture, Cooperative Extension, field staff
Volunteer monitoring	Ongoing	Moderate			
Interagency coordination	Ongoing	Not estimated	States in the watershed		Natural resource agencies, agriculture, Cooperative Extension, field staff, NPS

LYTHRUM SALICARIA (PURPLE LOOSESTRIFE)
IMPLEMENTATION TABLE: PREVENTION

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Long-term monitoring	Ongoing			State agencies	
Volunteer projects	Ongoing	Low	State agencies	Sportsmen's Associations, Garden clubs, etc.	

LYTHRUM SALICARIA (PURPLE LOOSESTRIFE)
IMPLEMENTATION TABLE: CONTROL AND MANAGEMENT

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Risk Assessment	Six months	\$15,000		USDA/PPQ	
Regional Mapping	One year	In-kind	State agencies	CBP	Virginia DGIF and Natural Heritage, Maryland Ag and DNR, USDA, PDA, PGC
Protocols for prioritizing				Multi-state panel	State agencies, USDA-APHIS
Prioritize Control Sites	Ongoing after the first year			Multi-state panel	State agencies, USDA-APHIS
Implement Controls	Ongoing after the first year				
Garlon (herbicide)	3-6 months			Chesapeake Bay Program	

LYTHRUM SALICARIA (PURPLE LOOSESTRIFE)
IMPLEMENTATION TABLE: COMMUNICATION & INFORMATION ACCESS

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Knowledge survey	Six months	\$10,000 – 15,000	American Horticultural Soc, League of Women Voters, etc	Chesapeake Bay Program	Natural Resource agencies, Cooperative Extension, NPS.
Regional Coordinator	Immediately and ongoing	~ \$40,000	States		
Clearinghouse	Begin by month three and ongoing.	None		Regional coordinator	
Targeted Education Programs	Begin end of year 1 and ongoing	unknown		State agencies	
IPM publications	6 months	Low	Sea Grant, state agencies		Regional coordinator, Mid-Atlantic Sea Grant programs, state agencies

**LYTHRUM SALICARIA
(PURPLE LOOSESTRIFE)**

KEY ISSUES

Goal

To reduce negative impacts of purple loosestrife, achieve no-net gain, maintain native diversity.

Key Issues

Identify threats using risk assessment and develop protocols to rank control sites

There was strong consensus among all the breakout group participants that the first need is a purple loosestrife risk assessment, so that environmental threats can be better identified. Such an assessment will make it possible to develop protocols for limiting the spread of purple loosestrife and to rank the most important sites for control. In addition, the ability to clearly identify the threats that purple loosestrife expansion poses will make it possible to develop more effective education and outreach programs for controlling its spread and promoting native plant diversity.

Develop a regional coordination framework, a clearinghouse for purple loosestrife outreach efforts, and improve species mapping

A regional coordination framework will go a long way towards more effective implementation of purple loosestrife control strategies throughout the watershed. With the growing awareness about invasive species by state agencies and groups such as garden and nature clubs, there is a great potential to help these groups operate more effectively through improved mapping and control efforts and the development of web-based reporting.

Develop a regional clearinghouse to coordinate outreach publications and related materials

There is a great deal of material on purple loosestrife, as there is on invasive species such as phragmites. A region wide clearinghouse that could reduce the extent of duplication and help target those areas that are most vulnerable to the spread of purple loosestrife could better help achieve the goal of no net gain and increased biodiversity of native plants.

DRAFT MANAGEMENT PLAN

TRAPA NATANS (WATER CHESTNUT)

BREAKOUT SESSION PARTICIPANTS

Facilitator

Dan Nees Maryland Sea Grant

Rapporteur

Tilly Egge Chesapeake Bay Program

Participants

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Dave Goshorn	Maryland Department of Natural Resources
Mike Naylor	Maryland Department of Natural Resources
Betsey Lyman	The Nature Conservancy
Deborah Landau	The Nature Conservancy
Katia Engelhardt	Appalachian Laboratory, University of Maryland, UMCES

DRAFT MANAGEMENT PLAN

TRAPA NATANS **(WATER CHESTNUT)**

SPECIES SUMMARY

Description

Trapa comes from the Latin term *calcitraba* referring to a spiked iron ball used as an ancient weapon. The descriptive species name *natans* means “floating.” *Trapa natans* is commonly known as bull nut or water chestnut. (Note: *Eleocharis dulcis*, the Chinese water chestnut, is often confused with European water chestnut, but is unrelated to the *Trapaceae* family.)

Trapa natans is an annual aquatic plant with a submerged flexuous stem that anchors into the mud and extends upward to the surface of the water. At the surface, the terminus of the plant contains a rosette of floating leaves. The saw-tooth edged leaves are triangular in shape and connect to an inflated petiole, which provides added buoyancy for the leafy portion of the plant. The inflated petioles are approximately 15 cm long, and the leaves are found to be 2 to 4 cm long. The long stems can reach 4-5 m in length. Additional feather-like leaves can be found along the submerged stem. The submersed leaves, structurally similar to adventitious root hairs, are sessile and photosynthetic. The very fine roots anchor the plant into a muddy substrate.

The white flower of water chestnut, which forms in late June from the axils of the leaf rosettes, has four petals, approximately 8 mm long, and is entomophilus (insect pollinated). The water chestnut fruit is a caltrop shaped nut, having four half-inch barbed spines.

Native to Europe, Asia and Africa, water chestnut grows best in shallow, nutrient-rich lakes and rivers and is generally found in waters with a pH range of 6.7 to 8.2 and alkalinity of 12 to 128 mg/L of calcium carbonate (Methe et al. 1993). Naturalized populations can be found in Australia and various locations of the northeastern United States.

Ecology

Water chestnut flowering for the northeastern United States begins in June and continues until mid-July. The ovary is two chambered each with an ovule, though generally only one seed per flower will develop (Groth et al. 1996). After fertilization, the fruit develops barely submerged beneath the rosette. The four triangular sepals of the flower develop into the barbed spines of the mature fruit. The fruit is technically a drupe and takes about one month to ripen. Mature fruits are thereophytes, which eventually fall to the lake or river bottom to overwinter. Lateral dispersal can occur when water chestnut plants are uprooted and float downstream. Seeds can remain viable for up to 12 years, although most will germinate within the first two years.

The seeds will germinate from the sediment substrate, firmly lodged by lateral roots; germination occurs in the late spring, and the first leaves reach the surface in mid-May. As a young plantlet, the submersed leaves develop and provide absorptive surface area for nutrients as well as a photosynthetic surface. Once the primary stem has developed and produced the first floating leaves, secondary offshoots begin to develop at a rapid rate. The rapid vegetation of water chestnut in low-density conditions contributes greatly to its success as an aquatic invader.

Each water chestnut seed can potentially create 15 to 20 rosettes. Each rosette can generate up to 20 seeds. The prolific plant can cover a given area in a mat-like manner often creating a canopy that reduces growth of other aquatic species and interrupts the passage of light needed to maintain a well-functioning aquatic ecosystem. The abundant detritus created by water chestnut could affect other aquatic organisms and also reduce oxygen levels in shallow habitats.

Introduction History

Water chestnut in North America was first observed near Concord, Massachusetts, in 1859 (Worobel 1996). The exact path or reason for the introduction is a mystery. Harvard botanist Asa Gray cultured the organism in his botanical garden in 1877. Its escape to local waters occurred by 1879 (Worobel 1996) and populations were documented in New York by the late 1800s. Further spread occurred through waterways and into Vermont and Massachusetts.

The first population of water chestnut in Maryland was documented in 1923 in a two-acre patch on the Potomac River outside of Washington D.C. Within a few years, the plant had spread over 40 river miles on the Potomac. The 10,000-acre coverage of water chestnut reaching past Quantico, Virginia, prompted removal efforts by the Army Corps of Engineers in 1939. Water chestnut was found in the Bird River, Baltimore County, in 1955 and subsequently in the Sassafras River, Kent County, in 1964.

The most problematic populations currently occur in the Potomac and Hudson rivers and in Connecticut River valley, Lake Champlain region. In 1998, water chestnut was found in the South River in Quebec, which is connected to the Lake Champlain outlet via the Richelieu River. Its spread has continued because of the suitability of habitat; in 2001, for example, water chestnut was discovered in the Pike River, which flows into Mississquoi Bay.

Water chestnut has been declared a noxious weed in Arizona, Massachusetts, New Hampshire, North Carolina and South Carolina, and sale is prohibited through most Southern States (USDA).

The dispersal of water chestnut by human hands to the United States and other parts of the world is anecdotally attributed to its status as an ornamental plant having medicinal and nutritional value. In many parts of Asia, the fruit is a staple food source and used for livestock feed. The fruit has been used medicinally to treat elephantitis, pestilent fevers, rheumatism and skin complaints (Worobel 1996).

In Europe, water chestnut populations have been dwindling in Belgium, Holland and Sweden; it has been listed as a strictly protected species by the Bern Convention March 1998 (Council of Europe, convention on the conservation of European wildlife and

natural habitats); in 1981 Germany issued stamps featuring four aquatic plants including water chestnut.

Distribution in the Chesapeake Bay Watershed?

Water chestnut is presently found on the Sassafras and Bird rivers of Maryland, and in a number of ponds including a non-tidal pond above Lloyds Creek and in Urieville Lake in Kent County, Maryland. Pennsylvania has reported populations in the Lower Susquehanna, areas around Philadelphia, and in isolated lakes. Most recently, a population was reported in the Upper Delaware River. Appendix I includes a map showing *Trapa natans* distribution in the Chesapeake Bay Watershed.

Maryland has a harvesting program that has been in effect since 1999. The program has focused on the water chestnut populations on the Bird and Sassafras rivers.

Maryland

Water chestnut was recorded in the Bird River in Baltimore County for the first time in 1955. The Maryland Departments of Game and Inland Fish and Tidewater Fisheries used mechanical removal and the herbicide 2,4-D, the only fully licensed herbicide that has been successfully employed for controlling water chestnut populations. However, in 1964 it reappeared in the Bird River and an additional 100 acres were discovered in the Sassafras River, of which 30 acres were mechanically removed. A combination of removal techniques was used once again in 1965, when 200 acres were found in the Sassafras River. This effort was believed to have been successful, and no plants had been noted in vegetation surveys until summer 1997 (MDNR web).

The Bird River water chestnut population spread from approximately 50 plants in summer 1997 to over three acres in 1998, and at least 20 acres in 1999. The Sassafras population is slightly larger, though determining its exact size has been difficult due to its remote location. A massive mechanical and volunteer harvesting effort was undertaken in both rivers in 1999 and resulted in the removal of approximately 400,000 pounds of plants from the two rivers.

Despite the discovery in 2001 of several new locations in which water chestnut grew, less than 500 pounds were harvested this year — about enough to fill the bed of a small pick-up truck. This was about half of the approximately 1,000 pounds last year, and a tiny fraction of the 200,000 pounds in 1999. With declining weights of plants harvested, and declines in plant density in the most affected areas, it seems that the eradication efforts to date have been successful.

Pennsylvania

Water chestnut infestations have been identified in isolated areas in the eastern half of Pennsylvania. There are no coordinated efforts to remove water chestnut in Pennsylvania at this time (Tim Block, Betsey Lyman pers. comm.).

Virginia

Virginia has no known populations of water chestnut (Keith Heffernan pers. comm.).

Research and Control Efforts

Biological control possibilities were investigated in the early 1990s. Surveys were conducted by the U.S. Department of Agriculture in 1992 and 1993 that sought natural enemies of water chestnut in Northeast Asia; in 1995, the survey was continued in Europe (Pemberton 1996). The prime candidate, *Galerucella birmanica*, a beetle that consumes up to 40% of water chestnut leaf tissue (Ahmad 1998) was found to have various other plant hosts, thereby making it unsuitable for bio-control purposes in the U.S. Other insects that fed exclusively on water chestnut were identified but not found to be damaging (Pemberton 1996). Predators found in the warmer climate of India have potential but could not withstand the cooler temperatures of water chestnut-infested Northeast regions of the United States.

Hand removal is an effective means for eradication of smaller populations: water chestnut roots are easily uplifted. Their removal is imperative as floating uplifted plants can further spread seeds downstream. The potential for water chestnut seeds to lay dormant for up to 12 years makes total eradication difficult. Nonetheless, hand-harvesting from canoes and raking have been useful and they are a means to promote community involvement.

For large-scale control of water chestnut populations, which can form dense, thick mats capable of covering miles at a time, herbicides and mechanical harvesting can both be effective. Aquatic plant harvesting boats are often employed in instances where waterways are blocked. For example, mechanical harvesting in 1999 on the Sassafras River removed an estimated 260,000 pounds of water chestnut (Naylor 1999). Unfortunately mechanical harvesting boats cannot operate in some of the shallow areas that water chestnut can inhabit. For this reason, mechanical harvesting has been complemented by hand harvesting in Maryland on the Bird and Sassafras rivers.

Herbicide 2,4-D has been tested, and deemed safe for use by federal and state agencies. Used widely in the U.S., it has not shown adverse affect on neighboring wildlife. Maryland and Virginia used 2,4-D in the 1960s to eradicate Eurasian watermilfoil populations in the Bay. Due to public perception, the use of herbicides is seen as a last resort option. Integrating all possible methods for water chestnut removal will be the most effective course for eradication.

Management Efforts within the Chesapeake Bay Watershed

Water chestnut infestations create havoc for boating and recreational areas. The dense mats make navigation difficult, while the spiky seeds, capable of puncturing shoe leather, are a danger to bathers and beach users. Private land owners, boat owner groups and park groups are active in eradication efforts where water chestnut occurs. The following groups were active in Maryland's 2000 eradication efforts: the State Highway Administration, U.S. Department of the Interior, C&O Canal National Historic Park, Echo Hill Environmental Education Center, USFWS, Baltimore Department of Environmental Protection, Horsehead Wetlands Center, Wildfowl Trust of North America, and Bird River Beach Community Association (Naylor, 2000).

Water chestnut has been listed as a noxious weed in South Carolina, New Hampshire and Arizona.

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- <http://www.nal.usda.gov/ttic/tektran/data/000008/23/0000082375.html>
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TRAPA NATANS
(WATER CHESTNUT)

EXPLANATORY TEXT FOR THE IMPLEMENTATION TABLE

Management Goal:

Outbreak eradication.

Leadership, Coordination and Regulatory Authority

Chesapeake Bay Program Lead

The Chesapeake Bay Program can provide the regional coordination for management. Specifically the Invasive Species work group under the Living Resources subcommittee should provide the appropriate forum for coordinating and reporting on removal efforts, providing information, and coordinating annual spring meetings. Partner groups should include Bay state agencies (MISC, MD DNR, VA DEQ, PA DEP), federal agencies (USCOE, NPS) and non-governmental organizations (TNC, CBF), and private landowners.

Prevention

Noxious weed classification

Designating water chestnut as a noxious weed is essential to the prevention of future outbreaks. The transfer, sale and personal use of the species should be prohibited. Other best prevention methods can be found under Early Detection.

Early Detection and Rapid Response

Effective management requires timely action. The optimal time for water chestnut removal is during late June and July, before mature seeds fall from the plant. Two early detection strategies were identified, active and passive. The active strategy requires monitoring previous outbreak sites, and the passive strategy requires broader public outreach to communities around potential sites.

Monitoring of previous outbreak sites (active)

In Maryland, where water chestnut outbreaks have occurred, annual spring-time monitoring is required to identify outbreak sites. Outbreak sites that are located should then be analyzed to determine the most appropriate method of eradication-- hand, mechanical, or chemical removal.

Public education (passive)

Though outbreaks have occurred in isolated areas of the watershed, there is a concern of spread. Threat of spread can be reduced through public education. The education components should focus on identification of the species and spread prevention. Identification information can be distributed by Internet, timely pamphlets, "most wanted" posters, and fact sheets. Target audiences include marinas, neighborhoods, and sportsmen's associations. Removal activities can also educate the public, e.g., press

releases and community meetings can promote awareness to water chestnut as an invasive species. Spread prevention should be taught to boat owners and people working within the exotic plant trade.

Control and Management

Removal

Water chestnut removal methods include hand, mechanical and chemical harvesting. There is not always one best management strategy; rather control measures must be determined on a case-by-case basis. Herbicides are considered a last resort technique due to political and ecological concern. Hand removal should occur at outbreaks under 50 acres and in areas with low plant density and water depth. Mechanical harvesting is required for outbreaks of greater acreage and density, although many mechanical harvesters cannot be used in low depth areas. In almost all cases, both hand and mechanical methods are necessary.

Cost Breakdown

The following cost breakdown was based on a sample population of 2-3 acres at 100 percent species density with and additional 10-20 acres of scattered density. These figures are based on past outbreaks.

Yr	CONTROL ACTION					
	Mechanical	Hand	2,4-D	Monitor	Mechanical (hand + mech .+ monitoring)	Chemical (2,4-2+hand + monitoring)
1	\$ 10 k	\$ 4k	\$1k	\$ 2k	\$ 16k	\$ 7k
2	\$ 4 k	\$ 4k	\$1k	\$ 2k	\$ 10k	\$ 7k
3	0	\$ 2k	0	\$ 2k	\$ 4k	\$ 4k
4		\$ 1k		\$ 2k	\$ 3k	\$ 3k
5		\$ 1k		\$ 2k	\$ 3k	\$ 3k
6- 10				\$ 10k	\$ 10k	\$ 10k
TOTALS:						\$ 46 k
						\$ 34 k

Communication and Information Access

Database for best management and eradication methods

Due to the isolated and localized nature of water chestnut outbreaks, local and state agencies would benefit from a database of all management and eradication case studies. Maryland, the only state in the watershed with experience in dealing with open water outbreaks, will serve as the lead for creating a regional database of water chestnut removal effort case studies to date. The framework for a national database is found in The Nature Conservancy's "element stewardship abstracts". The Agricultural Ecosystem Restoration Foundation (ACRF) can serve as an additional resource for information exchange.

Research

Further information could be beneficial on issues such as risk assessment, seed germination, and outbreak prevention.

***TRAPA NATANS* (WATER CHESTNUT)**
IMPLEMENTATION TABLE: LEADERSHIP, COORDINATION AND REGULATORY AUTHORITY

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Coordinate/ Report on removal efforts/ information exchange	Annual meetings in the spring	Low	Chesapeake Bay Program	Chesapeake Bay Program, LRSc, Invasive Species Workgroup	State, Federal, Private (MISC. MD DNR, VA DEQ, NPS, USCOE,

**TRAPA NATANS (*WATER CHESTNUT*)
IMPLEMENTATION TABLE: PREVENTION**

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Noxious Weed classification					
Enforcement					
Use of signs					

***TRAPA NATANS* (WATER CHESTNUT)**
IMPLEMENTATION TABLE: EARLY DETECTION AND RESPONSE

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Public Education	On-going	Low	state/local	MD DNR	Boat owner assoc., NGO's
Monitoring of previous outbreak sites	Annual spring time monitoring		state	MD DNR (agency of state with outbreak)	

***TRAPA NATANS* (WATER CHESTNUT)
IMPLEMENTATION TABLE: CONTROL AND MANAGEMENT**

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Removal	June-July annually	See table	State/local	DNR	NPS team, local groups

TRAPA NATANS (WATER CHESTNUT)
IMPLEMENTATION TABLE: COMMUNICATION AND INFORMATION ACCESS

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Regional case study database	On-going (1/03)	--	--	MD DNR	
National case study database	On-going (1/03)	--	--	TNC	

TRAPA NATANS **(WATER CHESTNUT)**

KEY ISSUES

Successful water chestnut management requires a commitment to outbreak eradication throughout the Chesapeake Bay watershed. Participants strongly supported a monitoring and, when needed rapid response eradication program to prevent the spread or establishment of the species in the Bay. Key components of this approach include:

- *Effective monitoring* for water chestnut infestations will require public education and citizen involvement as well as state monitoring in areas where water chestnut has occurred in the past.
- *Removal Coordination* of water chestnut among state agencies and community groups must be timed carefully to maximize the success of removal efforts.
- *Designate water chestnut as a noxious weed* to prohibit the transfer, sale and personal use of the species, and thereby reduce the likelihood of spread.

DRAFT MANAGEMENT PLAN

CYGNUS OLOR **(MUTE SWAN)**

BREAKOUT SESSION PARTICIPANTS

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Rapporteur

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Ian Gregg	Pennsylvania Game Commission
Larry Hindman	Maryland Department of Natural Resources
Jil Swearingen	National Park Service
David Whitehurst	Virginia Department of Game and Inland Fisheries

DRAFT MANAGEMENT PLAN

CYGNUS OLOR **(MUTE SWAN)**

SPECIES SUMMARY

Description

Included in the family Anatidae with ducks, geese and swans, mute swans are the largest bird in the Chesapeake Bay. Originating from Eurasia, mute swans were transported to northern Europe in the Middle Ages and, subsequently, to North America and have been favored among captive owners and breeders of waterfowl for their beauty and grace. Adult males are larger than females. Average mass for adult males is 10.2 kg and for adult females is 8.4 kg. Average length of males and females is 1.27 to 1.52 m. Adults can have a wing span of about 1.8 to 2.4 m. Adult birds are white and have orange bills with a characteristic black, basal knob and a black terminal nail, whereas the tundra swan, native to North America, has a simple, black bill. Legs and feet of adults can range in color from black to grayish pink. Mute swan cygnets are grayish brown or white, with slate gray legs and feet or pinkish/tan feet, respectively. Cygnets lack the basal knob. White morph cygnets have tan bills, while gray morph cygnets have slate bills.

Mute swans utilize a variety of aquatic habitats, including ponds and lagoons and fresh to salt water marshes. In the warmer months, mute swans spend most of their time in shallow water. As shallow water freezes, the birds move to deeper water, but will utilize deeper water throughout the year.

Population Ecology

The Chesapeake Bay has the largest and fastest growing mute swan population in the Atlantic flyway. The mean annual rate of population growth for mute swans in Maryland was 36% from 1962 to 1979. From 1986 to 1999, the mute swan numbers in Maryland increased from 264 to 3,955, an increase of 1,389%. The 1999 estimate of total mute swans in the Atlantic flyway was 12,600 birds. The growth rate for mute swans in the Chesapeake Bay since 1986 has been 1,271%. A nest survey in the Patuxent River in 2000 revealed five nests; a survey conducted in 2001 revealed 40 nests. Population modeling of Maryland's mute swan population indicates that it could include over 20,000 birds by 2010 if growth is unchecked (Harvey 2000). From 1989 to 1999, according to the Atlantic Flyway Survey, Massachusetts' mute swan population grew 68%, Rhode Island's 79%, New Jersey's 159%, Pennsylvania's 78% and Virginia's 713%.

Mute swans are year-round residents in the Chesapeake Bay and are not true migrants in any part of their range in North America. While occurring throughout the Bay, they are most concentrated from Rock Hall in Kent County south to Hoopers Island in Dorchester County. Until they are old enough to nest, and during the winter months, mute swans spend most of their time in large flocks composed of juvenile, sub-adult swans. Flocks of

600 to 1,000 birds have been recorded in the Chesapeake Bay. Breeding pairs remain on territories most of the year.

Mortality after mute swans reach breeding age is low. Causes of mortality can include disease, severe winter weather, lead toxicosis, collision with high tension wires or other man-made structures and incidental shooting in Virginia, Pennsylvania and Delaware where they are unprotected by state law. Once they reach breeding age, about 85% survive from one breeding season to the next. Average life expectancy is 11 years and the maximum is 21 years (Ciaranca et al. 1997).

Feeding Habits

Submerged aquatic vegetation (SAV) is the preferred diet of mute swans throughout the world, though they will also eat grain crops. In one Chesapeake Bay study, widgeon grass (*Ruppia maritima*) constituted 66 and 78% of the food eaten at Eastern Bay and Smith Island, respectively, whereas eel grass (*Zostera marina*) formed 2% and 32%, respectively, for these areas. Other SAV and invertebrates amounted to only 1% (M. Perry, USGS, Laurel, Maryland unpubl. data). Other SAV important to mute swan diet in the Chesapeake Bay include sago pondweed (*Potamogeton pectinatus*), clasping-leaved pondweed (*P. perfoliatus*), horned pondweed (*Zannichella palustris*) and *Myriophyllum spicatum*. Adult mute swans consume 1.8 to 3.6 kg of plant material each day (Fenwick 1983) and can reach SAV in 1.07 m of water (Owen and Cadbury 1975). They have been observed pulling plants up by the roots or rhizomes or paddling vigorously to dislodge whole plants to consume or to make available for cygnets (Owen and Kear 1972, Birkhead and Perrins 1986).

Breeding

Mute swans nest when they reach about three years of age; pairs generally remain together until one member dies, or the remaining member of a pair chooses, or does not choose, another mate. Nesting begins in March or early April and pairs often use the same nest sites over multiple years. Mute swans nest very close to the water on small islands, isolated shorelines or in shallow marshes. The nest is made from rushes and coarse emergent grasses and ranges from 4 to 6 feet in diameter and about 1.5 feet above the high-tide line. The female, or pen, does most of the nest building and is the principal incubator of the eggs. Unlike other waterfowl in the Northern Hemisphere, mute swan males have been observed incubating in the absence of a female (Witherby et al. 1952). Clutch size in the Chesapeake Bay ranges from 4 to 10 eggs, with a mean of 6.2 (Reese 1996). Incubation continues for about 35 days after the first egg is laid, between mid-May and mid-June. Mute swans generally nest once a year, though if a nest is disturbed early in the nesting season and eggs are lost, a pair may attempt to nest a second time. Mute swan pairs, especially males, can be aggressive to other waterfowl, humans and pets that venture into their nesting territory, which can include up to 13 acres. Aggressive defense of territories begins in late February. In rare instances, mute swans will nest in colonies (Maryland DNR files).

Cygnets are precocious. They begin swimming within a day or two of hatching and are fully grown in less than six months. They are independent at 125 to 132 days. In the Chesapeake Bay, 49% of eggs laid survive to hatching and about 83% of hatching

cygnets are able to fledge. Cygnets are ready to fly in about four to five months, and may then leave their parents territory. Female mute swans begin to molt in mid-July, while males delay their molt until their female partners regain flight. Most mute swan families break up in the fall, when young birds are forced out by their parents.

Ecological Concerns

Of primary concern to Chesapeake Bay ecologists is the rate of mute swan population growth in the Chesapeake Bay, its presence year-round and its preference for feeding on SAV. Certain SAV species, such as wild celery (*Vallisneria americana*), are especially vulnerable because their reproduction and growth are timed to avoid the heavy grazing of migratory waterfowl. Wild celery requires its reproduction process to be protected from grazing while its seeds are maturing. If consumed before seeds are mature, it will not reproduce and will waste living energy in this process. A large, resident mute swan population feeding on SAV all year could jeopardize the ability of SAV to recover from winter waterfowl grazing and make it less available for waterfowl the following winter. Declines in SAV abundance appear to correlate with declines in local black duck (*Anas rubripes*) abundance (Krementz 1991). Population trends suggest that habitat degradation in Chesapeake Bay, especially loss of SAV, may be the principal cause of the decline of the Bay's canvasback (*Aythya valisineria*) population (Haramis 1991). Furthermore, the loss of SAV over the past several decades has prompted the near abandonment of Bay waters by redheads (*Aythya americana*), leaving only a remnant population today (Haramis 1991).

In closed waterways in Europe, mute swans have been documented as removing entire species of SAV (Gillham 1956, Jennings et al. 1961, Mathaisson 1973, Chairman 1977, Neirheus and Van Ireland 1978, Scott and Birkhead 1983). In a recent Rhode Island exclosure study, for example, findings indicated that mute swans overgraze SAV when water is shallow (0.5 m), reducing SAV biomass by 92 to 95% (Allin and Husband 2000). The Chesapeake 2000 Agreement includes a commitment to restoring 114,000 acres of SAV; however, restoration efforts, particularly in the mid-Bay where SAV decline is most severe, are frequently obstructed by feeding mute swans.

Anecdotal reports suggest that mute swans may compete with native, wintering tundra swans (*Cygnus columbianus*) for shelter and food and harassment by mute swans may cause tundra swans to lose winter mass more rapidly, effecting their subsequent reproduction. Research has shown that tundra swans lose mass during the winter and depart from the wintering grounds at their lowest mass (Bortner 1985, Limpert et al. 1987). Research into tundra swan and mute swan interactions is underway (E. Thompson, pers. comm.).

In the early 1990s, a molting flock of between 600 to 1,000 mute swans utilized a beach area, Barren Island (off of Blackwater National Wildlife Refuge), as a loafing site. This same site was the last remaining nesting site for black skimmers (*Rynchops niger*) and the last natural nesting site for least terns (*Sterna antillarum*) in Maryland. The mute swan activity crushed eggs and young of birds nesting in the beach colony, which led to the black skimmers and least terns abandoning this area for three nesting seasons (Maryland DNR files).

Human/Economic Interests

Complaints about mute swans from citizens vary. Mute swans consume and disturb SAV beds in impoundments or sheltered coves that provide crabbing and fishing opportunities; and aggressive pairs can prevent the use of shoreline or adjacent water for recreation. In large concentrations, mute swans and other waterfowl can contribute to water quality problems by defecating in the water. On Long Island, New York, elevated counts of coliform bacteria have been detected where mute swans congregate. Public health authorities are concerned about the impact of nutrient loading where waterfowl congregate because coliform counts are widely used to determine whether waters may be used for drinking, swimming or shell fishing. Nutrient loading can also cause dangerous algal blooms, especially in inland ponds where rooted SAV has been removed by mute swans (NYDEC 1993).

Regulatory Status

In December 2001, the U.S. Court of Appeals ruled that mute swans are covered under the Migratory Bird Treaty Act (MBTA), which provides the U.S. Fish and Wildlife Service (USFWS) with authority over any activity that directly impacts the birds, their eggs or nests. Prior to this ruling, the USFWS did not consider the mute swan covered under the MBTA, and regulatory authority was designated to the states. Now that the USFWS is charged with the authority for managing mute swans, the Maryland Department of Natural Resources, Virginia Game and Inland Fish Commission, the Pennsylvania Game Commission, and the Delaware Department of Natural Resources and Environmental Conservation are responsible for carrying out and or modifying their state regulations under USFWS jurisdiction. The USFWS is currently considering a regulatory mechanism to delegate federal authority over mute swans back to the states. In the interim, states are applying for federal permits to conduct research and population control programs.

Before the December 2001 ruling, mute swans in Maryland were included in the statutory definition of “wetland game bird,” which gave the Maryland Department of Natural Resources jurisdiction over their management. Mute swans were not protected in Virginia, Delaware or Pennsylvania. In 1997, the Atlantic Flyway Council issued a mute swan policy encouraging state wildlife agencies and other resource management agencies to control mute swans in the Atlantic flyway (AFC 2000). In 1996, the USFWS directed all National Wildlife Refuges to control mute swans within their boundaries (USFWS Internal Memo, May 24, 1996).

Management Efforts Overview

State wildlife agencies have attempted various population control measures, including egg addling and relocation or killing of adult birds. Most recently, six states in the Atlantic flyway (Delaware, Maryland, New York, Rhode Island, Virginia, and Vermont) have attempted to control mute swan populations through both passive actions (encouraging landowner/manager control) to aggressive actions (state employees actively removing mute swans from state lands and waters). Vermont, in addition to establishing a policy prohibiting the establishment of wild mute swan populations in the state, has

regulated their treatment in captivity: birds are to be pinioned, their sale or importation prohibited, and the eggs addled.

Monitoring of mute swan populations in Atlantic flyway states is conducted by aerial surveys every three years, in mid-summer, when native swans and other migratory birds are not present in the Chesapeake Bay. Appendix I includes a mute swan distribution map for the Chesapeake Bay.

Management Efforts in the Chesapeake Bay Watershed

Delaware

Prior to the U.S. Court of Appeals ruling, Delaware officially treated mute swans as a deleterious species and birds were systematically removed from all public lands.

Maryland

Maryland is developing a statewide mute swan management plan, including research projects to examine the potential impacts of mute swans on declining populations of wintering tundra swans and on SAV. The state has obtained federal permits for intensive egg addling in 2002, and is developing strict regulations for their sale, importation, breeding and captive management. It is also considering public forums to educate citizens about mute swans and their impacts and to learn more about public perception. Maryland has permitted the removal of several hundred swans by game breeders for shipment to Asia. In this program, mute swans, whose origin is Eurasia, are examined and certified as healthy by a veterinarian prior to their new placement. In addition, as part of its mute swan plan, the state has identified sensitive Bay areas to target for exclusion of mute swans, including SAV restoration sites, areas where rare SAV grows naturally and nesting sites for rare birds. Maryland is also considering annual surveys of mute swan population growth and is testing the use of male sterilization in preventing the growth of the population.

Pennsylvania

Prior to the U.S. Court of Appeals ruling, mute swans were unprotected in Pennsylvania: they could be taken without permit at any time of the year.

Virginia

Prior to the U.S. Court of Appeal ruling, Virginia permitted the capture and relocation of same sex pairs to inland waters. As an unprotected species, mute swans were open to hunting at any time of the year by hunters or landowners who could demonstrate that the swans presented a conflict or threat. A small number of mute swans were also taken incidentally during limited tundra swan hunting seasons held in Virginia. The Virginia Department of Game and Inland Fish conducted limited egg addling and removal of adult birds.

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CYGNUS OLOR (MUTE SWAN)

EXPLANATORY TEXT FOR THE IMPLEMENTATION TABLE

Leadership, Coordination and Regulatory Authority

Overall Clarification of Goals

Key to the successful implementation of a management strategy for mute swan in the Chesapeake Bay region will be agreement on clear goals. The primary goals of a mute swan management strategy as recommended by the breakout participants are:

1. To manage the population at a level that:
 - Minimizes impacts on native species, important habitats and local economies;
 - Minimizes conflicts with humans;
 - Is in agreement with *Chesapeake 2000* goals for SAV and exotic invasive species;
 - Is in agreement with the Atlantic Flyway Council Plan.
2. To examine the human dimensions involved and to encourage a sophisticated citizenry through:
 - Public education;
 - A stakeholder process that supports management goals.

Coordination of Data Collection and Management

Key to the effectiveness of the regional effort will be the coordination of data collection and database management. This should involve an inventory of available data and a description of current databases during the next two years. State and federal agencies will have the lead here, including the U.S. Fish and Wildlife Service.

In the immediate future, the Maryland Department of Natural Resources will expand its population model Bay wide to facilitate an estimate of the potential problem if current populations were to grow unchecked.

Managing to Protect Resources

In the case of managing the mute swan, region-wide leadership will require a concerted effort at coordination among states and other stakeholders, including both the Federal government and local jurisdictions. That leadership should be driven by a commitment to manage the swan population to protect important resources. The approach cannot be simplistic, and careful leadership will need to determine at precisely what levels the population should be managed and where control or removal should occur. Due to Federal regulation, the U.S. Fish and Wildlife Service has at present a primary responsibility for the management of mute swans.¹

¹ The U.S. Court of Appeals for the District of Columbia ruled December 2001 that because the Migratory Bird Treaty Act does not exclude non-native species, it protects the mute swan despite its destructive habits and status as an invasive species.

Detection and Monitoring

In order to effectively monitor mute swan populations, jurisdictions will need to:

- Improve data collection and database management.
- Institute Bay wide surveys to locate nests.
- Develop process for citizens to provide reports of mute swan sightings.
- Investigate how swans move to find nesting territories, especially across state lines.
- Assess impacts of mute swans on SAV, habitat and native species.

Population Monitoring and Research

Addressing the problem of rapid expansion of mute swans in the Chesapeake Bay region will require a better understanding of their range, reproduction and movement. This in turn will require better collection and coordination of data throughout the watershed, including the use of aerial surveys by the states, in cooperation with the Atlantic Flyway Council and the U.S. Fish and Wildlife Service. Monitoring and tracking efforts should also make good use of volunteers. While Maryland currently conducts aerial population surveys during the summer and surveys of nests during the spring, Pennsylvania and Virginia carry out mid-summer surveys once every three years. Mounting a sufficient monitoring and research effort in all three states will require additional funding, most likely from state and federal sources.

Process for Reporting Sightings

The workgroup called for improved methods for reporting swans and their nests. Jurisdictions should explore using annual birding surveys (i.e., for a range of species) to help spot mute swans.

Investigating Movement, Especially Across State Lines

The mute swan discussion group advised jurisdictions to investigate how swans move to find nesting territories especially across state lines. Funding will be needed to support this kind of investigation and analysis, but in order to prepare for the near term, studies should be underway before 2004. Private funds, as well as federal grants, should be sought. The states, USFWS and universities should all cooperate on this effort, and volunteers and graduate students should be able to assist.

Prevention, Control and Management

Effective management will require that the jurisdictions:

- Determine where control or removal should occur, whether resource or issue driven;
- Determine at what level population should be managed;
- Determine how to set guidelines for control on private and/or public properties and waterways;
- Contain distribution and restrict movement across state lines.

Identifying Sensitive Areas

Important to the effective management of mute swans will be a deeper understanding of the ecological impacts resulting from an expanding mute swan population. This will require research on impacts Bayside, including assessing reductions of impacts through

population control. Studies of mute swan effects on native wildlife and SAV populations should be coupled with on-going research into other factors (e.g. sedimentation, pollution, habitat loss, eutrophication) that may effect these populations. These efforts should be coordinated with the Chesapeake Bay Program SAV workgroup and other groups involved in monitoring habitat and resources. Resource agencies will therefore need to identify important SAV areas, sensitive natural communities, and important habitats for native fish and wildlife. These areas will include publicly owned and managed wetland areas.

Setting Guidelines for Control

Effectively controlling mute swans on both private and public properties and waters will require new guidelines, and the development of regulations pertaining to the sale, breeding and importation of mute swans. This will help contain their distribution and restrict their movement across state lines. Such clarification of permitting and regulations should be accomplished within the next three years.

Control Population Growth

Control of mute swan populations should be driven by resource protection, as determined by the above studies. Agencies can in this way determine where control or removal should occur. Where practical, agencies should use non-lethal methods for population control, including physical exclusion from sensitive areas, scare-tactics, addling or oiling of eggs, and reproductive intervention, such as vasectomy. When necessary adult birds should be removed, using the philosophy and strategies of integrated pest management (IPM). Agencies involved should include state natural resource departments and the U.S. Fish and Wildlife Service, the U.S. Geological Survey, the U.S. Department of Agriculture.

Local governments, watershed associations, bird clubs, landowners and conservation groups can all be partners in spotting swans, addling eggs and taking other measures. As noted above, the Chesapeake Bay Program SAV workgroup can play a key role in helping to designate areas in need of protection.

In Pennsylvania and Virginia depredation will occur this year to protect particular areas. Maryland has also identified areas to protect this year. This strategy should be refined and implemented Bay wide in 2003. A key challenge will be to determine at what level population should be managed, a determination that will depend on our evolving understanding of mute swan reproduction and movement, and of their impact on sensitive ecological areas.

Communication & Information Access

Effective public education and outreach will require the jurisdictions to:

- Identify target audiences;
- Assess knowledge, perceptions and values of key audiences;
- Develop communications and outreach plan;
- Group with other invasives in message;
- Determine how best to manage and clarify message to media;
- Use all available resources.

Key to the successful implementation of an effective mute swan management plan will be aggressive public education and outreach. Responsible agencies and institutions will need to cooperate to identify target audiences, and to assess their knowledge, perceptions and values. They will then need to develop appropriate communications and outreach plans, grouping the mute swan with other invasive species as they spread a consistent message, using all available outlets and methods.

CYGNUS OLOR (MUTE SWAN)
IMPLEMENTATION TABLE: LEADERSHIP, COORDINATION AND REGULATORY AUTHORITY

Goal	Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Adopt clear goals	Seek agreement among jurisdictions on common goals for minimizing impact, in concert with Chesapeake 2000 and AFC.	2002	None	NA	State and Federal agencies, USFWS, CBP	Citizen and stakeholder input.
Coordinate data collection and database management	Inventory data collection points and current databases.	During next two years.	Low	State, Federal sources	States, USFWS	University researchers, private groups involved in voluntary monitoring.
Expand pop. model to entire bay	Adopt current model (MD)	2002	Low	No additional funds needed.	States	
Manage population to protect important resources.	Determine at what level population should be managed. Determine where control or removal should occur.	PA and VA depredation to protect areas 2002. MD identifies areas to protect 2002. Refine implement Bay-Wide 2003.	TBD	State, Federal sources	USFWS, USGS, USDA, States	Local governments, watershed associations, bird clubs, citizens/landowners, conservation groups. CBP SAV Work Group to help refine areas to protect.

CYGNUS OLOR (MUTE SWAN)
IMPLEMENTATION TABLE: DETECTION AND MONITORING

Goal	Action	Time Frame	Cost	Funding Source(s)	Lead Agencies	Partners
Population Monitoring & Research	Conduct annual aerial surveys of population [States, AFC, USFWS, Summer (MD)]. Conduct annual aerial surveys of nests. [States, AFC, USFWS, Spring (MD)]. PA, VA will only do mid-summer survey every three years. VA does annual Eastern Shore survey; rest of nests are located on the ground.	Bay wide annual surveys to locate nests. Annual population survey in MD; every three years in PA and VA. Nest Surveys already started in MD; start in other states in 2003, pending funds available.	TBD	Funding Needed Long-term, consistent sources -state or federal	States, USFWS, Atlantic Flyway Council	Volunteers
Develop process for reporting sightings	Provide contacts in states to report swan nests and swans. Use annual birding surveys.	Spring 2003	Little	States, Private birding groups	States	Volunteers, citizens, bird clubs, watershed associations
Investigate how swans move to find nesting territories esp. across state lines	Support investigation and analysis.	2004	TBD	Funding needed: Federal grants; Private grants	States/USFWS	Universities, Grad students

CYGNUS OLOR (MUTE SWAN)
IMPLEMENTATION TABLE: PREVENTION, CONTROL AND MANAGEMENT

Goal	Action	Time Frame	Cost	Funding Source(s)	Lead Agencies	Partners
Identify important SAV and sensitive natural areas, habitats for native fish and wildlife, publicly owned or managed wetlands	Research on impacts bay-wide, assessment of reduction of impacts through population control. Coordinate w/CBP SAV workgroup and other groups monitoring resources under CBP. Compare with studies of other factors (e.g. nutrients, sedimentation, habitat loss) effecting SAVs and native wildlife.	MD will start in 2002 and 2003	TBD	Funding needed	States, USFWS, Bay Program	Universities, Sea Grant, Chesapeake Bay Foundation, Dept. of Defense
Set guidance for control on private and public property and waters	Develop regulations pertaining to the sale, breeding and importation of mute swans. Contain distribution, and restrict movement across state lines	Within the next three years	TBD	State, Federal responsibility.	State agencies, USFWS, USDA	Commercial sector
Control population growth	Where practical, use non-lethal methods: exclusion, adding eggs, etc. If remove adult birds, employ integrated pest management (IPM).	Ongoing	High	State, Federal sources, but funding needed.	State agencies and USFWS	Private organizations, such as watershed groups and other concerned citizens

CYGNUS OLOR (MUTE SWAN)
IMPLEMENTATION TABLE: COMMUNICATION & INFORMATION ACCESS

Goal	Action	Time Frame	Cost	Funding Source(s)	Lead Agencies	Partners
Improve public education and outreach	I.D. target audiences and assess their knowledge, perceptions, values. Develop outreach plan. Group with other invasives in message. Clarify message and information for media. Use all available resources	Begin immediately, continue for the next three to five years.	TBD	State and Federal agencies, private foundations	State agencies, USFWS, USDA.	Citizen groups, watershed organizations, Sea Grant, CBF, ACB, private foundations

CYGNUS OLOR (MUTE SWAN)

KEY ISSUES

Issue and Needs

The mute swan's dramatic beauty and size make it among the most high profile of exotic and invasive species. Its image appears in paintings and on the covers of fairy tale stories and other books. In the Chesapeake Bay region, however, the mute swan poses a series of threats to the local ecosystem, most notably displacing native birds — due to its highly territorial nature — and consuming large amounts of submersed aquatic vegetation (SAV). Restoring underwater grasses to the Chesapeake is, of course, one of the principle aims of the current multi-million dollar Bay restoration effort.

A key issue, then, is the need for public education, to make clear why these birds, though beautiful, can be detrimental to the environment, and why their spread should be halted.

At the same time, much remains to be learned about the region-wide movement of mute swans. Monitoring efforts should be expanded, and state and federal agencies in particular should fund research into the mechanisms for migration, establishment and reproduction. Beyond this, some very difficult decisions remain about what population levels are acceptable in the Chesapeake region.

Current needs include:

- The need to agree on common goals (e.g. a population objective);
- The need to control population growth (at some level);
- The need to mitigate damage to underwater grasses, disturbance of native species and habitats, and noxious interactions with humans;
- The need to strengthen the stakeholder process through conflict resolution and public involvement;
- The need to coordinate with the Atlantic Flyway Council Plan.

Coordination and Funding

Central to addressing these needs will be adequate coordination and funding. Coordination will not happen on its own, but will require concerted effort on the part of state and federal agencies, as well as interested private groups and foundations, to assure that strategies and implementation plans are carried out in effective and complementary ways. It will be especially important for states and jurisdictions in the Chesapeake watershed to coordinate their efforts, and the Chesapeake Bay Program can help guide this process.

Research, Monitoring and Outreach

Equally important will be the targeting of adequate funding toward key questions about swan reproduction and behavior, and about the effect of swans on important habitats and sensitive ecosystems. The burden for this funding will need to be shared by federal, state and private sources. Federal funds will prove especially important for supporting research on swan movement and behavior; state funds will be key for monitoring and

depredation efforts; and private sources will help augment both targeted research projects and public outreach efforts, including the enlistment of volunteers to aid in surveys.

Without adequate research, monitoring and outreach, controlling the Bay region's mute swan populations will prove problematic at best — poorly directed and in danger of being resisted by the broad public.

DRAFT MANAGEMENT PLAN

MYOCASTOR COYPUS **(NUTRIA)**

BREAKOUT SESSION PARTICIPANTS

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DRAFT MANAGEMENT PLAN

MYOCASTOR COYPUS **(NUTRIA)**

SPECIES SUMMARY

Description

Nutria are semi-aquatic rodents that exhibit rat-like features and are intermediate in general appearance and size, between muskrat and beaver. Adult nutria weigh about 15 to 20 pounds and are 2 to 25 inches in length. They have a round and scaly tail sparsely covered with bristles that comprises up to approximately 35 percent of their length. Nutria have webs between the inner four toes of their hind feet, but not between the fourth and fifth (outer toes). Their small, black, unwebbed front feet are much smaller than their hind feet. They have large front teeth, which range from yellow to dark orange. Their pelage consists of long, coarse guard hairs, which nearly conceal a thick, dense underfur. The general coloration of the upper parts is dark yellowish brown or reddish brown, masking the dark slate underfur (Burt and Grossheider 1976). Nutria are native to Brazil, Bolivia, Paraguay, Uruguay, Argentina and Chile (Nowak 1991).

Ecology

Sexual maturity occurs at about four to six months of age and is dependent upon food supply and availability. Nutria reproduce throughout the year, having two to three litters annually (Brown 1975; Willner et al. 1979). The gestation period of nutria is approximately 130 days after which 1 to 11 (typically four to six) young are born fully haired and with their eyes open (Nowak 1991). However, the rate of miscarriages is 45% and only 65% of the embryos survive to be born.

Nests are made with plant materials and consist of burrows dug into the river bank, or alternatively they are made in the burrows of other animals, such as in lodges of beavers and muskrats. When a female is in heat she may breed with one or several males each time she comes in heat. Nutria will breed both in and out of the water.

Female nutria usually come in estrus every 24 to 26 days and stay in heat for one to four days. Estrus begins within a day or two after giving birth or after miscarriage. Males are fertile and capable of breeding all year long. Young weigh approximately 225 grams at birth (Nowak 1991). They swim with their mother and feed on plant matter within 24 hours of birth (Whitaker 1988). Female nutria have four to five pairs of nipples located on the side of their torso, which allow them to suckle their young while swimming or to stand up and watch for predators (Gingerich 1994). The young are weaned in five to seven weeks (Lowery 1974; O'Neil and Linscombe 1977).

Nutria prefer a semi-aquatic habitat in swamps and marshes and along the shores of rivers and lakes. They generally live in pairs; however, the presence of many animals in a favorable habitat may give the impression of colonial living (Nowak 1991). Wild

individuals rarely live more than three years; captive individuals may live six to seven years with some reports of captive individuals living as many as 10 years. Predation, disease and parasitism, water level fluctuations, habitat quality, highway traffic, and weather extremes affect mortality. Population wide annual mortality is between 60 to 80% (Willner 1982).

Nutria feed on almost any terrestrial or aquatic green plants and occasionally consume grains (Whitaker 1988). Important food plants in the United States include cordgrasses (*Spartina* spp.), bulrushes (*Scirpus* spp.), spikerushes (*Eleocharis* spp.), chaffflower (*Alternanthera* spp.), pickerelweeds (*Pontederia* spp.), cattails (*Typha* spp.), arrowheads (*Sagittaria* spp.) and flatsedges (*Cyperus* spp.). Work by Gosling (1974) found that nutria could consume up to 25% of their body weight in plants per day. Where abundant, they may cause severe damage to vegetation. Feeding habits of nutria vary considerably. They feed while in the water, on floating objects or on land. Nutria commonly cut off a preferred food near the waterline and swim it or carry it to a feeding platform (five to six feet across) for eating. They seem to prefer the soft, succulent parts near the bases of plants, especially when eating coarse plants such as cattail, cord grass and reeds.

Introduction History

Nutria were intentionally introduced into North America for their fur. The first nutria for fur farming in North America were imported in 1899 from South America to Elizabeth Lake, California; these nutria apparently were not successful in reproducing, and very little information is available on their eventual fate. The 1930s are generally considered the boom years for establishing nutria ranches in the United States, though between 1899 and 1940 ranches were established in California, Washington, Oregon, Michigan, New Mexico, Louisiana, Ohio, Utah and elsewhere (Evans 1970).

Shortly after the boom years, World War II came and nutria farming virtually collapsed, a collapse that can be attributed to poor reproduction, low fur prices and competition with beaver pelts (also bringing low prices). Some ranchers released their nutria or did nothing to recapture those that escaped because of inadequate holding facilities, storms or floods (Evans 1970). State and federal agencies and individuals translocated nutria into Alabama, Arkansas, Georgia, Kentucky, Maryland, Mississippi, Oklahoma, Louisiana and Texas, with the intent that nutria would control undesirable vegetation and enhance trapping opportunities. Nutria were also sold as “weed cutters” to an unknowing public throughout the Southeast. A hurricane in the late 1940s aided dispersal by scattering nutria over wide areas of coastal southwest Louisiana and southeast Texas (Evans 1983).

Nutria were introduced in Maryland in the 1950s to promote the fur industry. Earlier, in 1943, the federal government brought nutria to Dorchester County, Maryland. This location on Maryland’s lower Eastern Shore was part of an experimental fur station at Blackwater National Wildlife Refuge (Blackwater NWR). In a relatively short period of time, captive rearing proved unprofitable and the remaining project nutria either escaped and/or were inadvertently released; in addition, a limited number of nutria were reportedly released by adjacent landowners (Willner, 1979). These animals functioned as the origin of the now overwhelming populations in the state (Robert Colona, pers. comm.). Currently, there is virtually no commercial fur market and only a very small meat market for nutria. This situation combined with the animal’s reproductive success

has led to a population boom: for example, estimates on a 10,000 acre parcel of land located in Dorchester County have expanded from less than 150 nutria in 1968 to 35,000 to 50,000 animals today (Robert Colona, pers. comm.).

Because of its high rate of productivity, aggressive nature and similar habitat needs, nutria compete with and displace native muskrats. Although foxes, owls and racoons prey upon young nutria, humans are the only predators to take adults in this region. Nutria feeding habits can also be extremely destructive to marsh vegetation: the animal forages directly on the vegetative root mat causing what is called an “eat out.” This type of feeding loosens the plant’s hold on the soil; without this binding mechanism, the soil washes away. Animals start the process by grazing; wind, waves and tides then remove any remaining soil and plants. “Eat-outs” can turn productive wetlands into barren mud flats that often cannot be re-vegetated.

Distribution in the Chesapeake Bay Watershed

There are confirmed reports of nutria from the Chesapeake Bay Bridge to Ocean City, Maryland, and south to the Virginia border (see Appendix I nutria distribution map). Nutria are also on the western shore of Maryland in the Patuxent and Potomac rivers, and to the northeast in Delaware (Bounds 1998). There are established populations in at least eight counties on the eastern shore of Maryland, with the densest populations in Dorchester County (Robert Colona, pers. comm.).

Management Efforts within in the Chesapeake Bay

Delaware

There have been sightings of nutria along the Nanticoke River but population numbers and distribution are limited. There are no research or management activities associated with nutria at this time.

Maryland

Rapidly increasing numbers of nutria, coupled with resultant marsh loss, prompted the formation of a nutria control partnership in Maryland. This partnership, which includes over 27 state and federal agencies and private organizations, produced a comprehensive pilot project proposal in 1998 entitled, “Marsh Restoration: Nutria Control in Maryland.” The project focused on development of techniques for both removing nutria and reversing marshland degradation (Robert Colona, pers. comm.).

On October 30, 1998, President Clinton signed PL 105-322, which authorized the Department of the Interior to expend up to \$2.9 million for the three-year pilot project. The Pilot Project began in January 1, 2000, and will end in December 2004. The project’s management team includes the Maryland Cooperative Fish and Wildlife Research Unit, Maryland Department of Natural Resources, University of Maryland Eastern Shore, and U.S. Fish and Wildlife Service. Its three phases include: (1) conducting public outreach and education; (2) collecting baseline data on nutria behavior and reproductive physiology; and (3) testing various control methods for the purpose of eradicating nutria in the study sites.

For the third objective, there will be a brief three month period (January to April 2002) of trapping to assemble pre-intensive harvest baseline data. Intensive harvest will then be

implemented in March 2002 on three discrete areas in Dorchester County (Blackwater NWR, Tudor Farms, and Fishing Bay Wildlife Management Area). These harvested areas will be paired with three equal size areas where limited harvest will occur, and three equal size areas where no harvest will occur. Harvest will initially be focused on 1,500 acres of marsh, though this area may expand if eradication occurs quickly. Effects of intensive harvest on home range and movement, health and reproductive behavior and performance of nutria will be examined and compared to baseline data collected in 2000 and 2001. The management team will also examine how intensive harvest affects temporal patterns of gonadal steroid secretion during their reproductive cycle. This information will be used to formulate effective strategies for controlling nutria.

In April 2002, a pilot eradication effort will begin in Maryland on Blackwater NWR, Fishing Bay Wildlife Management Area (WMA) and Tudor Farms. The pilot will test two prospective eradication methods, perimeter trapping and saturation trapping using both foothold and conibear type traps, to determine the most efficient eradication method. A sustained trapping effort based on the average daily movements of nutria (about 40 acres) and landscape habitat features will proceed in a strategic and directional manner across the marshes on these properties in order to compare the two methods. Follow-up trapping efforts will be conducted in already trapped areas, and trapping parameters correlating to a reasonable conclusion of successful eradication will be developed. A monitoring protocol to determine ultimate success or failure of eradication efforts at already trapped sites will be implemented. It is hoped that the two-year effort will answer the elemental questions of whether or not nutria can indeed be eradicated from the Chesapeake Bay ecosystem, and what level of effort is required to do so.

Virginia

At this time, there are no research or management activities associated with nutria in Virginia. Population numbers and distribution are limited. Individuals have been sighted and trapped at Saxis WMA and Back Bay NWR. There has been no evidence of marsh damage or “eat outs” by the nutria in these two areas.

Legal Status of Nutria

Delaware

Nutria are regulated as a furbearer species.

Maryland

Nutria are listed as “unprotected”; therefore the Maryland Department of Natural Resources does not have the authority to regulate them, though they can be controlled or eradicated within the Department’s authority to control wildlife populations that cause damage to other resources or economic interests.

Virginia

Nutria are considered a “nuisance” species in Virginia. It is unlawful to take, possess, transport or sell all other wildlife species not classified as game, furbearer, or nuisance, or otherwise specifically permitted by law or regulation. There is a continuous open season for trapping nuisance species.

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- Nutria and Trade <http://www.american.edu/TED/NUTRIA.HTM>
- Nutria <http://www.nationaltrappers.com/nutria.html>
- "The effect of nutria (*Myocaster coypus*) on marsh loss in the lower eastern shore of Maryland: an exclosure study" <http://www.pwrc.nbs.gov/resshow/nutria.htm>

USGS Nonindigenous Species Mammal Distribution Information

<http://nas.eer.usgs.gov/mammals/>

United States Fish and Wildlife Service Chesapeake Bay Nutria Control

<http://invasives.fws.gov/Indexhottop.NU.html>

MYOCASTOR COYPUS (NUTRIA)

EXPLANATORY TEXT FOR THE IMPLEMENTATION TABLE

Introduction

The group agreed that nutria present a unique case among the six species examined at the workshop. First, they agreed that the nutria problem has two distinct foci—the Blackwater “hot spot” and the Virginia population(s). Second, an infrastructure for nutria management now exists (*Nutria Control/Marsh Restoration Partnership*). Congress has authorized the U.S. Department of Interior to fund this effort (\$2.9 million for a three year pilot project) that will focus on control and marsh restoration techniques in Dorchester County, MD. Together, these factors will structure the development and implementation of the management plan. In general terms, the group felt that it was essential to build upon the *Nutria Control/Marsh Restoration Partnership* and to develop a strategy that will ultimately shift from localized to regional efforts directed at this species.

Leadership Coordination and Regulatory Authority

The group felt that the biggest challenges for this species is coordination of control and management among the different states in the Chesapeake Bay region. They questioned whether the states are managing the species in the same way, and discussed the importance of regional coordination on several levels—from upper-level agency managers to the individuals who are tasked with monitoring and control. In addition, because of the infrastructure established through the *Nutria Control/Marsh Restoration Partnership* (henceforth referred to as “*The NC/MRP*”) it is important that there be coordination with academic as well as federal participants throughout. The participants felt that actions to enlist Delaware (and possibly Pennsylvania) to develop a regional working group that will share information and provide a structure for seeking agreement on strategies among the relevant agencies could be initiated in very short order and would be of great benefit. The participants recognized the need for formal memoranda of understanding and mechanisms to link to the *NC/MRP*. This will prepare the states for their role in management of this species after the *NC/MRP* is completed. The participants also agreed that enhanced linkages to federal agencies and states outside the region would be essential as a long term strategy to gain control of nutria in the Chesapeake Bay ecosystem. The *NC/MRP* should be used to model the management plan but adaptive management should be utilized as results from the pilot project come in to ensure that new information and strategies are built into ongoing efforts in a proactive, timely manner.

A particularly important challenge with regard to leadership and regulation is the issue of gaining access to access to private lands. Identifying landowners with nutria on their property was seen as a first step. The group felt that a concerted effort would be needed on several fronts (particularly regulatory and education) to overcome this barrier. For instance, a demonstration project where managers and researchers could communicate

and educate the public could be developed to help landowners see the need for the wide scale effort. Leadership should recognize that a major objective in the regional nutria plan should be to gain public trust. Efforts to enlist non-governmental organizations and to provide opportunities for public comment to be used in the development of policy regarding nutria were also discussed and seen as an important leadership responsibility. In addition, designation of nutria as noxious species would provide a separate avenue to gain access. Many of these activities would be facilitated by designation of a “nutria coordinator” who could act as the point person on this issue.

Early Detection and Rapid Response

The participants concurred that discussions of Chesapeake Bay nutria should emphasize that there are two different populations—Maryland and Virginia—and that there is some geographical isolation of the Dorchester County, Maryland population. Because of this isolation there should be a focus on eradication in Maryland. Further more, we should also attempt to understand the impacts and dynamics of the southern Virginia population and look at physical barriers on the western shore. These basic conclusions will structure monitoring and response efforts. At the outset, the participants felt that more monitoring needs to be conducted in areas other than Dorchester County.

The group discussed whether populations in Delaware and Virginia are genetically different from the extensive population in Dorchester County. This information is of critical importance as a key consideration is whether nutria are dispersing from the Blackwater “hot spot” into Dorchester County and potentially to Delaware. The group felt that there are potentially two different populations in Virginia—one with a source population from North Carolina and one with a source population from Dorchester County, MD.

The participants felt that it was essential to establish a barrier—using appropriate control and or eradication techniques—for movement of the southern nutria population (Back Bay, VA) to new environments on the Western Shore of the Bay and the Dorchester County, MD population out from the Blackwater “hot spot”. Monitoring efforts were viewed as an essential component of the management plan in this regard. The group endorsed the idea that the potential of new monitoring technologies (i.e., forward looking infrared radar) should be explored.

Control and Management

There was general consensus within the group that this species is a problem and they concurred that the management plan should focus on efforts to eradicate nutria in the Chesapeake Bay. However, with that noted, they recognized the need to fully communicate the impact of nutria on marsh environments—both in an ecological and economic sense. The group felt that management was hindered by the fact that stakeholders do not fully understand the scope of the problem. The effects of nutria on the marsh environment depend on population dynamics, when they were introduced, if they immigrated into an area and a variety of factors including weather and climate (i.e., the severity of winters). Hence outreach that outlines need and justification for eradication should be undertaken and appropriate stakeholders contacted. The group also discussed eradication and if this was the only solution to minimizing the ecological

effects (marsh loss, competition with muskrat, etc.) that nutria cause. There was a question of whether there could be some level of harvest (versus full eradication) in which minimal ecological effects would occur. For instance, what population level would you have to achieve to insure that the species would not be reproductively viable? The participants also discussed options for and alternatives to eradication. Sterilization has been considered, but several participants noted that some animal populations that are sterilized live longer and still impact the environment. Sterile nutria might still cause severe degradation of marsh habitat, however participants noted that nutria sterilization research could further clarify the effectiveness of a nutria sterilization alternative to eradication. The use of toxicants was also discussed, however the participants raised concerns regarding the non-specific nature of this approach. The group agreed that studies of alternative methods of control/eradication should be undertaken and that all efforts should seek to find effective methods that minimize pain and suffering to the animal.

Communication and Information Access

The group talked extensively about the need for a concerted education effort that extends from broad approaches to personal contacts with private landowners. Complex economic factors that reach from the local to the global levels underlie this issue and will impact eradication efforts. Explanations that focus a common message with an emphasis on the economic and ecological value of the animal and the marsh habitat (and loss thereof) were seen as being of central importance. It was noted that the public should be aware that other factors (e.g. development, sea level rise) are also important factors effect marsh damage and loss. There was concern noted in the group that the public needs to understand that long-term efforts to protect marshes will need to go beyond nutria management.

Outreach should use multiple routes that make use of partnerships in state agencies as well as the academic community. Both Land and Sea Grant Extension were seen as potential partners in this regard. The group suggested that trappers or peers of private landowners be enlisted for outreach Education of trappers—in particular that there is a net loss in muskrat revenue due to the presence of nutria was noted as a priority. This approach would enfranchise key communities. The participants also recognized the need for an outreach infrastructure (web, print and personnel). The “nutria coordinator” was viewed as an essential component.

MYOCASTOR COYPUS (NUTRIA)
IMPLEMENTATION TABLE: CONTROL AND MANAGEMENT

Action	Time	Cost	Source	Agency	Partners
<p>Give the <i>Nutria Control/Marsh Restoration Partnership</i> sufficient time to test methodologies and develop strategies. Emphasis should be on “adaptive management” during the course of the project.</p>	Through 12/04	\$2.9 M	Department of Interior	FWS, MDDNR, UMES	27 different partners
<p>Seek additional funding for long-term efforts to insure that findings and techniques developed during the <i>Nutria Control/Marsh Restoration Partnership</i> program can be fully implemented,</p>	Ongoing		Congress		
<p>Develop targeted research projects to provide:</p> <ul style="list-style-type: none"> • Alternative methods of control with an emphasis on reducing pain and suffering • Improved tagging and studies of dispersal • Understanding population genetics of Chesapeake Bay nutria • Economic valuation of nutria and an analysis of environmental impact of marsh loss attributable to the animal • Comparison of nutria impacts on marshes with other factors (sea level rise etc.) 	Ongoing		NWRC (Wildlife Services), NGOs, 1990 Capacity Building Grant National Sea Grant		State Agencies and academic researchers

***Myocastor coypus* (Nutria)**
IMPLEMENTATION TABLE: EARLY DETECTION AND RESPONSE

Action	Time	Cost	Source of Funds	Performing Agency	Partners
Monitor Extant Populations <ul style="list-style-type: none"> • Eastern Shore of VA • DE (along Nanticoke) • Dorchester County, MD 	Ongoing		State Agencies	State Natural Resource Agencies	<ul style="list-style-type: none"> • Citizens using web based reporting • Cooperative Extension to disseminate results
Conduct a trapping survey to assess the range of the VA nutria population	1-3 months	\$2,000	State Agencies	VA State Management agencies	
Monitor areas surrounding current population centers to quickly detect breakout to new areas <ul style="list-style-type: none"> • Particular emphasis should be placed on northward spread of the VA population to the Western Shore of the Chesapeake and spread of the Blackwater population to Delaware. 	Ongoing		State Agencies	State, Federal, NGO's, Cooperative extension	
Conduct research to support monitoring efforts. Emphasis should be placed upon <ul style="list-style-type: none"> • Research, development and testing of new monitoring protocols • Pilot test of forward looking infrared radar to assess eradication efforts 	12-24 months	\$300,000 \$5,000	Federal Agencies Sea Grant	State Agencies and Academic Institutions	State Agencies and Academic Institutions

MYOCASTOR COYPUS (NUTRIA)
IMPLEMENTATION TABLE: LEADERSHIP, COORDINATION & REGULATORY AUTHORITY

Action	Time	Cost	Source	Agency	Partners
Involve Delaware in all activities to establish better regional coordination	Immediately			Don't have furbearer management -Go to Wildlife and Heritage?	Local, state and federal agencies
Conduct an initial survey to establish listing of relevant agency personnel (DE, MD, PA, VA) and initiate a dialogue at the appropriate management levels	2-4 months			State management agencies	State management agencies
Establish links with relevant NGO's, (<i>i.e.</i> , The Nature Conservancy) with an emphasis on the Nanticoke River	6-12 months			State management agencies	Academic Institutions, other agencies
Initiate groundwork for designating nutria as a noxious species in Maryland	12 months			Eastern Shore Delegation	
Recognize and examine private lands issues and their impact on control strategies.	12-24 months			Academic Institutions, other agencies	State management agencies
Develop mechanisms for national coordination by seeking input from relevant state and federal agencies across nutria's range.	12-24 months			Dept of Interior Dept of Agriculture and others	
Establish nutria Coordinator position (.5FTE)	12 months				

MYOCASTOR COYPUS (NUTRIA)
IMPLEMENTATION TABLE: COMMUNICATION & INFORMATION ACCESS

Action	Time	Cost	Source	Agency	Partners
Widely communicate the results of the <i>Nutria Control/Marsh Restoration Partnership</i> studies	Ongoing				
Involve Cooperative Extension (Land and Sea) personnel in various outreach efforts as appropriate	3-6 months			DNR FWS	Maryland Cooperative Extension, Sea Grant
Undertake multiple efforts to educate and involve citizens—including contacts with NGO's, hunters and outdoor enthusiasts (boaters, fisherman, etc.)	3-6 months			DNR FWS	
Develop a viable information infrastructure including a Web Clearinghouse and GIS database, establish multiple routes for public input (phone, paper, web) and implement systemic verification of public sightings by relevant agencies	6 months			DNR FWS	
Develop outreach that recognizes the complex nature of the problem including the value of nutria vs. muskrat and a discussion of harvest issues	6-12 months			DNR FWS	Maryland Cooperative Extension, Sea Grant

**MYOCASTOR COYPUS
(NUTRIA)**

KEY ISSUES

- The *Nutria Control/Marsh Restoration Partnership* (henceforth referred to as “*The NC/MRP*”) provides a strong foundation upon which viable strategies and mechanisms for eradication of nutria may be developed. Given the strong federal support and the extensive partnership developed by the NC/MRP, it is essential to use this vehicle as the base for nutria management in the Chesapeake region.
- Recognizing there are separate populations of nutria in the Bay and separate state jurisdictions makes it essential to quickly develop regional coordination between all the states. Particular emphasis should be placed upon appropriate monitoring with a special focus on discerning if “breakout” of the Blackwater and/or Virginia populations occurs.
- A focused outreach effort designed to explain the risk from nutria and to enfranchise relevant stakeholders in the control effort is essential to the long-term success of the program.

DRAFT MANAGEMENT PLAN

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Paul Fofonoff	Smithsonian Environmental
Adam Frederick	Maryland Sea Grant
Kevin Gilbert	US Coast Guard, Baltimore
Jeff Gregg	Pennsylvania Game Commission
Tom Horvath	University of New York at Oneonta
Roberta Marinelli	Chesapeake Bay Laboratory
Eric Obert	Pennsylvania Sea Grant
Tony Shaw	Pennsylvania Depart. of Environmental Protection
Harley Speir	MD Dept. of Natural Resources
Tom Wilcox	VA Dept. of Game and Inland Fisheries

DRAFT MANAGEMENT PLAN

DREISSENA POLYMORPHA **(ZEBRA MUSSEL)**

SPECIES SUMMARY

Description

Zebra mussels are temperate, freshwater bivalve molluscs. Adults range from 0.5 to 3.5 cm in length. External coloration of the shell is highly variable (thus the species name *polymorpha*), though most exhibit some form of the characteristic dark brown and cream concentric banding that gives the organism its common name. The anterior end of the shell is greatly reduced; the posterior is inflated. The ventral side is wide and flat.

Biology

Zebra mussels are dioecious (either male or female) broadcast spawners. Mature females can produce 30,000 to one million eggs per year. Spawning occurs when water temperatures exceed 12°C and peaks at 15° to 17°C (Nichols 1993; Claudi and Mackie 1993). The veliger larvae are planktonic, and it is during this stage that currents can easily transport larval zebra mussels from one body of water to another. Following the planktonic larval stage, which can last from three days to three months depending on water temperature (Nichols 1993), the zebra mussel larvae settle to the bottom; their survival depends on settling on a hard surface. Zebra mussels will colonize almost anything solid: rocks, aquatic plants, boat hulls, pier pilings, buoys, water intake screens and the shells of other molluscs are common points of attachment. They often grow in large colonies as young mussels settle on the older, larger zebra mussels, forming a clump called a “druse” (Claudi and Mackie 1993). Attachment is by strong byssal threads.

Temperature, salinity and calcium are limiting factors. Zebra mussels grow and reproduce best in water with a temperature range of 12 to 26°C and a calcium content of 25 to 35 mg/L. Calcium is important for growth and maintenance of the shell. Food is obtained through filter feeding; phytoplankton, small zooplankton, bacteria and detritus in the size range of 15 to 40 µm make up the bulk of their food. The filtering capacity of zebra mussels has been estimated at 10 to 100 ml/individual/hour (Claudi and Mackie 1993).

Distribution

D. polymorpha is native to eastern Europe, including the Black, Azov and Caspian seas. It spread through western Europe via canals and inland waterways that were connected to facilitate trade during the Industrial Revolution (Morton 1993). Although a freshwater organism, the zebra mussel can survive in slightly brackish water.

Zebra mussels were first documented in North America in Lake St. Clair in 1988. They were most likely transported unintentionally in the ballast water of transoceanic ships. By the fall of 1989 they were widespread in Lake Erie (Leach 1992), and by December 1993

zebra mussels were in all the Great Lakes, 18 states, and two provinces. By 2000, zebra mussels inhabited most stretches of the Mississippi, Illinois, Ohio, Mohawk, Hudson, St. Lawrence, Cumberland, Tennessee and Arkansas rivers as well as tributaries including the Missouri, Allegheny, Monongahela, Wabash and St. Croix rivers. Zebra mussels have colonized New York's Finger Lakes, Lake Champlain, Wisconsin's Lake Winnebago, Kentucky Lake and nearly 100 smaller inland lakes in seven of the eight states bordering the Great Lakes. A second *Dreissena* species, *D. bugensis* or the quagga mussel (named after an extinct zebra-like horse), appeared in North America in 1991 in Lake Erie and Lake Ontario. It is now found in the St. Lawrence River as far downstream as Montreal as well as in Lake Michigan and Lake Huron (University of Wisconsin Sea Grant Institute, Sea Grant Great Lakes Network).

In the summer of 2000, an established population of zebra mussels was found in the northernmost part of the Chesapeake Bay watershed, in Eaton Brook Reservoir in Madison County, New York. This population is currently being monitored by Dr. Thomas Horvath from the State University of New York-Onoenta and Scott Ingmire of the Madison County Planning Department (Scott Ingmire pers. comm.). A map of U.S. occurrence of zebra mussels is available from New York Sea Grant (North American Range of the Zebra Mussel, March 2002) at www.seagrant.sunysb.edu.

Ecological Concerns

Zebra mussels filter large amounts of phytoplankton from the water, which can lead to significant changes in ecosystem trophic dynamics. Such filtering activity has been observed to improve water clarity, which can increase light penetration; Pillsbury and Lowe (1994) found, for example, a proliferation of aquatic plants and changes in species dominance, including shifts from benthic diatoms to benthic filamentous green algae.

Zebra mussels can tolerate moderate pollutant stress and bioaccumulate contaminants; there is evidence they are involved in the trophic transfer of pollutants, particularly where waterfowl feed on zebra mussels (de Kock and Bowmer 1993). They can also cause major changes in the structure of benthic colonizing surfaces as they rapidly cover all available rock or similar hard substrate. The resulting mass of zebra mussel shells presents a more complex, three-dimensional substrate, which can lead to a change in the populations of benthic organisms that inhabit the area (Pillsbury and Lowe 1994).

Zebra mussels are a major threat to endangered North American freshwater mussels: their growth on the shell of unionids causes stress and mortality due to feeding interference. Zebra mussels rapidly encrust the native mussel's shell, competing with the unionid for food and impairing its ability to open and close its shell and to move and burrow (Parker et al. 1998).

Economic Concerns

Zebra mussels are major biofouling organisms. Their rapid colonization of solid surfaces causes serious problems at water treatment facilities, power plants, marinas, docks and boatyards. Intake pipes and screens become clogged with massive clumps of zebra mussels; buoys have sunk from the weight of the shells, and piers, pilings and boat hulls have become heavily fouled. In addition, recreational beaches have been altered when the shells of dead zebra mussels wash up in large drifts. The U.S. Geological Survey has

estimated that the cost of controlling zebra mussels in the Great Lakes region alone, may soon reach \$5 billion annually. It is estimated that the mussel has cost the power industry \$3.1 billion since 1993; the estimated impact on industries, businesses and communities is over \$5 billion (New York Sea Grant 1994).

Control Strategies

The need for controlling zebra mussels has spawned a multi-million dollar industry. Removal of established zebra mussels is usually a temporary solution. Treatments must be repeated periodically as recolonization occurs unless *Dreissena* is completely removed from the entire body of water, which is relatively impossible in most cases.

Methods of controlling zebra mussels include:

- Chemical controls
- Biological controls
- Oxygen deprivation
- Thermal treatment
- Exposure and dessication
- Radiation
- Manual scraping
- High-pressure jetting
- Mechanical filtration
- Removable substrates

Describing these methods is beyond the scope of this briefing paper. For research abstracts and other information on each of the control strategies listed, see the excellent bibliographic database on the Sea Grant National Aquatic Nuisance Species website <http://www.cce.cornell.edu/aquaticinvaders/>.

Federal Regulations

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 amended the Lacey Act to include the zebra mussel to the list of injurious fish, molluscs and crustaceans. The U.S. Fish and Wildlife Service (USFWS) has also amended its regulations to include the zebra mussel. Effective December 9, 1991, the importation of live zebra mussels, veligers or viable eggs into the United States, or transportation between the continental United States, the District of Columbia, Hawaii, the Commonwealth of Puerto Rico, or any territory or possession of the United States by any means is prohibited except by permit for zoological, educational, medical or scientific purposes. This prohibition includes any species of the genus *Dreissena*. Permits are issued by the director of the USFWS.

Management Efforts in the Chesapeake Bay Watershed

Delaware

No identified established populations of zebra mussels have been confirmed in Delaware. The Department of Natural Resources and Environmental Control is the contact agency.

Maryland

No identified established populations of zebra mussels have been confirmed in Maryland. The Maryland Department of Natural Resources Fisheries Service is the contact agency for sightings and for information requests.

Pennsylvania

Zebra mussels are established in western Pennsylvania; there has been one confirmed point sighting in eastern Pennsylvania (west of the Delaware River). The Pennsylvania Department of Environmental Protection Zebra Mussel Monitoring Program functions as a tracking and information referral service. As new sightings are reported, local water users are notified so they can implement preventive measures in their area.

Virginia

No identified established populations of zebra mussels have been confirmed in Virginia. The Department of Game and Inland Fisheries is the contact agency for reports of zebra mussel sightings. The Virginia Sea Grant Marine Advisory Program at the Virginia Institute of Marine Science assists in responding to reports of zebra mussel sightings.

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DREISSENA POLYMORPHA
(ZEBRA MUSSEL)

EXPLANATORY TEXT FOR THE IMPLEMENTATION TABLE

Leadership, Coordination and Regulatory Authority

Establish Panel for Rapid Response

The participants felt that establishment of a rapid response mechanism was a high priority based on the presence of zebra mussels in the Eaton Brook Reservoir in New York, within the Chesapeake Bay watershed. The group noted that during the discussion following Dr. Tom Horvath's presentation on Day 1 it seemed possible to delay/prevent the spread of zebra mussels throughout the Chesapeake basin by eradicating them from Eaton Brook Reservoir where zebra mussels are established. A rapid response to eradicate the zebra mussel population in Eaton Brook Reservoir could serve as a model for rapid response and eradication of zebra mussels introduced into the watershed. The participants thought such a proactive approach in prevention would set an important precedent in zebra mussel management.

Early Detection and Response

Adapt Existing Policy and Implementation Plan

Three members of the Exotic species workgroup (Chesapeake Bay Program) participated in the zebra mussel session. All three had participated actively in the development of the CBP Policy for the Introduction of Non-Indigenous Species (CBP—Dec., 1993) and felt that much of the discussion focused on issues that had been considered in the Policy deliberations. The participants suggested providing electronic copies of the Policy to the workshop participants and others that will be involved in this issue. The Maryland Sea Grant Program's exotics web site (www.mdsg.umd.edu/exotics) may be a good location for the electronic information.

Establish Zebra Mussel Monitoring Stations and Review Existing Programs

Because introduction of zebra mussels into Maryland and Virginia appears imminent, the participants felt that establishment of zebra mussel monitoring stations was a high priority. Zebra mussel monitoring is in progress, but it is important that States review their monitoring program in light of recent zebra mussel distribution records and modify accordingly.

Website reporting for zebra mussel sightings

Although "hotlines" for zebra mussels are active, an alternative reporting method based on the Web is appealing. Participants suggested building a reporting site into the CBP website with links to Sea Grant Programs.

Evaluate and Communicate Sampling Protocols

Sampling protocols were discussed during the development of the CBP Policy (noted above), but standardization among jurisdictions was deemed impractical. With increasing

risk of introduction to the Bay-contiguous states this may be a good time to review and possibly standardize methods.

Control and Management

List of Approved Treatment Methods

With increasing risk of introduction it is important to provide information to water -based utilities on approved treatment methods for zebra mussels. Much of this information is available through the Zebra Mussel Clearing house maintained by Chuck O'Neill (NY Sea Grant).

Regulatory Enforcement

The group felt that the existing regulatory base at State and Federal levels could be more effectively implemented through enforcement. This is a fairly long-term goal since it would require training existing personnel or the addition of new personnel.

Boat Cleaning and Boat Inspection

Recreational boating is a high-risk activity for zebra mussel distribution. Boat inspection and cleaning programs have been important in other parts of the country and should be developed here as well.

Increase Visibility of Zebra Mussel Clearinghouse

The visibility of the Zebra Mussel clearinghouse as a source of information on zebra mussels generally and control methods should be increased.

Clarify Permit Requirements in the Jurisdictions

As a corollary to the effort to list treatment methods, the group felt that it was important to clarify permit requirements within jurisdictions for the various control options.

Communication and Information Access

Enhance Pennsylvania's role as a Clearinghouse

Pennsylvania is currently very active in zebra mussel education/outreach and their role as a clearinghouse should be enhanced.

Chesapeake Bay Web site

Information on individual Bay nuisance species should be made available on a web site. These summaries could include information on identification, impacts, reporting and management.

Produce New Posters and Identification Cards

In the early preparations for zebra mussel introduction into the region posters with zebra mussel information and contact numbers were distributed to marinas and boat launch areas. In addition, identification cards were developed and made available at Tackle shops etc. These materials should be updated and new strategies for dissemination developed.

Distribute Existing Science Education Programs

Most Sea Grant programs have someone trained on the issue of zebra mussels and exotic species as well as supporting educational programs. Modifications to these programs

should be made available in a downloadable format to educators and others interested in presenting this information.

Wildlife Mapping Program

The Wildlife Mapping Program has been used in Virginia as a volunteer based method of gathering information on the distribution and ecology of wildlife. This program could be used as a method to increase volunteer monitoring by providing training on zebra mussels and other exotic species.

Prevention

Education about Introduction

The most immediate action is to increase educational activity on activities that have a high risk for zebra mussel introduction. Examples include: fish transfer (pond stocking, aquaculture), recreational boating, and angling (live bait).

Implement Rapid Response

Additional effort is needed to develop the necessary legislation and regulatory structure to prevent introduction. One possible approach proposed is the “DNR crab model” in which legislation was passed giving MD-DNR authority to develop regulations pertaining to non-indigenous crab species.

Work towards Legislation and Regulations for Rapid Response Mechanism

Implementation of a rapid response mechanism for eradication of zebra mussels in high-risk locations was considered a major consideration for prevention.

DREISSENA POLYMORPHA (ZEBRA MUSSEL)
IMPLEMENTATION TABLE: LEADERSHIP, COORDINATION AND REGULATORY AUTHORITY

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Est. panel for rapid response				CBP, state agencies	Stakeholders. Asst. Secretaries of resource agencies

DREISSENA POLYMORPHA (ZEBRA MUSSEL)
IMPLEMENTATION TABLE: EARLY DETECTION AND RESPONSE

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Adapt existing policy and impl. Plan (on disc)	6 mos.	Low	CBP	CBP, ESWG	
Est. ZM Monitoring Stations and review	1 year	High	State agencies, Federal grants	State agencies	
Website reporting for ZN sightings	1 yr	Low-moderate	CBP (build into Existing website)	CBP	Volunteer Orgs (Alliance for Bay, etc.
Evaluate and communicate samp. Protocols	3 mos.	Low		ZM Clearinghouse (Chuck O'Neill)	

DREISSENA POLYMORPHA (ZEBRA MUSSEL)
IMPLEMENTATION TABLE: CONTROL AND MANAGEMENT

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
List of Approved Treatment comps and methods	3 mos. (summer intern)			CBP, MDE,	
Regulatory enforcement	3 years to get it going	Moderate (use existing personnel)	State agencies	State agencies	
Boat cleaning and boat inspection	1 year to implement	Mod-high	State agencies	State Agencies	CBP, Coast Guard Aux, marinas
Increase public visibility for ZM Clearinghouse	Few months	Low	Sea Grant	Sea Grant	
Clarify permit requirements for controls	2 years	Moderate	State Resource Agencies	State Resource Agencies	

DREISSENA POLYMORPHA (ZEBRA MUSSEL)
IMPLEMENTATION TABLE: COMMUNICATION & INFORMATION ACCESS

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Enhance PA role as clearinghouse	3 mos.	Low		PA DEP (Tony Shaw)	CBP, all state resource agencies, SG
Website for Ches Bay nuisance species (ZM first!)	9 months	Low	CBP	CBP	Resource agencies and sea grant, researchers
Produce new and updated posters, ID cards	6 mos.	Moderate	Sea Grant	Sea Grant, CBP	State Agencies
Dist. Existing Sci Ed programs: Web and Cd	6 mos.	Low-mod	Sea Grant	Sea Grant	State Agencies, CBP
Wildlife mapping Program	3 mos.	Low	Va. Dept. of Game and Fish (J. Trollinger)	VDGIF	Volunteers

DREISSENA POLYMORPHA (ZEBRA MUSSEL)
IMPLEMENTATION TABLE: PREVENTION

Action	Time	Cost	Funding Source(s)	Lead Agency	Partner
Education about introductions	6 mos. –1 year	Low (existing info)	Sea Grant, Agencies?	Sea Grant	Resource agencies
Implement rapid response (see CBP policy)	6 months	Low (exists)	CBP	CBP	Sea Grant, state agencies, stakeholders
Work toward legislation/regs (use DNR crab Model)	Long term	Ridiculous	State coffers	State Nat. Res. Agencies	

DREISSENA POLYMORPHA **(ZEBRA MUSSEL)**

KEY ISSUES

Eradication of zebra mussel population in Eaton Brook Reservoir, NY

A high priority for the participants in this breakout session was the issue of zebra mussels in the Eaton Brook Reservoir, New York and the threat this established population posed to the rest of the watershed. The participants thought it was critical that States in the Chesapeake Bay region investigate the possibility of eradicating zebra mussels from Eaton Brook Reservoir, to alleviate risk of introductions to Chesapeake Bay watershed and to develop a model for hypothetical rapid response. The participants suggested developing a rapid response process to address the zebra mussel problem in Eaton Brook Reservoir and using that process as a model for a rapid response system that would apply under a variety of circumstances for different species. A panel of volunteers was assembled to synthesize information related to the Eaton Brook Reservoir situation including: Tom Horvath (NY) Eric Obert, (Pa. Sea Grant) and Harley Speir (MD_DNR). The participants developed the following rapid response outline for actions that the States could take in response to the establishment of a zebra mussel population, such as in Eaton Brook Reservoir.

RAPID RESPONSE MODEL: Hypothetical example of action to take to address control of zebra mussel population in Eaton Brook Reservoir, NY

- State source contacts CBP Exotic Species Workgroup
- Follow Exotic Species Working Group (ESWG) implementation plan (p. 14, Implementation Plan, CBP/TRS 146/96, EPA-903-R-96-004, Aug.1996) taking the following steps:
 - First, establish a small *ad hoc* panel with representatives from each state, including at-risk facilities and regulatory agencies, to identify and summarize sensitive components of ecosystems and facilities at risk.
 - Second, the committee evaluates and/or develops environmentally sound preventative and treatment control strategies as needed.
 - Third, *ad hoc* committee prepares a report summarizing finding and recommendations. Report is submitted to Living Resources Subcommittee for review.
- Dissemination to agencies involved.
- ESWG solicits input, then drafts advisory letter and offers ideas of plan of action.

Engaging the political process is an important component to ensuring that action is taken to contain or eradicate a newly discovered invasive species population (especially if scenario includes a non-signatory state). Increasing public awareness of the issue through education and outreach can lead to greater public participation in the issue, often resulting in political action being taken. The participants felt that it was very important to develop a rapid response program to control or eradicate the zebra mussel population in Eaton Brook Reservoir and recognized that

developing such a program would require public participation, action by regulatory agencies, and engagement of political leaders.

CONCLUSION

The purpose of this workshop was to develop management strategy frameworks to minimize the effects of six invasive species in the Chesapeake Bay watershed. Through the leadership of the Chesapeake Bay Program's Invasive Species Workgroup, these frameworks are to be developed into final invasive species management plans that Bay jurisdictions can then implement. The six framework strategies contained herein all highlight key issues and set out timetables for action.

It is broadly recognized that the effective management of invasive species often requires cooperation and coordination among all levels of government, as well as with the public and private sector. This workshop made a unique contribution by demonstrating an approach that multi-jurisdiction watersheds, such as the Chesapeake Bay, can use to develop regional strategies for managing invasive species. Although numerous other workshops and task forces have developed single aquatic species management strategies, this workshop took a broader approach by developing management strategies for numerous species simultaneously. The strength of such an approach is that it brings a variety of specialists together and provides an opportunity for cross-disciplinary, cross-jurisdictional, and cross-agency discussions on the best ways to share resources in the concurrent management of various invasive species across the watershed.

As the workshop participants discovered, there were areas of overlap for managing each of the species. There was consensus that monitoring needed to be strengthened, that there was a need for better communication across jurisdictions, and that public outreach needed to be strengthened. Rather than meeting these needs for each species, it was clear that combining efforts to include the broader range of Chesapeake Bay watershed species would constitute better use of limited resources.

Participants discussed the importance of the role of the Chesapeake Bay Program in facilitating efforts to meet the challenges outlined above and to coordinate with groups beyond the Bay watershed, such as the Aquatic Nuisance Species Task Force. They recognized that numerous government agencies must be involved as these six management strategy frameworks are finalized. Furthermore, because of the limited size of the workshop, the participants felt that further development of the management strategies required additional public participation and consensus building in the Bay region. A recurring theme throughout the workshop was the need for increasing public awareness of invasive species. There was consensus that effective management of invasive species required a strong public–industry–government partnership.

The ultimate success of this workshop will depend on the further actions taken to finalize these draft management plans. The jurisdictions have a strong commitment to the Chesapeake Bay 2000 Agreement, and to attaining the Agreement's goal: "to develop and implement management plans for those species deemed problematic to the restoration and integrity of the Bay's ecosystem." This commitment by the jurisdictions, combined with these comprehensive draft invasive species management strategy frameworks, bodes well for the successful completion and implementation of these plans. The Chesapeake Bay Program has the opportunity to lead the nation by implementing this plan for minimizing, on a regional scale, the effects of multiple aquatic invasive species.

ACKNOWLEDGMENTS

The design and organization of the workshop, including preparation of the species summaries, was guided by a steering committee composed of the following members:

Vicki Clark, Virginia Institute of Marine Science
Leo Dunn, Pennsylvania Department of Agriculture
Tilly Egge, EPA Chesapeake Bay Program
Richard Hammerschlag, U.S. Geological Survey
Fredrika Moser, Maryland Sea Grant College
Edith Thompson, Maryland Department of Natural Resources
Julie Thompson, U.S. Environmental Protection Agency
Tom Wilcox, Virginia Department of Game and Inland Fisheries
Maryland Sea Grant is grateful to them for their time and dedication to the workshop.

Thanks also to the many contributors to the final report and to the Workshop briefing book on which much of this final report is based. Those contributors include: Vicki Clark, Tilly Egge, Jack Greer, Jon Kramer, Merrill Leffler, Annette Meredith, Dan Nees, Edith Thompson, Julie Thompson, Dan Terlizzi and Kirstin Wakefield. Maryland Sea Grant staff, in particular Kim Cox, Rosali Lynn and Sandy Rogers, contributed significantly to running the workshop and preparation of workshop materials.

Pat Nowlin, GIS specialist at EPA, and Dave Morton, GIS Coordinator at the Virginia Department of Game and Inland Fisheries provided the species distribution.



Most importantly, thanks go to the workshop participants. Their energy, interest, and commitment to the difficult problem of invasive species management made this workshop a success.

APPENDIX I

SPECIES DISTRIBUTION MAPS

Nutria Presence in the Chesapeake Bay Watershed

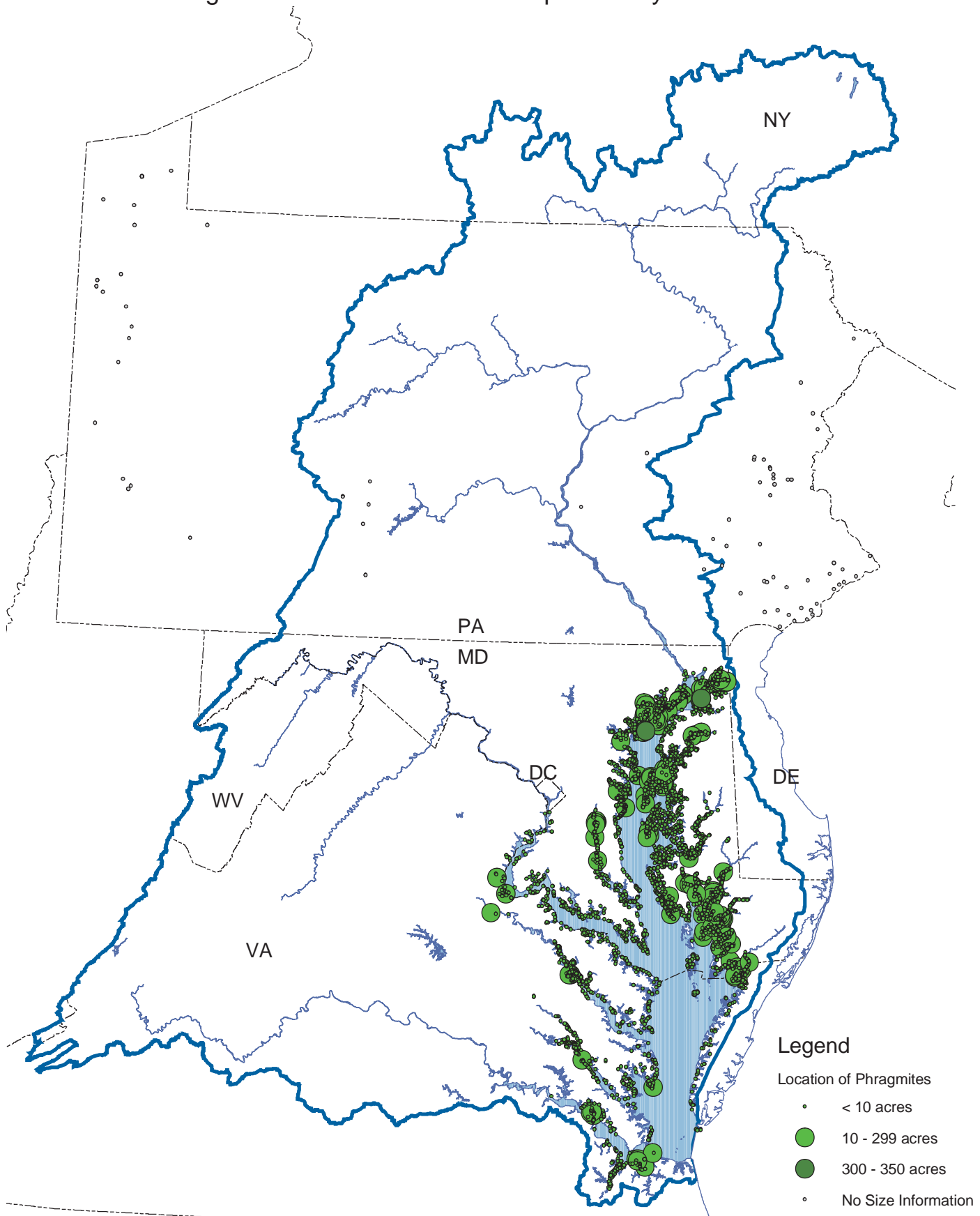
Legend

-  Nutria Present
-  Large Nutria Populations

Data Sources: Virginia distribution is by 14-digit watershed. The source is VDGIF and is current to 2002. Maryland distribution is by county. The information is from MD DNR. The large nutria population is in Dorchester County Maryland where Nutria were introduced in 1943. Locations in Delaware were identified by Julie Thompson of the U.S. Fish and Wildlife Service and are current as of June 2000. The Delaware areas are 1/6th USGS topo quads.



Phragmites Presence in the Chesapeake Bay Watershed



Data Sources: 1995 U.S. Fish and Wildlife Service survey.
Three Virginia Natural Area Preserve surveys between 1997
and 2001. Pennsylvania information is from the Morris Arboretum.
The Arboretum data ranges from historic to present times.



0 50 100 Miles



Mute Swan Presence in the Chesapeake Bay Watershed

Legend

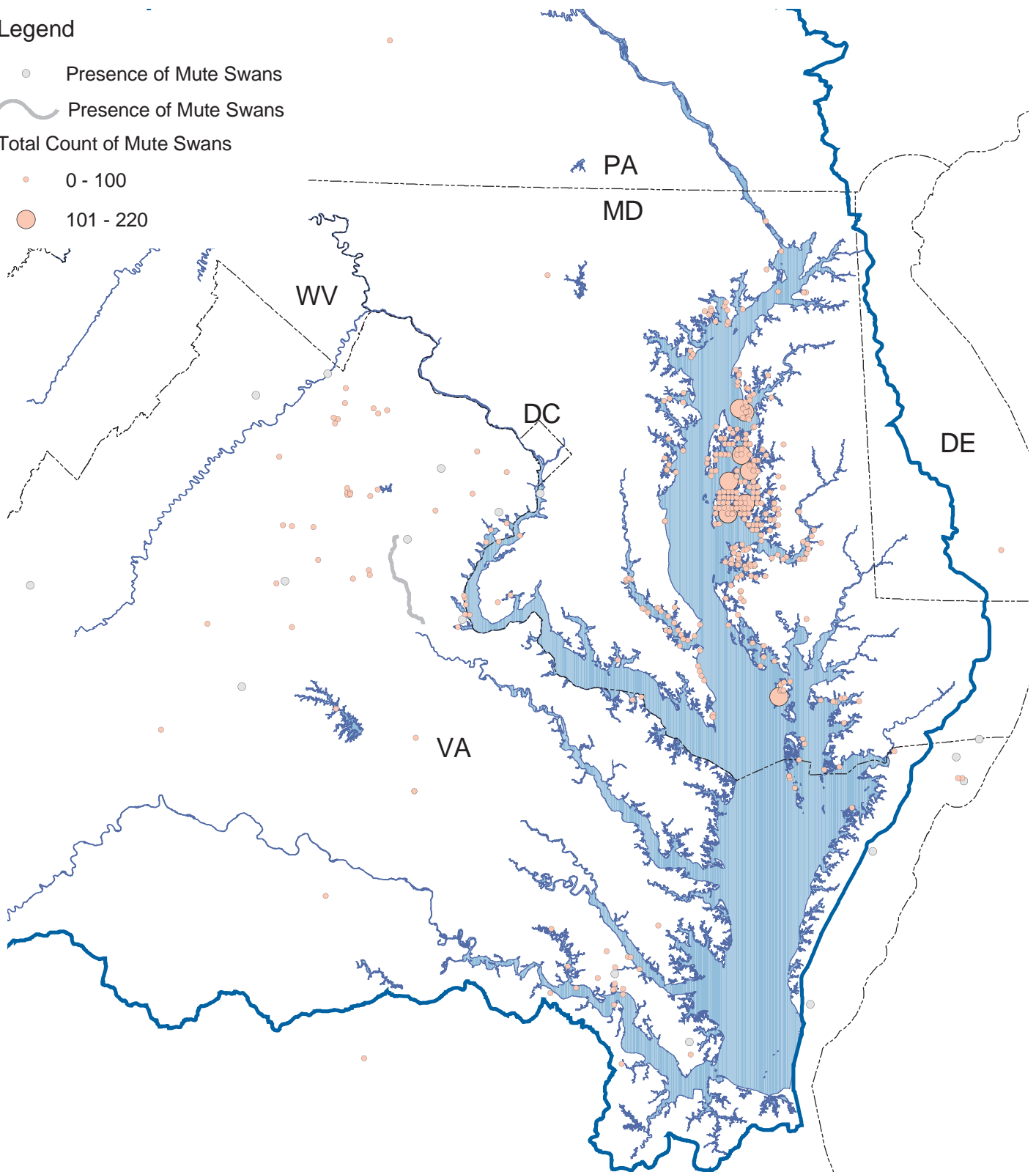
● Presence of Mute Swans

— Presence of Mute Swans

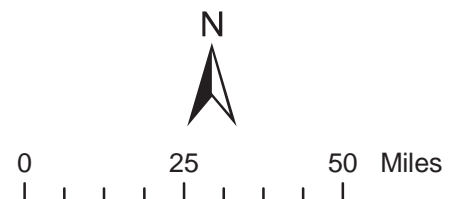
Total Count of Mute Swans

● 0 - 100

● 101 - 220



Data Sources: All Maryland data is from a 1999 USFWS aerial survey. Some of the Virginia data that has a count of mute swans is from the same USFWS survey. Other Virginia data with counts is from VGDIF in 1999. Additional Virginia data showing the presence of mute swans is from the breeding bird survey (linear feature on the map) in 1999, breeding bird atlas from 1984-1989 and the Christmas Bird Count from around 1966-1990.



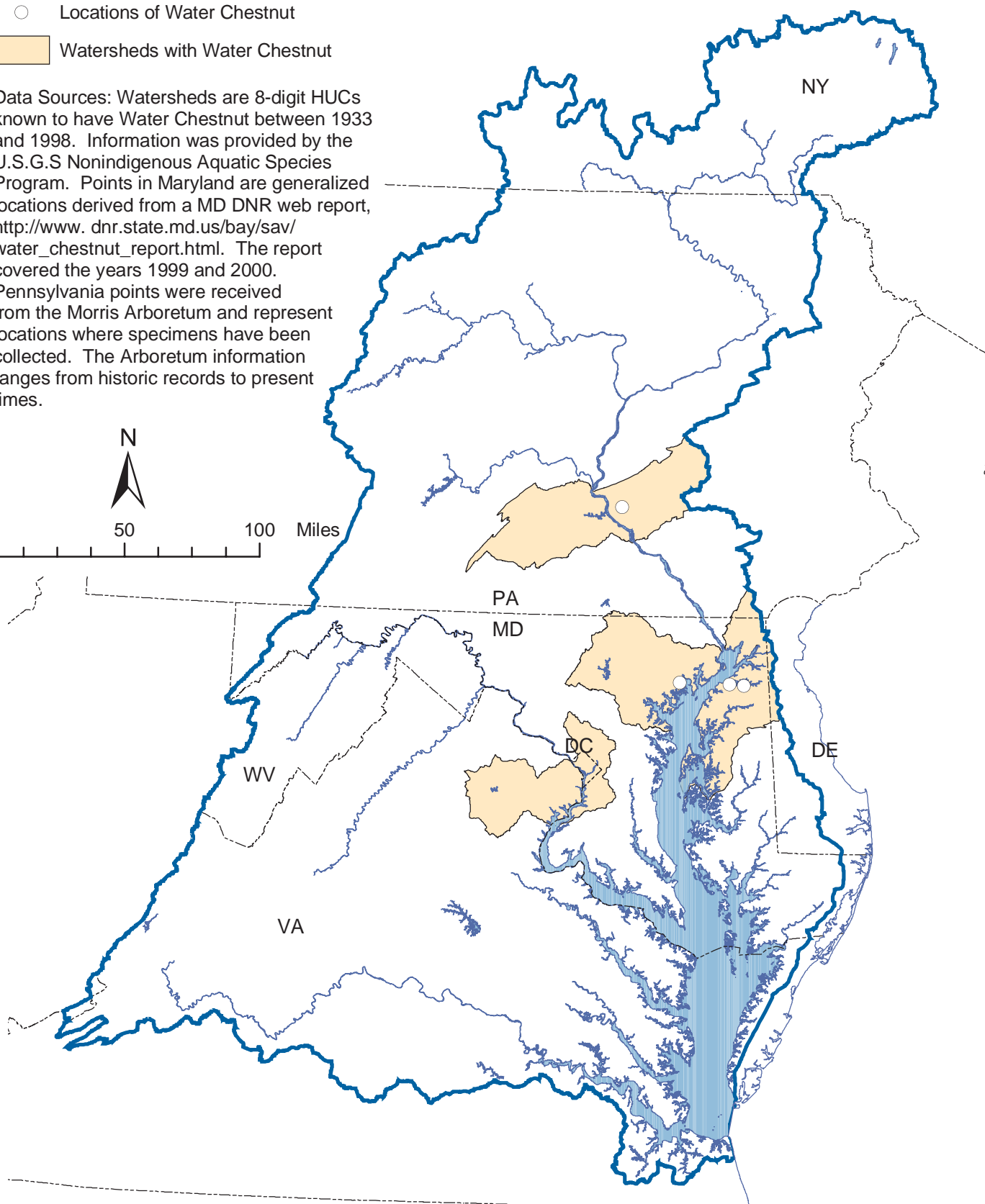
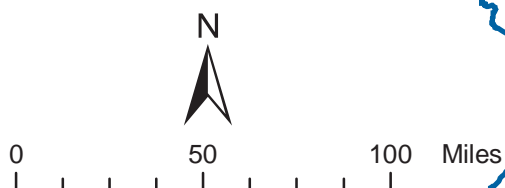
Water Chestnut Presence in the Chesapeake Bay Watershed

Legend

○ Locations of Water Chestnut

■ Watersheds with Water Chestnut

Data Sources: Watersheds are 8-digit HUCs known to have Water Chestnut between 1933 and 1998. Information was provided by the U.S.G.S Nonindigenous Aquatic Species Program. Points in Maryland are generalized locations derived from a MD DNR web report, http://www.dnr.state.md.us/bay/sav/water_chestnut_report.html. The report covered the years 1999 and 2000. Pennsylvania points were received from the Morris Arboretum and represent locations where specimens have been collected. The Arboretum information ranges from historic records to present times.



APPENDIX II

Invasive Species in the Chesapeake Bay as grouped by the ISW September 20, 2001.

Group 1. Species for Which Management Plans Will Be Written

Mute Swan (*Cygnus olor*)
Nutria (*Myocastor coypus*)
Phragmites (*Phragmites australis*)
Purple Loosestrife (*Lythrum salicaria*)
Water Chestnut (*Trapa natans*)
Zebra Mussel (*Dreissena polymorpha*)

Group 2. Species for Which Risk Assessments Will Be Conducted

Asiatic Clam, Corbicula (low) (*Corbicula fluminea*)
Suminoe Oyster (*Crassostrea ariakensis*)
Blue Catfish (high) (*Ictalurus furcatus*)
Green Crab (high) (*Carcinus maenas*)
Hydrilla (high) (*Hydrilla verticillata*)
Japanese Shore Crab (high) (*Hemigrapsus sanguineus*)
Rapa Whelk (high) (*Rapana venosa*)

Group 3. Species for Which Gap Analysis Will Be Conducted

Asian Long-Horn Beetle (*Anoplophora glabripennis*)
Gypsy Moth (*Lymantria dispar*)
Japanese Honeysuckle (*Lonicera japonica*)
Japanese Knotweed (*Polygonum cuspidatum*)
Japanese Stiltgrass (*Microstegium vimineum*)
Mile-a-Minute Weed (*Polygonum perfoliatum*)
Morrow's Honeysuckle (*Lonicera morrowii*)
Multiflora Rose (*Rosa multiflora*)
Oriental Bittersweet (*Celastrus orbiculatus*)
Tree-of-Heaven (*Ailanthus altissima*)
Woolly Adelgid (*Adelges tsugae*)

Group 4: Species for Which Status and Management Will Be Assessed

Asian Swamp Eel (*Monopterus albus*)
Brazilian Elodea (*Egeria Densa*)
Cabomba (*Cabomba caroliniana*)
Chinese Mitten Crab (*Eriocheir sinensis*)
Eurasian River Ruffe (*Gymnocephalus cernuus*)
Eurasian Watermilfoil (*Myriophyllum spicatum* L.)
Flathead Catfish (*Pylodictis olivaris*)
Giant Salvinia (*Salvinia molesta*)
Grass Carp (*Ctenopharyngodon idella*)
Quagga Mussel (*Dreissena bugensis*)
Round Goby (*Neogobius melanostromus*)

APPENDIX III

Guidance Document for Developing a Regional Species Management Strategy Framework

Each breakout session is encouraged to consider adhering to the process suggested in this guidance document when meeting their primary goal of developing a framework species management strategy. Five different components can work together to achieve the goal:

- 1) Leadership, Coordination, and Regulatory Authority,
- 2) Prevention,
- 3) Early Detection and Rapid Response,
- 4) Control and Management, and
- 5) Communication and Information Access.

Prevention is an essential regional invasive species management component – however, it may not be applicable to all of the species addressed at this workshop².

An implementation table, coupled with the identification of key issues, is the suggested format to use in developing a species management strategy. Each breakout session should consider developing an implementation table for the components listed above. Participants are encouraged to identify specific actions within each component that should be taken to meet the goal(s) of their management strategy. The implementation table may also include a time frame for completing the task, the agencies responsible for leading the task, the partners that should be involved, the funding/cost share, and the source for funding. Below is a list of possible actions that could be considered when developing each management strategy. If time allows consideration should be given to ranking the actions by considering issues such as importance, cost, and practicality.

Components of a Species Management Strategy

Leadership, Coordination and Regulatory Authority

Some of the actions associated with this component are: identifying mechanisms for cooperation, jurisdictional overlap, regulatory authority, cost sharing, inclusion of all concerned parties, public participation, identifying legislative and budget opportunities to address those needs.

Early Detection and Rapid Response

Possible actions by this component include the detection and identification of introduced invasive species, coordination across jurisdictional boundaries, and legislative support for rapid response activities.

Control and Management

Activities by this component range across a broad spectrum and include: the eradication within “determined” areas, population suppression, reducing invasive effects, defining the implication of “eradication” and “control” for the species, monitoring and surveillance and research

² For those species for which it is important, the following actions could be considered: identification of pathways, risk analysis, frequency of pathway use, industry role, technology approaches, regulation of pathways, reducing further risk, communication of risks.

(pathways, risk, others?). Other factors to consider include: what might be ideal versus realistic within existing resource allocations, how can regional priorities be determined, what are the dispersal mechanisms for the species, is legislation for federal-state matching monies important in a management strategy, and is mapping of species an important component of a management strategy?

Communication and Information Access

Activities for this component might include: developing a website for the species that includes information on activities in the region and links to national programs, central data management and analysis of relevant data (raw data restrictions), educational information, links for schools, calendar of meetings, public forums and on-going activities for the species.