Delaware
Invasive Species
Management Plan

August 2005

Delaware Invasive Species Council, Inc.
2320 S. DuPont Highway
Dover, DE 19901
(302) 739-4811
(800) 282-8686 (DE only)

Vision Statement

"Protecting Delaware's ecosystems by preventing the introduction and reducing the impact of non-native invasive species."

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State of Delaware
Office of the Governor

Ruth Ann Minner
Governor

The Citizens of Delaware

As a long-time supporter of efforts to improve public awareness of environmental issues, I applaud the Delaware Invasive Species Council (DISC) for taking the initiative in bringing the problems associated with invasive plant and animal species to the attention of the general public. We will not successfully meet the dangers posed by invasive species to Delaware's forests, wetlands, farmlands, and our precious natural heritage without fully engaging representatives of state agencies, universities, and conservation organizations, as well as the general public.

DISC is working hard to do just that. DISC's efforts to educate the public, launch an invasive species tracking system, and conduct innovative research on important issues regarding invasive species have demonstrated once again how much can be accomplished by dedicated people. I am proud that Delaware was the first of the Mid-Atlantic states to establish an invasive species council.

As productive as DISC has been, I realize that it will take more than the efforts of the council to make significant progress against the ever-increasing onslaught of alien invaders of our great state. When I speak of creating a "livable" Delaware, I do not only mean a state conducive to the health and well-being of my fellow Delawareans. I also mean a Delaware in which our native plants and animals can thrive without being overrun by invasive species.

Sincerely,

Ruth Ann Minner
Governor

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DELAWARE INVASIVE SPECIES COUNCIL

Protecting Delaware's ecosystems by preventing the introduction and reducing the impact of non-native invasive species.

July 1, 2004

The Honorable Ruth Ann Minner, Governor
The State of Delaware
Tatnall Building
William Penn Street, 2nd Floor
Dover, Delaware 19901

Dear Governor Minner:

On behalf of the Delaware Invasive Species Council, it is with great pleasure that I submit the Invasive Species Management Plan for the State of Delaware for your review and signature. As you are aware, the Delaware Invasive Species Council, or DISC, was formed in 1999 to deal with the increasing problems caused by the accidental or intentional introduction of non-native invasive plants and animals into our state. Over the past four years, member groups of DISC have struggled with how best to deal with the mounting ecological problems caused by invasive species and the increasing costs involved with controlling them. The plan was the result of considerable research, review, and discussion by members of state agencies, environmental groups, and business interests. Needless to say, without the support of your administration, this effort would not be where it is today.

From the breaking waves along the Sussex County coast to the rolling hills of northern New Castle County, invasive species have taken a foothold and threaten our local ecosystems. For example, it is estimated that 25 percent of the plants in Delaware today are non-native species, many of which have displaced more desirable native plants. This is why the membership of DISC and many other groups feel that this issue presents the single greatest threat to the flora and fauna that make Delaware such a special place.

This plan is based on a framework outlined in the National Invasive Species Council's Management Plan but was developed in Delaware, by Delawareans, for Delaware. Certainly, many of the issues, goals, and objectives outlined in the plan involve our neighboring states and will be coordinated at all levels, but this is a plan that reflects the cooperative, voluntary nature of all Delawareans and is something that we can all be proud of now and in the future.

Thank you for your support and interest in this matter of concern to us all. Please do not hesitate to contact me if you have any questions.

Sincerely,

Faith B. Kuehn

Faith B. Kuehn, Ph.D.
Chair, Delaware Invasive Species Council

A. Executive Summary

An invasive species is *an alien species whose introduction causes or is likely to cause economic or environmental harm or harm to human health* according to the National Invasive Species Monitoring Plan. The spread of invasive species is a pervasive and growing problem within Delaware and the United States. Some estimates put the national cost of invasive species management at more than $138 million annually.

The **Delaware Invasive Species Council, Inc.** (DISC) was formed to help Delaware deal with this rapidly growing problem. DISC, with input and guidance from over 40 stakeholders, prepared this document after a workshop held in January of 2003. This document:

- Describes the DISC administration and management;
- Reviews existing laws and policy regarding invasive species pointing out the gaps caused by the current piecemeal approach to invasive species management;
- Reviews the state of the science of invasive species data collection and management in Delaware;
- Proposes methods for Invasive Species Risk Assessments so that actions can be commensurate with actual danger;
- Lists and discusses the socio-economic, human health, environmental, and ecological impacts of invasive species, mentioning the direct-costs, as well as the costs of no action;
- Proposes specific management actions and research needs;
- Gives an outreach and education plan to educate the citizens of Delaware concerning the invasive species problem;
- Proposes self-monitoring plans to examine the efficacy of this Invasive Species Management Plan;
- Provides lists of Invasive Species known to be problematic in Delaware; and,
- Includes an initial publication listing invasive plant species.

Throughout this document the authors have endeavored to provide information that defines the existing state of affairs and identifies opportunities or gaps, and to give specific steps to alleviate any identified shortcomings. DISC realizes that it will require a concerted and coordinated effort to overcome some of the problems brought on by the introduction of invasive species to Delaware. The Invasive Species Management Plan suggests ways to combat the invasive species problem that include:

- Educational outreach to specialized users groups such as sportsmen and gardeners, as well as the general populace;
- Changes in enabling legislation;
- Suggested alliances among resource and regulatory agencies;
- Funding requirements;
- Research needs; and

- Staffing needs that will permit the control of invasive species within Delaware.

As stated earlier, this document was prepared using the thoughts and deliberations of over 40 stakeholders from throughout Delaware, written by members of the DISC Board, and further reviewed by the original stakeholders.

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B. Introduction

Bruce Richards, Pump Systems, Inc., 311 Blue jay Drive, Hockessin, DE 19707, & Former - Chair Delaware Invasive Species Council, 467 Highway One, Lewes, DE, 19959

"An invasive species is an alien species whose introduction causes or is likely to cause economic or environmental harm or harm to human health" according to the National Invasive Species Monitoring Plan (2001). There are many examples of environmental and economic damage caused by invasive species. The introduction of Sea Lampreys into the Great Lakes virtually destroyed commercial fisheries in the Great Lakes. The Zebra Mussel currently causes untold financial damage to water supply systems and power plants throughout the northeast US, and its southern spread seems inexorable. Historically, Delaware has not been immune to the damage of invasive species. The Chestnut blight has nearly exterminated the American Chestnut nationally and in Delaware, causing the destruction (and required removal) of beautiful street trees, and ending economically valuable nut harvesting and timber industries. Certain horticulturally desirable species such as Oriental Bittersweet have the capacity to pull down mature trees due to their rampant vining habit. Currently Delaware suffers from the introduction and spread of West Nile Virus, an invasive species with potentially dire health and concomitant financial consequences.

The spread of invasive species is a pervasive and growing problem within Delaware and the United States. Some estimates put the national cost of invasive species management at more than $138 million annually. Delaware has not been spared expense in the management of invasive species. Several Delaware programs exist for the management of invasive species, notably the *Phragmites* control program.

It is the piecemeal approach to controlling invasive species in Delaware that inspired the members of the Delaware Invasive Species Council**,** Inc**.** (DISC) to organize, and to eventually develop this Invasive Species Management Plan. Their purpose was to unite the efforts of the many disparate actions directed at invasive species control into a cohesive, rational, and fair, management plan. The DISC organizes state-wide meetings to discuss invasive species issues, maintains a database of invasive species data, and in January of 2003 convened a workshop of more than 40 Delaware stakeholders to begin to develop this Invasive Species Management Plan. At the workshop, the participants discussed the Invasive Species problem in Delaware, and formulated a list of items that should be included in a state management plan. Members of the DISC Board of Directors used these ideas to create the Delaware Invasive Species Management Plan.

This Invasive Species Management Plan describes the management of invasive species within Delaware from several different frames of reference. The nature, goals, and organization of the Delaware Invasive Species Council, Inc. (DISC) are described. A review of the existing Laws and Policy governing invasive species nationally, and in Delaware is provided. The state of the science with respect to data collection, data management and invasive species risk assessments is given. The environmental, human health and economic risks of invasive species and control actions, and the no action to control invasive species are summarized. Certain management actions are discussed. A review of the research into invasive species is given. In each section of this management plan suggestions are given as to how to progress in the control of invasive species within Delaware. Suggestions for changes in existing policy and laws,

further research needs, education and outreach programs are given, as are plans to monitor the success of this management plan.

Literature Cited

National Invasive Species Council. 2001. Meeting the Invasive Species Challenge: National Invasive Species Management Plan. Washington, D.C. 80 pp.

C. Impacts

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1. INTRODUCTION

The State of Delaware is a virtual microcosm of the United States, having the same proportion of urban to rural populations as the country in general. Despite its small size, it has fairly diverse habitats and land use patterns. Consequently, it is subject to many of the same problems caused by invasive species as other states. Long before Executive Order 13112 requiring restoration of native species and habitat conditions in invaded ecosystems, invasive species had taken a toll on Delaware ecosystems and communities. For example, chestnut blight has forever changed the composition of Eastern forests (Pratt 1974)—once a dominant tree supplying excellent wood and delicious nuts, the chestnut is now represented only by sucker growth from old roots, such as may be seen at Blackbird State Forest near Smyrna, DE. In the urban setting, owners of stately colonial homes in historic New Castle, DE, must pay for expensive injections to preserve their ancient American elm trees from the ravages of Dutch elm disease, which has destroyed many elms in the eastern half of the United States.

Expenditures to control invading nonindigenous species in the United States cause major environmental damages and losses adding up to more than $138 billion per year (Pimentel et al. 1999). Because of its small size, control or suppression costs for invasive species in Delaware are much lower, but they are substantial. The impact, of course, doesn't end with control costs, but includes the costs of taking no action, as well as those incurred in attempting to prevent the introduction of invasive species in the first place. Finally, additional costs accrue in the research needed to develop controls for new invasive species or improved controls in the case of those invasive species. Invasive species not only affect the socio-economic sectors, such as agriculture, fisheries, and recreation, but negatively impact human health and natural ecosystems. In addition to economic losses, there are intangible losses ranging from aesthetic damage in one's yard caused by gypsy moth defoliation to pain and suffering caused by a nonindigenous pathogen (or indirectly by an introduced vector).

We have organized the impact of invasive species into three categories: (1) socio-economic, (2) human health, and (3) natural/ecological. Some pests can impact more than one of these categories or sectors. The gypsy moth, *Lymantria dispar*, has had adverse impacts in all three areas (USDA 1995). Socio-economic impacts include diminished recreation and tourist business in outbreak areas due to human avoidance, damage to woodlots with subsequent reductions in property values, and control costs for various intervention measures. Human health effects include the development of rashes or other skin irritations on people (especially children) exposed to the caterpillars, development of allergies after repeated exposures over several years, falls due to slippery conditions when caterpillars or droppings are abundant on streets and sidewalks, injuries caused by limbs falling from trees killed by defoliation, and psychological stress (entomophobia) to some individuals when gypsy moth populations are very high. Adverse environmental effects of heavy gypsy moth defoliation include large-scale starvation of caterpillars of other moths and butterflies, declines in population of small mammals and amphibians, movement of bats and turkeys to non-defoliated areas, reduced oxygen levels in nearby streams, and mortality of oaks and other preferred trees.

2. CURRENT STATE OF THE ART

Impact assessment of invasive species varies greatly in difficulty. Generally, socio-economic impacts are the easiest to assess, because there are specific inspection or suppression dollar costs that can be tracked accurately. Human health impacts are somewhat more difficult to assess, because some of them (i.e., discomfort, risk to population) cannot be readily measured, especially in advance. The impacts of invasive species on natural/ecological systems are usually the most difficult to measure, because baseline data needed to measure the changes following introduction are lacking and diverse interest groups (e.g., conservationists and hunters) might disagree as to whether an invasive species is bad or good. Moreover, some of the factors (e.g., aesthetic value) are subjective and cannot be associated with an economic cost. There is no doubt that the scope is great—Wilcove *et al.* (1998) have calculated that invasive species have played a role in the displacement of 35-46% of the animals and plants on the Federal Endangered Species List.

Tools and technologies for estimating the impact of invasive species are varied, but only a few examples can be given here. As stated earlier, budgets and financial reports can be used to associate dollar costs with quarantine and control programs. Biotech-based diagnostic tests can be used to provide reliable data on cases of infectious diseases caused by nonindigenous pathogens. A case in point is the incredibly rapid determination of the genome of the virus that causes SARS (Severe Acute Respiratory Syndrome), accomplished less than a year after the first cases were reported. Satellite imagery can be used to measure changes in plant cover and delineate certain kinds of damage (defoliation or death of trees) caused by invasive species.

3. GOAL

Assessing the impact or potential impact of an invasive species is important from several viewpoints: (1) it enables regulatory officials and land managers to prioritize their quarantine or control efforts so as to obtain the greatest benefit from the use of finite resources; (2) quantifying the impact of an invasive species is useful in mobilizing public opinion and political attention on the problem; and (3) the baseline data acquired initially can be used to evaluate the success of intervention programs implemented.

The need for impact assessment should not be underestimated. Two insect cases can serve as examples. USDA has compiled good figures on gypsy moth spread and defoliation since 1924. These provided the data needed to justify the U.S. Forest Service's Slow-the-Spread Program which has the objective of slowing the movement of the gypsy moth to the west and south by early detection and eradication of small isolated colonies ahead of the moving population front (Leonard and Sharov 1995). The Asian Longhorned beetle (ALB), *Anoplophora glabripennis*, was known to be an important pest in poplar plantations in China, so a panel of scientists convened to evaluate the problem soon after its initial discovery in New York recommended that its eradication be attempted. So far, the Federal-State ALB eradication program seems to progressing well, with diminishing numbers of infested trees being discovered in both New York and Illinois over the past two years (2001-2002).

The goals of this section (Impacts) of the management plan are to

Goal 1. Provide an overview of the scope and importance of the invasive species problem in Delaware;

Goal 2. Demonstrate that invasive species affect every citizen;

Goal 3. Demonstrate that the state incurs a substantial cost for the depredations of invasive species; and

Goal 4. Present the challenges and opportunities involved in dealing with invasive species.

4. CHALLENGES AND OPPORTUNITIES

Socio-Economic Impacts

Direct Costs

Control costs can involve a number of activities: (1) detection surveys to find or delimit the distribution of an invasive species, (2) eradication programs to eliminate an invasive species (used when there are only a few known infestations of limited scope), and (3) suppression programs for invasive species that are well established and widely distributed. In addition, these can be combined. For example, in 1998, an infestation of red imported fire ants, *Solenopsis invicta*, was found in the vicinity of Bear, DE. Once the initial control efforts were implemented, local follow up surveys were made the two succeeding years to verify that the infestation had, in fact, been eradicated successfully. Of course, inspection of nursery stock to prevent future infestations of *S. invicta* will require continuing expenditures.

Currently the Delaware Division of Natural Resources and Environmental Control (DNREC), in partnership with the U.S. Department of Agriculture's Natural Resource Conservation Service, offers a cost-sharing program (87.5% state and federal, 12.5% landowner) for control of *Phragmites* (Delaware Department of Natural Resources and Environment Control 2003). In 2002, the program was applied across 2,410 acres at a total cost of $168,700 (Bennett 2003). Doing that over the entire infested area would cost many times more.

Costs of No Action

One option in dealing with the socio-economic effects of invasive species is to take no action, i.e., allow invasive, exotic species to invade and become established within forests, wetlands, agro-ecosystems, cities, suburbs, bodies of water or other habitats and accept the changes that will occur in these due to their impact. When this course of action is taken, the habitat or commodity affected continues to degrade until it is virtually useless. Frequently, whole sectors of the economy are eliminated over substantial areas. For example, when European green crabs almost destroyed Maine's soft shell clam industry in the 1980's, clam diggers had to buy new equipment to harvest other seafood, or find employment elsewhere. In the case of socio-economic and human health impacts, this option is rarely politically viable, so some kind of intervention generally results, but unfortunately, in the case of invasive species having adverse ecological or environmental effects, we often see too little, too late.

Quarantine Actions

Many nonindigenous invasive species present in the United States (often in adjoining states) represent a potential danger to Delaware. For example, the Asian Longhorned beetle, which has killed many urban trees in New York City and adjacent areas of Long Island, was recently discovered in Jersey City, NJ, where eradication efforts are in progress. If it spreads to Delaware, it will pose a serious threat to our urban and community forests which are comprised in large part of Norway, Red, Sugar, Silver, and

Boxelder Maple, all preferred hosts for the beetle. The Fire Ant, alluded to above, is the object of continuous inspections of nursery stock coming into Delaware.

The Zebra Mussel, *Dreissena polymorpha*, a socio-economic concern because of its biofouling habits and an environmental concern because of its competitive exclusion of endangered native mussels, has been found in Eastern Pennsylvania and the Chesapeake Watershed (Maryland Sea Grant 2002). Thus both the Delaware River – Delaware Bay and Susquehanna River - Chesapeake Bay serve as likely avenues of invasion for Delaware. The U.S. Geological Survey has estimated that the cost of controlling Zebra Mussels in just the Great Lakes region, will 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).

The most recent invasive species to appear on the quarantine horizon is the Emerald Ash Borer, *Agrilus planipennis*. First found in the Detroit vicinity in 2002, this buprestid beetle from the Far East has killed over six million trees in the region, and has spread into adjacent areas of Canada and northwestern Ohio. It was discovered at a nursery in Maryland in late summer, 2003. Although the Maryland infestation has apparently been successfully eradicated, it is clear that constant and diligent inspection of incoming nursery stock from the Great Lakes Region will be needed to prevent a remote infestation from becoming established in Delaware. Prospects for preventing long-term natural spread of this species into the Middle Atlantic States are poor, and biological control with natural enemies from its region of origin appears to be the most viable long-term solution to the problem.

In addition to spread from nearby states, independent introductions of previously established or new invasive species are always possible through hitchhikers on commodities imported from overseas. The most likely points of entrance of concern to Delaware would be Philadelphia and Baltimore-Washington International Airports and the ports of Philadelphia, Baltimore, and Wilmington. Inspectors from USDA's Animal and Plant Health Inspection Service provide the main line of defense in these and other venues.

Alternative Actions

The Gypsy Moth first reached Delaware in 1980, and spread throughout the state within 10-12 years. Statewide populations of gypsy moth peaked in 1996, when over 60,000 acres sustained substantial defoliation. Gypsy Moth populations dropped to very low levels in 1997, and have remained low up to the present time. Although a number of natural enemies from Europe and the Far East were released in Delaware and adjoining states between 1973 and 1993, a Gypsy Moth fungus from Japan, *Entomophaga maimaiga*, is probably responsible for the state-wide population decline (Delaware Department of Agriculture 1998). Thus, biological control seems to have greatly alleviated the Gypsy Moth problem in Delaware.

Human Health Impacts

Species Induced

West Nile Virus (WNV) has recently been discovered in Delaware. This pathogen, a flavivirus commonly found in Africa, West Asia, and the Middle East, is transmitted to humans by mosquitoes that have fed on the blood of infested animals, especially birds. The disease, West Nile encephalitis, is an infection of the brain. It is not passed directly

from human to human. So far, direct impacts in Delaware have not been catastrophic, only one human case being reported in 2002, without any fatalities. Case-fatality rates range from 3% to 15% and are highest in the elderly. Only 13 veterinary (pets, livestock, or wildlife) cases were reported in 2002, but over 200 tissue samples from dead and diseased birds, mostly crows, have tested positive for WNV (Nation's Biological Information Infrastructure 2002). Thus there is a substantial reservoir of the pathogen in bird populations. The Epidemiology Branch, Delaware Department of Public Health has implemented a West Nile Encephalitis Surveillance Program.

The Asian Tiger Mosquito, *Aedes albopictus,* another invasive species accidentally introduced in Texas, reached Delaware in 1987, and is also a carrier of West Nile Virus.

There are numerous other pathogens that pose a threat to human health. In 2000, researchers detected the human Cholera pathogen, *Vibrio cholerae* in the ballast water of all tested ships arriving in Chesapeake Bay from foreign ports. In addition, release of ballast water is believed to have brought Red Tide from seas bordering the Far East to American coastal systems. Red Tide blooms are linked to fish kills and the toxins emitted from Red Tide produces saxotoxins that cause serious human health problems.

Resulting from Control/Management

In December 1999, CDC announced the availability of fiscal year 2000 supplemental funds to support WN Virus surveillance, prevention, and control projects. As a fund recipient, Delaware has increased surveillance activities and enhanced laboratory capacity for detecting West Nile Virus and other arthropod-borne viruses. Because there is no control area where intervention programs have not been implemented, it is difficult to say how many cases of West Nile Encephalitis have been prevented. Likewise, it is difficult to determine to what extent larvicidal and adulticidal applications for mosquito control might have affected the health of humans or wildlife in treated areas.

Unintended Consequences

Many pathogenic invasive species (disease causing organisms) are transmitted by mosquitoes or other arthropods. Because of this, control measures are frequently directed at their vectors. Therefore, increased pesticide use is often the most visible reaction to foreign pest species, which creates its own risks to human health and the environment.

Environmental and Ecological Impacts

Loss/Damage from Invasive &/or Control Management

Conservationists estimate that in the United States, infestations of nonindigenous invasive plants cover 100 million acres and are increasing at a rate of 14% per year, an area twice the size of Delaware (USDA 1999). Multiflora Rose, one of the worst invasive plants in Delaware, was originally introduced from Japan as a hardy rootstock for ornamental roses and was also promoted as a suitable plant for erosion control and livestock fencing. Some of Delaware's most important open space areas are now endangered by this stubborn plant, which dislocates native plants that once provided food and shelter for wildlife. Projects for control of invasive plants, even when augmented by volunteer help and the cooperation of private landowners, can cost up to $600 per acre (U.S. Fish and Wildlife Service 2001).

Purple Loosestrife, *Lythrum salicaria,* also adversely affects the viability of native fish and wildlife habitats. This European invader has become the dominant plant in many

wetlands, out competing most indigenous plants, resulting in the elimination of food and cover for wildlife, including habitat for the bog turtle, a threatened species. Most waterfowl do not eat this plant and can actually die of starvation (VanKirk 1998). The Delaware Department of Agriculture has implemented a biological control program using specialized herbivores from Europe. These natural enemies have been very successful in reducing infestations in other regions (Malecki et al. 1993), but it remains to be seen how well it will work in Delaware. A detailed history and analysis of the Purple Loosestrife problem appears in Thompson et al. (1987).

Animal pathogens can also have adverse effects on the ecology of a region. A New York State senior wildlife pathologist has identified the type E Botulism Bacterium, *Clostridium botulinum*, in several species of dead birds, including a dead Bald Eagle collected along Lake Erie. It is believed that the Round Goby, an exotic fish that is a food source for many species of birds, plays an important role in the transfer of the disease.

Hybridization

The hybridization of an invasive species with a native species can be beneficial or detrimental, depending on the circumstances. The Purple Loosestrife problem in Delaware has been exacerbated by the purchase of the plant for ornamental purposes and its subsequent escape into favorable habitats. However, infertile hybrid stocks incapable of producing seed capsules exist (Thompson et al.1987), and should be substituted for the *L. salicaria* shipped and sold commercially.

The Red Imported Fire Ant, *Solenopsis invicta*, can hybridize with a congener, *S. richteri,* raising fears that the hybrid might be able to colonize more northern locations such as Delaware (Calcott et al. 2000).

Displacement/Habitat Alteration

Kudzu, frequently referred to as “the vine that ate the South,” is present at a number of sites in Delaware. This plant poses a hazard to both natural and managed forest stands, because it is a vigorous climber and its dense foliage blocks out the sunlight, eventually killing even mature trees.

With respect to the successful suppression of Purple Loosestrife by biological control agents, the results concerning the types of replacement communities that have developed have been mixed (Blossey 2002). Generally, the results are desirable with a diverse wetland plant community replacing the previously monotypic stands of *L. salicaria*. At some sites, however, other invasive species such as *Phragmites australis* (Common Reed) or *Phalaris arundinacea* L. (Reed Canary Grass) may expand as Purple Loosestrife is controlled, an undesired result. At yet other sites, dense Purple Loosestrife litter can limit the growth of native species, and options (fire, disking, flooding, mowing, etc.) for dealing with this are under investigation.

5. LITERATURE CITED

Bennett, K. 2002. What is the Division doing about invasive species? The Observer Newsletter, Fall 2002.

Blossey, B. 2002. Purple Loosestrife, pp. 149-157. *In*: Van Driesche, R., et al, Biological Control of Invasive Plants in the Eastern United States, USDA Forest Service Publication FHTET-2002-04, 413 p.

Calcott, A.-M., D. H. Oi, H. L. Collins, D. F. Williams, and T. C. Lockley. 2000. Seasonal Studies Of An Isolated Red Imported Fire Ant (*Hymenoptera*: *Formicidae*) Population In Eastern Tennessee. Environ. Entomol. 29: 788-794.

Delaware Department of Agriculture. 1999. Delaware Forest Health Highlights – 1998. Web page: http://www.fs.fed.us/na/morgantown/fhp/fhh/fhh99/de/de99.htm

Delaware Department of Natural Resources and Environment Control. 2003. DNREC and Federal Government Offer Landowners Cost Share Funds. DNREC News 33(181):1-2. Web page: http://www.dnrec.state.de

Leonard, D.S., and A.A. Sharov. 1995. Slow The Spread Project Update: Developing A Process For Evaluation, pp. 82-85. *In* Proceedings, U.S. Department Of Agriculture Interagency Gypsy Moth Research Forum 1995. Gen. Tech. Rep. NE-213, Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Malecki, R. A., B. Blossey, S. D. Hight, D. Schroeder, L. T. Kok, and J. R. Coulson. 1993. Biological Control Of Purple Loosestrife. Bioscience 43: 480-486.

Maryland Sea Grant website. 2002. Invasive Species In The Chesapeake Watershed – Zebra Mussel. http://www.mdsg.umd.edu/exotics/workshop/zebra_mussel.html

Nation's Biological Information Infrastructure. 2002. NBII site, Center for Biological Informatics, U.S. Geological Survey. http://westnilevirus.nbii.gov/human.html

Natural Conference of State Legislatures. 2001. Environment, Energy and Transportation Program - Invasive Species Web Report. http://www.ncsl.org/programs/esnr/invaspecies.htm

New York Sea Grant. 1994. "Policy issues." *Dreissena polymorpha*. Information Review. Zebra Mussel. Clearinghouse Newsletter 5(1):14-15.

Pennsylvania Sea Grant. 2002. Keystone Shorelines Newsletter, Summer 2002. http://www.pserie.psu.edu/seagrant/communication/news/summer02.html#top

Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2000. Environmental And Economic Costs Of Nonindigenous Species In The United States. BioScience 50:53-65.

Pratt, R. 1974. A Pocket Guide To Trees. Pocket Books, New York.

State of Maine. 2002. Action Plan For Managing Invasive Aquatic Species. http://www.state.me.us/dep/blwq/topic/invasives/invplan02.pdf

Thompson, D. Q., R. L. Stuckey, and E. B. Thompson. 1987. Spread, Impact, and Control of Purple Loosestrife (*Lythrum salicaria*) in North American Wetlands. U.S. Fish and Wildlife Service. 55 pages. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/1999/loosstrf/loosstrf.htm(Version 04JUN99).

USDA. 1995. Gypsy Moth Management In The United States: A Cooperative Approach. Final Environmental Impact Statement, Vol. 1, Summary. USDA, Forest Service, Northeastern Area State and Private Forestry, Radnor, PA.

USDA. 1999. Invasive Species. U.S. Dept. Agric., Animal and Plant Health Inspection Service. http://www.aphis.usda.gov/oa/pubs/invasive.html

U.S. Congress, Office of Technology Assessment. 1993. Harmful Non-indigenous Species in the United Statements. OTA-F-565. U.S. Government Printing Office. Washington, D.C. 391 pp.

U.S. Fish and Wildlife Service. 2001. Partners for Fish and Wildlife Program – Delaware. http://partners.fws.gov/pdfs/DE-needs.pdf

VanKirk, J. R. 1998. Taming the Beautiful Beast. IPM in the Northeast Region website. http://northeastipm.org/reports/neipm/nerpt98/CTloostr.html

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying Threats To Imperiled Species In The United States. BioScience 48:607-615.

D. Administration/ Implementation

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1. INTRODUCTION

The administration of the Delaware Invasive Species Council (DISC) is predicated on the commitment and collaboration of both public and private partners engaged in the management of invasive species in the State of Delaware. DISC plays a critical role in administering, organizing and thereby focusing state efforts on managing the threats of invasive species and taking coordinated steps to eliminate the problems associated with the introduction of non-indigenous plants and animals both on the land as well as in the waters of Delaware.

2. CURRENT STATUS OF ADMINISTRATION/IMPLEMENTATION OF THE DISC

The current structure and administration of DISC is provided through a voluntary board of DISC members elected to serve as Chair, Vice Chair, and Secretary/Treasurer which compose the Executive Committee of the DISC board. The DISC board meets at least quarterly with an annual meeting once a year in the spring. The Committee Chairs are appointed by the Executive Committee and are equal members of the DISC board. Committees of the board are clarified in the DISC by-laws and listed as follows:

Charter and By-Laws- responsible for drafting and maintaining the organization's charter and By-Laws, and incorporating all duly transacted amendments.

Public Awareness and Education- responsible for developing education and outreach programs.

Invasive Species Inventory Committee- responsible for compilation and maintenance of up to date listing of invasive species in Delaware and making that information available to DISC and eventually the general public

Research and Projects Committee- responsible for focusing research on high priority species

3. GOALS

The Goals of the Delaware Invasive Species Council are to coordinate the efforts of both public and private agencies and organizations to develop programs and strategies.

Goal 1.Promote a public awareness of problems caused by non-native invasive species.

Goal 2.Facilitate the communication and exchange of information on non-native invasive species and their control.

Goal 3.Promote the use of locally native species.

Goal 4.Encourage support for research, management, and funding for non-native invasive species prevention and control.

Goal 5.Serve as an advisory panel for various interests concerned with non-native invasive species and review management problems and activities associated with such species and provide updated information for specific management needs.

4. GAPS, CHALLENGES AND NEEDS

Delaware, a small state of approximately 830,000 is geographically, culturally and politically diverse. Government agencies, environmental organizations, corporations and small businesses are still rather unaware of the problems of invasive species. If they are aware, many have other priorities and often do not concern themselves with invasive species. For instance, the DE Department of Natural Resources and Environmental Control may be more concerned with direct threats to air and water pollution than the slow spread of some exotic (and harmful) plant, insect or algae. Environmental organizations also are slow to prioritize invasive species as a key concern when open space is threatened by urban sprawl. Landscapers often use invasive plant species in homes and businesses.

Communication between these groups and organizations is limited. Media coverage as well as educational programs on invasive species is still minimal. There needs to be statewide improvement in the public's awareness of the destructive features of invasive plants and animals. Too often the standard approach to managing harmful invasive species is to focus the attention strictly on the particular animal or plant of concern. This approach certainly must be taken in specific cases. For example, a Delaware agricultural scientist may be concerned with a particular insect pest such as the destructive features of fire ants and may need to develop a plan to combat this pest; however, the challenge of DISC is to develop broad strategies to manage the ***processes*** (pathways of introduction, predator/prey interactions, etc.) that enable invasive species to flourish.

Obviously, in order for the State of Delaware to formalize an organized approach to control and manage the spread of invasive species, we need a strong organizational structure to plan and implement our management plan. The Delaware Invasive Species Council (DISC) was established to meet many of the challenges associated with the onslaught of destructive exotics. Through DISC, the public and policy makers can learn about existing and new invasive plants and animals. Through DISC, public and private entities can collaborate and communicate strategies, projects and programs to identify new invasive species, monitor existing invasive species, develop strategies for preventing new introductions, identify existing invasive species pathways and even construct eradication efforts to rid Delaware locations of a particular problematic invasive species.

Goal 1. Promote a public awareness of problems caused by non-native invasive species.

Invasive species are hardly a subject well understood by the general public. News coverage of invasive plants, insects and some aquatic invasives are becoming increasingly popular in feature stories. Inadvertent transport of invasives into the state is also a problem of awareness and understanding.

Goal 2. Facilitate the communication and exchange of information on non-native invasive species and their control.

State governmental agencies, non-governmental organizations, and environmental interest groups have few opportunities to exchange information about the control of invasive species. In order to begin the process of eradicating invasive species, it is imperative that we improve communication between groups that can directly impact invasive species.

Goal 3. Promote the use of locally native species.

Few consumers of landscaping plants are aware of the ecological benefits of selecting indigenous plants for their homes. Local environmental groups (like the Delaware Nature Society) are promoting native plant sales. Landscaping firms are concerned about the loss of sales of (invasive) plants often desired by the consumer. The promotion of native species is as much an educational effort needed for the consumer as it is for the landscaping industry. In the southeast coast of Florida, a fish tank fern called *Caulerpa taxifolia* was released into local waters and has now decimated major near shore environments. Pet stores are the likely source of this fern. Little is known about Delaware pet stores and the potential release of non-indigenous invertebrates, fish, birds, snakes and aquatic plants into the environment.

Goal 4. Encourage support for research, management, and funding for non-native invasive species prevention and control.

Other than the efforts of the Research Committee of the Delaware Invasive Species Council, little coordination of scientific research is done in Delaware. Comprehensive management of invasive species is largely the role of DISC and its participating members and agencies. Sporadic funding of invasive species projects has been done among university researchers and state biologists. The Delaware Department of Agriculture (DDA) has conducted several successful efforts to prevent invasive plants and insects from entering the state through inspections. The Department of Natural Resources and Environmental Control (DNREC) has also conducted successful programs to spray and kill invasive weeds (like *Phragmites*) and insects (such as gypsy moths). Other than the efforts of DNREC and DDA, there are few statewide programs in prevention and control.

Goal 5. Serve as an advisory panel for various interests concerned with non-native invasive species and review management problems and activities associated with such species and provide updated information for specific management needs.

The role of DISC as an advisory panel to parties interested in controlling non-native species is a major goal of this organization. Hiring a full time executive director to provide day-to-day leadership to curtail the spread of invasive species is a need cited by the Executive Committee of DISC.

5. ACTION STEPS

The key actions for administering the Delaware Invasive Species Management Plan is through the organization of the Delaware Invasive Species Council (DISC) under the direction of the officers, board, committees and committed members of DISC that oversee the plan's implementation.

The officers are voluntary positions elected by the membership of DISC and include the Chair of the board, the Vice Chair and the Secretary/ Treasurer. The Chair has overall leadership responsibility for the administration of DISC. The Vice Chair serves under the Chair and coordinates the annual DISC meeting, while the Secretary/Treasurer handles the correspondence and fiscal responsibilities of the organization.

Goal 1. Promote a public awareness of problems caused by non-native invasive species.

Develop and implement a statewide comprehensive educational plan to promote the understanding the problems of non-native invasive species. Coordinate all educational efforts with the DISC educational committee.

Goal 2. Facilitate the communication and exchange of information on non-native invasive species and their control.

Develop better DISC task forces to exchange information. Fortify the DISC website to include information on invasives, training events, links to other sites. Integrate the DISC website to the existing DISC database of invasive species. Increase training opportunities for DISC members and the general public.

Goal 3. Promote the use of locally native species.

Develop a voluntary program to encourage use of native landscape plants. Strengthen linkages to other business concerns that may have the potential of spreading invasive species such as cargo transporters, seafood wholesalers, or pet storeowners.

Goal 4. Encourage support for research, management, and funding for non-native invasive species prevention and control.

Hire a full time professional executive director to provide the day-to-day leadership of DISC, manage and coordinate statewide invasive species programs, obtain grants and funding support for DISC. The executive director would also lead the state in invasive species prevention and control efforts. Convince state policy makers that the state of Delaware needs to invest state dollars in combating the problems associated with the introduction and spread of invasive species.

Goal 5. Serve as an advisory panel for various interests concerned with non-native invasive species and review management problems and activities associated with such species and provide updated information for specific management needs.

The DISC board should be elevated to Governor's Advisory Council or Commission with some authority to develop statewide policies to eliminate the spread of invasive species. Conduct yearly DISC species priority ranking of the invasive species by DISC members and invited experts. Next, develop a cost/effective approach to managing the higher priority invasive species of particular concern to Delaware.

6. LEAD AGENCY: DISC OFFICERS AND DISC BOARD OF DIRECTORS

E: Laws, Policy and Programs

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1. INTRODUCTION

Delaware has a series of laws and regulations designed to prevent the import and establishment of invasive species. Two State agencies, the Department of Agriculture (DDA) and the Department of Natural Resources and Environmental Control (DNREC) administer laws involving invasive species. These agencies have a number of regulatory tools available to State agencies, namely the following: permits and licenses, transportation and shipping requirements, monitoring, and bonds and insurance.

2. GOALS

Goal 1. Prevent the introduction of invasive species that are not known to exist in Delaware. This is the most effective form of invasive species management.

Goal 2. For invasive species that already exist in Delaware, develop and implement containment strategies using cost-effective, regionally-proven approaches.

Goal 3. Determine current legal authority to deal with invasive species and acquire additional authority as needed.

3. EXISTING LAWS AND REGULATIONS

Wildlife

The introduction of any species of domestic or wild animal onto lands administered by the Division of Parks and Recreation, DNREC, is prohibited.[1] A permit is required to import, possess, sell, or exhibit any live wild mammal or live reptile not native to or generally found in Delaware; [2] however, DNREC can exempt mammals and reptiles that do not represent a significant threat to community interests. Miscellaneous wildlife are covered under Delaware Code Title 7, §768, 770, and 795.

Birds and Poultry

No person may catch, possess, purchase, transport, or ship any wild bird other than a game bird, except as expressly permitted by law.[3] The Department of Agriculture may enter any premises where exotic avian species are kept to determine if any birds are infected with a contagious disease capable of affecting poultry.[4]

Fish

DNREC DFW must grant permission to stock any species of fish in the non-tidal public waters of Delaware and to transport, purchase, possess, or sell walking catfish, white amur, or grass carp.[5] Aquaculture activities must not promote the introduction of any nonindigenous species that harbors disease or parasites or are capable of competing with indigenous plant or animal species.[6] Every fee-fishing operation must be registered with the Department of Agriculture, [7] and it must be a closed system.

Aquatic Plants

Under existing law, DNREC may institute programs of control for common reed, (*Phragmites australis*).[8] The Department has the authority to enter into agreements with counties to survey and control this species.

Nuisance Aquatic Species

The surface waters of Delaware must be free of substances attributable to wastes resulting from human activity, including any pollutant that may result in the dominance of nuisance species.[9] Nuisance species are fish, other animals or plants living in or near the water, which cause unreasonable interference with the designated uses of the waters or of adjoining land areas.

Noxious Weeds

The Delaware Department of Agriculture currently designates 4 plant species as noxious weeds, Canada thistle (*Cirsium arvense*), Burcucumber (*Sicyos angulatus*), giant ragweed (*Ambrosia trifica*) and Johnsongrass (*Sorghum halapense*).[10] It is unlawful to allow any of these weeds to flower or exceed a height of 24 inches.

Seeds

DDA administers a Seed Law, which allows the Department to sample, inspect, analyze and test seeds transported within the state.[11] The Department has authority over prohibited noxious weed seeds and restricted noxious weed seeds. It is illegal to transport or sell agricultural, vegetable, flower, or tree or shrub seeds within Delaware containing prohibited or restricted noxious weed seeds.[12] Animal feed, fertilizer, and soil conditioners sold within the state must not contain an excess amount of viable weed seeds.[13]

Biological Control Agents

DDA regulates and controls the sale and use of biological control agents, to ensure their safety and effectiveness.[14] Movement, shipment, and sale of biological control agents requires a State and Federal permit.

Plant Pests and Diseases

The Plant Pest Law grants DDA the general authority to prevent the introduction of, or to control dangerously injurious plant pests.[15] Legal instruments include quarantines, permits penalties, and the authority to write additional regulations.

Nursery Industry

A license from DDA is required for persons to sell or distribute plants, nursery stock, or horticultural products.[16] Imported plants and nursery stock must be accompanied by a certificate from the state or origin, ensuring that the plants have been examined and found (apparently) free of dangerously injurious plant pests.[17]

Apiary

Beekeepers in Delaware must register with the State, and their apiaries examined at least annually.[18] The importation of bees or used beekeeping equipment requires an entry permit from DDA, also presentation of an inspection certificate from the sate of origin stating that the bees or equipment are free of all diseases, mites, and Africanized honeybees.[19]

4. EXISTING PROGRAMS

Phragmites Cost Share Program

The Division of Fish and Wildlife and National Resources Conservation Service provides financial/operational support to private marsh owners to help them control this species. The Division contracts the helicopter, buys the herbicide, and provides all operational

support/logistics. The landowner is billed their share of the cost as calculated on a per acre basis. In 2002, the Division covered 50% of the treatment costs. In 2003, with USDA-NRCS as a partner, 87.5% of the cost was covered and 3167 Acres were treated. Approximately 1854 acres of private marsh is treated/retreated each year. (Jones 2004)

Northern DE Wetland Rehabilitation Program (NDWRP)

Though not specifically an invasive species initiative, this program of the Division of Fish & Wildlife, Mosquito Control has restored over 2,200 acres of tidal or semi-tidal (impounded) wetlands in New Castle Co. *Phragmites* control is a major component of this restoration effort along with improving site hydrology, which may further reduce invasive species established in the affected marsh.

Estuarine Enhancement Program (EEP)

Though established as a mitigation project with funding from PSE&G, this program's main focus has been control of *Phragmites* on over 4,600 acres of tidal marsh and restoration of native biota to enhance juvenile estuarine fish utilization. It is administered by the Division of Fish & Wildlife.

Cooperative Agricultural Pest Survey (CAPS)

CAPS is a joint effort between the Delaware Department of Agriculture and the United States Department of Agriculture (USDA) to conduct surveillance, detection and monitoring of agricultural crop pests and biological control agents. One of the main goals of CAPS is to detect exotic pests before they can become well established. Data from DE and other states are incorporated into a national database (National Agricultural Pest Information System or NAPIS). The pests in Delaware's survey program are listed in Appendix 1.

Gypsy moth

DDA administers and funds a gypsy moth (*Lymantria dispar*) survey and suppression program on approximately 44,000 acres of State and private land. If fall egg mass densities exceed an established threshold, an aerial spray program is undertaken the following spring. Gypsy moth populations in Delaware and surrounding states have declined over the past few years, and there has not been a spray program in this state since 1997.

Forest Health Survey

Since 1999, DDA's Forest Service, in cooperation with the USDA Forest Health Service, has conducted a Botanical Survey of the State Forests. A total of 97 plots are surveyed for alien, native, and adventive plant species.

Enhancing Delaware Highways

Delaware Department of Transportation, Delaware Center for Horticulture, and the University of Delaware are cooperating on a 5-year project to reduce invasive plant species along the highways.

Native Plants Policy

DNREC's Division of Parks and Recreation, in cooperation with the Natural Heritage Program, is phasing in a Native Plants Policy, which directs the Division to use native plant species for any new plantings or replantings on lands managed by the Division. The policy also discourages the use of non-native, exotic ornamental species.

Claude E. Phillips Herbarium

This resource is located on the campus of Delaware State University. It is a repository of specimens of vascular plants, and is involved with invasive species identification, documentation, collection, education, and research.

5. GAPS, CHALLENGES, AND NEEDS

Goal 1. Prevent the introduction of invasive species that are not known to exist in Delaware.

This is the most effective form of invasive species management.

At the Federal, inter-state level, Animal Plant Health Inspection Service- (APHIS-PPQ) does not have the staff to properly enforce control of plants listed on the Federal Noxious Weed list. Recent internet surveillance will help.

There are no regulations or statutes prohibiting the release of non-native wildlife species (or plants) on public lands (other than Parklands per State Parks Rules and Regulations § 19.1).

There is very limited regulation of discharge of ballast water into U.S. waters (rivers, bays, coastal areas). An existing US Coast Guard (USCG) program is only voluntary.

The use of live bait is not regulated. Even though there is well-documented evidence of damage caused by the Green Crab (*Carcinus maenas*) to soft shell clams and other bivalves in New England. Another problem with the live aquatics bait industry involves the potential risk of introducing "hitchhikers" in the packing materials used (seaweeds etc) for the transport of baitworms, etc. There is limited research in Delaware on the potential impacts of live bait importation. At the College of Marine Studies a research project is underway funded by Sea Grant Aquatic Nuisance Species Research Program: *Risks of survival and establishment of tropical introduced bait species—A case study of the nuclear worm, Namalycastis sp*. Headed up by Douglas C. Miller, Associate Professor of Marine Studies in Lewes

There are several unregulated gaps for private property, including the following: Stocking of private impoundments, raising terrapin in a private pond, cultured aquatic stock in transit to, or in, or removed from, registered aquaculture facilities (pursuant to Chapter 4 of Title 3). Currently, there is no regulation on how or what is raised via aquaculture. The Delaware Department of Agriculture has completed a draft of regulations for aquaculture in non-tidal waters (developed with the consensus of local producers) that has successfully been through two public hearings but that needs to be formally adopted. These draft regulations do not cover all the items mentioned above but they do provide a listing of restricted species.

Goal 2. For invasive species that already exist in Delaware, develop and implement containment strategies using cost-effective, regionally-proven approaches.

Delaware Department of Agriculture Noxious Weed Law is limited to 4 weeds, and is focused on agriculture. The State has enforcement powers (under the Plant Pest Law), but it is difficult to place additional weeds on the State Noxious Weed list, if they are not a threat to agriculture.

DNREC *Phragmites* Program requires a minimum of 5 acres to qualify for cost share, at 50% of treatment cost. Many lands with *Phragmites* problems are too small to qualify for

treatment. Some large landowners and farmers are hesitant to pay the cost share portion, as they receive no income from the marshlands. Spot treatment is required to control regrowth of *Phragmites* after the initial 2-year program.

The Town of Smyrna has an ordinance for Bamboo control, however it is limited to the town area and covers only 1 weed.

The New Castle County Council incorporated the Delaware Natural Heritage Program's list of invasive plants into the County Code. The Unified Development Code is a large, complex document, and the Natural Heritage list is a little known and less enforced portion of it.

Any species propagated, sold or possessed wholly within a state is not subject to the Lacey Act even if the species is listed as injurious wildlife [unless species is transported out of the state]. Originally enacted in 1900 and administered by the U.S. Fish and Wildlife Service, the Lacey act is the key federal mechanism for controlling or banning "injurious animal" introductions. The Act gives the Department of the Interior authority to prohibit importation and possession of certain animal species that are "injurious to human beings, the interests of agriculture, horticulture, forestry, or to wildlife and other wildlife resources of the United States."

The Division of Fish and Wildlife has no inspection authority on private lands for monitoring or surveying invasive species nor emergency authority to force the resolution of an invasive species introduction (on private property).

There are separate divisions of legal authority and the three different advisory councils make the process of managing the invasive species issue complex, even at the Delaware Division of Fish and Wildlife (DF&W) level within DNREC. In addition, 3 different sections within DDA administer invasive species regulations and programs.

Goal 3. Determine current legal authority to deal with invasive species and acquire additional authority as needed.

Legal authority for invasive species is dependent on the impacted resources and species involved. Therefore it is split among several agencies and gaps occur. Areas where legal authority is lacking should be addressed, e.g. the authority to seize non-native invertebrates if deemed a danger to the environment by either DDA or DFW, or the overseeing of the bait trade which does not currently reside in either the DDA or DFW. A mechanism is needed to develop a "clean list" of species approved for importation and possession. It is much easier to develop a "dirty list" of prohibited species, but then the burden of proof is on the governmental agencies and usually by the time the species is known to be a hazard, it has been released. Development of a "clean list" is a more proactive approach for the prevention of potentially invasive species (Environmental Law Institute, 2002).

A statewide definition of an invasive species based on the one proposed in the National Invasive Species Management Plan (2001) should be adopted.

An invasive species is an alien species whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

National Invasive Species Management Plan. 2001

6. ACTION STEPS

Goal 1. Prevent the introduction of invasive species that are not known to exist in Delaware.

This is the most effective form of invasive species management. Education of the public and specific users groups as detailed in the education section of this Management Plan will help to achieve this goal, but other steps are required.

Cooperate with the Aquatic Nuisance Species Task Force (ANS), working through the United States Fish and Wildlife Service (USFWS) and USCG. They have developed a "Stop Aquatic Hitchhikers" logo and theme for use by state fish and wildlife agencies. A web site, www.protectyourwaters.net, and list serve are also available. *Agency: DNREC*

Develop regulations making it illegal to release any non-native plants, fish, wildlife, or invertebrates on public lands or waters (both tidal and non-tidal) without a permit from the Director Division, Fish & Wildlife of DNREC. *Agencies: DNREC*

Obtain the legal authority to develop a "clean" list of organisms that can be stocked, released, possessed, etc. *Agencies: DNREC, DDA*

Goal 2. For invasive species that already exist in Delaware, develop and implement containment strategies using cost-effective, regionally-proven approaches.

Support and promote use of the ***Delaware Invasive Species Tracking System***, a monitoring and database program which is further discussed in the Data Management Section of this Management Plan. *Agencies: DISC NGOs and all appropriate State Agencies.*

Establish an ***Early Warning System*** telephone contact that is well publicized for people to contact for sightings of unusual species. *Agencies: DDA, DNREC*

Require the use of native species for any new plantings or replantings on lands managed by the Division, similar to the *Native Plants Policy* being phased in by the Division of Parks and Recreation. *Agencies: DDA, DNREC*

Establish an inspection and emergency authority to address invasive species in a privately owned pond or property. *Agencies: DDA, DNREC*

Work with private landowners to develop more cost-share invasive species control program through new funds from federal government and other sources.

Develop and publish an ***Official List Of Invasive Plants For Delaware***, along with a realistic and workable control plan. *Agencies: DDA, DNREC*

Seek funds from the state legislature to provide funding for these activities. *Agencies: DDA, DNREC*

Goal 3. Determine current legal authority to deal with invasive species and acquire additional authority as needed.

The Lacey Act of 1900 is the federal law preventing the importation of "injurious wildlife" into the United States. However, since 1900 very few species have been placed on this list (two genera of mammals, four genera of birds, and two families of fishes [Environmental Law Institute 2002] and two invertebrates, the Mitten Crab and Zebra

Mussel). The US Fish & Wildlife Service recently prohibited all 28 species of snakehead fish in the *Channidae* family as injurious fishes under the Lacey Act. A separate amendment in 1981 makes illegal the interstate transport of fish, wildlife, or plants taken or sold in violation of federal or state law. However, any species propagated, sold or possessed wholly within a state is not subject to the Lacey Act even if the species is listed as injurious wildlife, until the organism is transported across State lines**.** The Federal Noxious Weed list, promulgated by the USDA, is similar to the Lacey Act in that it prohibits certain plant species. Similarly, USDA permit 526 is required to transport any plant-feeding insect across state lines. Because federal laws and policies do not provide complete protection for the problem of invasive species, each state must acquire the necessary tools and develop a comprehensive plan to address the issue. In Delaware, the steps that need to be taken to accomplish this task are:

Provide funding to determine the current status of legal authority, which is dependent on the impacted resource and species involved. The Environmental Law Institute (2002) summarized the legal tools available for states to manage invasive species and evaluated the status of legal authority of each state for five categories of organisms (aquatic, wildlife, plant, insects, and plant diseases). *Agencies: DNREC (DFW, DPR) and DDA.*

List the gaps where legal authority occur and fill them using legislation, regulations, and governmental policy. *Agencies: DNREC and DDA*.

7. CITATIONS

[1] DNREC, Parks and Recreation Rules and Regulations §19.1; 70-300

[2] Delaware Code Title 3, §7201

[3] Delaware Code Title 7, §734

[4] Delaware Code Title 3, §8101

[5] DNREC, Division of Fish and Wildlife, Non-Tidal Fishing Regulation NT-7 §§1-2; 70-200 Code of DE Regulations, 001

[6] Delaware Code Title 3, §406

[7] Delaware Code Title 3, §408

[8] Delaware Code Title 7, §3802

[9] DNREC, Division of Water Resources, Surface Water Quality Standards §4.1; 70-500 Code of DE Regulations 009

[10] DDA, Noxious Weed Control Rules and Regulations §2; 13-100, Code of DE Regulations 009

[11] Delaware Code Title 3, §1501

[12] Delaware Code Title 3, §1504

[13] Delaware Code Title 3, §§1707, 2111

[14] Delaware Code Title 3, §1107

[15] Delaware Code Title 3, §1103

[16] Delaware Code Title 3, §1302

[17] Delaware Code Title 3, §1306

[18] Delaware Code Title 3, §7504 §7502

[19] Delaware Code Title 3, §7510

Jones, B. 2004. Delaware Phragmites Control Program Information. Personal Communication - Statistics provided by Bill Jones, DE Division of F&W

F. Data Collection, Data Management and Risk Assessment

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1. Introduction/Vision

Problems with invasive species are extensive and ever-increasing. Efficient and effective response depends on collection and management of data on location and extent, and on assessment of the risk posed by particular species and individual infestations. Elected officials, administrators, land managers, researchers and property owners require both in order to have a rational, defensible basis for prioritizing actions in light of constraints on budgets, human resources and schedules.

2. Current Status of Data Collection and Management and Risk Assessment

Throughout the country, some managed areas have targeted collection of invasive species data within their boundaries, including many national parks, wildlife refuges and forests. Targeted data collection is also conducted for particular species, especially those of economic importance. However, for larger areas, such as counties and states, and most species, data is typically collected incidental to other fieldwork.

There are a variety of systems used for managing data on the location and extent of invasive species, far more for plants than animals. Many provide readily accessible data only in tabular form, although some make tabular and map data available on the Web. Among the more prominent examples for plants are the USDA-NRCS Plants Database (http://plants.usda.gov/), USGS Nonindigenous Aquatic Species website (http://nas.er.usgs.gov/), Southwest Exotic Plant Information Clearinghouse (http://www.usgs.nau.edu/SWEPIC/), Invasive Plant Atlas of New England (http://invasives.eeb.uconn.edu/ipane/) and Montana Noxious Weed Survey and Mapping System (http://www.montana.edu/places/mtweeds/). Many such systems follow the North American Invasive Plant Mapping Standards (http://www.nawma.org/documents/Mapping%20Standards/Invasive%20Plant%20Mapping%20Standards.pdf), which are described in the following section.

There are far fewer data management systems for animals than for plants, and currently no standards. Most animal datasets are species-specific and are geared toward species of economic importance. These include zebra mussel and other aquatic animals (http://nas.er.usgs.gov/), Asian tiger mosquito (http://www.cdc.gov/ncidod/dvbid/westnile/index.htm), European gypsy moth (http://www.fs.fed.us/ne/morgantown/4557/gmoth/), and a variety of agricultural pests (http://www.ceris.purdue.edu/napis/).

As with data collection and management, there are many schemes for assessing the risk posed by invasive plants. These are typically qualitative, and vary greatly in the detail level of factors used to assess risk. Such systems have been developed by the Brooklyn Botanic Garden (http://www.bbg.org/gar2/pestalerts/invasives/worst_nym.html#3), Connecticut Invasive Plant Working Group (http://www.hort.uconn.edu/cipwg/), Maryland Invasive Species Council (http://www.mdinvasivesp.org/invasive_species_md.html), Tennessee Exotic Pest Plant Council (http://www.se-eppc.org/states/TN/TNIList.html), Florida Exotic Pest Plant Council (http://www.fleppc.org/Plantlist/03list.htm), and others. Only one scheme

is apparently in use for animals, a pathway-based approach for pests of agricultural and horticultural plants (http://www.aphis.usda.gov/ppq/pra/).

Semi-quantitative risk assessment schemes have also been developed for plants. The first of these, the Alien Plant Ranking System (http://www.npwrc.usgs.gov/resource/2000/aprs/aprs.htm), was initiated by NPS. It addresses three factors in detail – threat significance, innate invasiveness and control effort – and assigns numerical scores for each that can be compared among species. In 2002, TNC and NatureServe expanded this approach into their "Criteria for Categorizing Alien Plant Species that Threaten Native Biodiversity" (Randall et al. 2002). This is described in more detail below.

3. CURRENT STATUS IN DELAWARE

Delaware has collected data on the location and extent of some invasive species for a number of years:

Species	Agency	Year Data First Collected
Common Reed	DNREC	1940's
Purple Loosestrife	DNREC	2001
European Gypsy Moth	DDA	1980
Mosquitoes	DNREC	1930's

Limited data on some of Delaware's remaining invasive species have been collected incidental to other work. This includes surveys for rare plants and animals, and freshwater pond and stream surveys by the Delaware Division of Fish and Wildlife; and Forest Health Monitoring surveys and Cooperative Agricultural Pest Surveys by the Delaware Department of Agriculture. Some managed areas in the state have been surveyed – or are currently being surveyed – for invasive plants. These include Bombay Hook and Prime Hook National Wildlife Refuges, and properties of the Delaware Nature Society and the Delaware Chapter of The Nature Conservancy.

Data for some of the above species and areas are managed with proprietary systems developed exclusively for particular projects and programs. However, until recently there was no formal data management system for the majority of the state's invasives. In the summer of 2003, testing began for the Delaware Invasive Species Tracking System (DISTS). DISTS integrates a GIS and a database into an "atlas" for documenting the abundance, distribution and current status of invasive plants and animals throughout the state. Both tabular and map data can be viewed on the Web at http://www.lsc.usgs.gov/gis/dists/intro.asp. DISTS was developed by the Delaware Invasive Species Council, Inc. through a cooperative agreement between the Delaware Natural Heritage Program (DNHP) and the U.S. Geological Survey (USGS). The data collected will be used to increase public awareness, support policy and regulation development, and guide management actions. The test phase is being conducted with the assistance of selected cooperators and for a limited number of invasive species.

DISTS is compatible with the North American Invasive Plant Mapping Standards, which set out a minimum level of information needed for decision-making. This includes plant identification, location and date of observation, infested area, percent cover, observer name and property information. DISTS allows observers to collect information in the field, either during targeted surveys or incidental to other work, and then transcribe this

data to a web-based GIS and database. For each occurrence noted in the field, the information recorded includes species, latitude/longitude, date of observation, area covered/number of individuals, habitats, and identity of the observer. Upon entry of the information into the website, the GIS adds other attributes such as watershed, USGS quad, and physiographic province. Decision-makers, land managers and the general public can access the website, where the data can be queried geographically or by the attributes listed above.

A work group of state, non-profit and private-sector representatives began work in 2002 on a risk assessment scheme for Delaware's invasive plants. This scheme closely follows the "Criteria" developed by TNC and NatureServe with only minor modifications. Four groups of factors are considered:

- Impact on ecosystems, natural communities and native species – ecosystem processes, community structure and function, native species populations, etc;
- Current distribution – range size, extent of impacts, diversity of ecological systems invaded, etc;
- Potential distribution – population trend, reproductive characteristics, etc; and
- Management difficulty – time, human resource and financial commitments, impacts of control methods on native species, etc.

Each of these factors is rated on a four-part scale ranging from "Major," "Highly Significant" or the like, to "None," "Insignificant" or something similar. Each rank has an associated numerical score and contains either a detailed description or quantification. The individual ranks are then compiled for an overall invasiveness score for that species. Plants are then divided into three groups depending on their scores and current distributions:

- Widespread and Invasive;
- Restricted and Invasive; and
- Potentially Invasive.

Approximately 20 plants have been assessed for risk as of mid-2003. These species are among a group initially chosen to be ranked based on professional judgment that they represented the worst invaders in Delaware; the ranking process has validated that choice. No similar effort has been undertaken for invasive animals in the state. The consensus among resource managers is that an approach similar to that for plants – covering the same four groups of risk factors – should work for animals. Some adjustments would be needed for the widely varying taxa to be considered, from microbes to vertebrates.

4. GOALS

Goal 1. Conduct long-term, targeted data collection for invasive species and for natural areas.

Goal 2. Provide a central repository for all invasive species distributional information.

Goal 3. Complete risk assessments for all non-native plants.

Goal 4. Develop a risk assessment scheme for invasive animals and complete assessments for all non-native animals.

5. GAPS, CHALLENGES, OPPORTUNITIES

Goal 1. Conduct long-term, targeted data collection for invasive species and for natural areas.

Incidental data collection will rarely – if ever – provide sufficient basis for decision-making. However, current funding for targeted surveys is very limited relative to the scope of the problem. In addition to the projects and programs mentioned in earlier sections, money will become available for invasive plant surveys of state wildlife areas in the near future through the State Wildlife Grants program. Like many other programs, though, this is a one-time appropriation that is insufficient to meet the larger need and provides no means for on-going monitoring.

Goal 2. Provide a central repository for all invasive species distributional information.

DISTS provides all of the tools necessary for serving as Delaware's principal location for data on invasive species distribution, although the system has not been formally designated as such. USGS has committed to continuing to host the website for the next several years, but the state will have to assume responsibility after that. Also, day-to-day management of DISTS data input and output is currently assigned to DNREC staff with many other duties; significantly expanded use of the site could not be supported by this position.

Goal 3. Complete risk assessments for non-native plants.

In the absence of staff explicitly assigned to invasive species issues, preparation of plant risk assessments to date has made steady, but slow, progress. Completion of assessments for all non-native species will take years at the current rate.

Goal 4. Develop a risk assessment scheme for invasive animals and complete assessments for non-native animals.

Given the overlapping federal and state jurisdictions for animals, the taxonomic dissimilarities involved, and the scarcity of existing schemes, development of risk assessment criteria for invasive animals will likely be more complex than for plants. As with plants, present staff limitations will make producing animal assessments a lengthy process.

6. ACTION STEPS

Goal 1. Conduct long-term, targeted data collection for invasive species and for natural areas.

Provide permanent funding for state agencies to collect data, both initial surveys and long-term monitoring. *Agencies: DNREC, DDA, DelDOT*

Work with conservation partners and private-sector land managers to ensure funding for data collection. *Agencies: DNREC, DDA*

Expand use of DISTS to the general public. *Agency: DNREC*

Goal 2. Provide a central repository for all invasive species distributional information.

Require use of DISTS by all state invasive species data collection programs and projects not having proprietary data management systems. For those with proprietary systems, require that the information be shared with DISTS on a periodic basis. Strongly encourage use of DISTS, and/or sharing of data with DISTS, by non-state entities. *Agencies: DNREC, DDA*

Upgrade DISTS to reflect user comments and to take advantage of improvements in technology. This includes increasing utility by integrating into DISTS a TNC data input program for hand-held devices. *Agency: DNREC*

Obtain the necessary hardware, software and agency commitment to host the website. *Agency: DNREC*

Provide permanent funding for a staff position to manage DISTS data input and output. *Agency: DNREC*

Goal 3. Complete risk assessments for non-native plants.

Provide temporary staff (reassignment, contractor, short-term hire, etc.) for producing plant risk assessments, and complete all assessments. *Agencies: DDA, DNREC*

Goal 4. Develop a risk assessment scheme for invasive animals and complete assessments for non-native animals.

Establish a work group consisting of state, non-profit and private-sector representatives to develop a risk assessment scheme for animals by. *Agencies: DNREC, DDA, UD, DISC and others.*

Provide temporary staff (reassignment, contractor, short-term hire, etc.) for producing animal risk assessments, and complete all assessments. *Agencies: DNREC, DDA*

7. LITERATURE CITED

Randall, J.M., L.E. Morse, N. Benton and R. Hiebert. 2002. Criteria for categorizing alien plant species that threaten native biodiversity: review draft, September 2002. The Nature Conservancy and NatureServe. 14 pp.

G. Management Actions

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1. INTRODUCTION

The most effective method to minimize invasive species is through education of the public to minimize their introduction, elimination of common pathways, and authorization of regulatory authority. However, when invasive species become established within the State, management actions are necessary to minimize the effects on the natural environment, human health, and/or the economy. Management actions are species-dependent, but all are influenced by several factors:

Type of invasion & pathway

Extent of coverage/ incidence

Regulatory authority

Best management practices (BMPs)

Cost

Political boundaries involved

Some Examples of Management Actions

Species	Fire ants	Hydrilla
Time	2000	Since 1980
Type of infestation	Spot introductions	Established in many public ponds
Pathway	Nursery stock	Aquarium trade & waterfowl
Impact	Southern Pest/ human health& wildlife	Adversely impacts pond habitat & recreation
Lead agency	DDA	DFW; DPR on park areas
Authority	Through DDA	DFW
BMP	Eradication is possible	Herbicide application in selected areas
Funding	DDA	DFW/ GF & Fed. Aid

2. GOALS

Goal 1. Develop Memorandum of Understanding (MOU) between appropriate agencies that deal with invasive species issues as part of their responsibilities.

Goal 2. Establish landowner incentive programs to effect invasive species control efforts on privately owned lands.

Goal 3. Develop standard criteria for the evaluation of management options on a per-species basis.

Goal 4. Evaluate the need for restoration efforts by habitat, establish Best Management Practice (BMPs), and provide coordination of a statewide plan.

3. GAPS, CHALLENGES, NEEDS

Goal 1. Develop MOU between appropriate agencies that deal with invasive species issues as part of their responsibilities and provide coordination of a statewide plan.

Because many biological invasions cross political boundaries, coordination among federal, state, and local agencies, and Non-Governmental Organizations (NGOs) is critical. Sharing information, coordinating management priorities, and recognizing agency capabilities will increase the cost-effectiveness of control programs and management efforts.

Currently, invasive species management efforts are accomplished by many staff as part of their regular duties. A full-time manager is needed whose sole responsibility will be to provide coordination of a statewide plan across all agencies, NGOs, and private landowners.

Goal 2. Establish landowner incentive programs to effect invasive species control efforts on privately owned lands.

Although many infestations of invasive species occur on private lands, these species can spread to public lands if left untreated. Therefore it is important for private landowners to control certain pests. In some cases, the invasive species may be detrimental enough to legally require treatment or control. This situation has precedence in the Noxious Weed Control Rules and Regulations (DDA), which require removal of certain weed species before they produce seed (Johnson Grass, Canada Thistle, Burcucumber, and Giant Ragweed).

However, incentive programs would be useful in encouraging private landowners to control invasive species on their lands. The ongoing *Phragmites* cost-share program (DFW and USDA-NRCS) is an example of such a program.

Public outreach and educational efforts are valuable both in the aspect of minimizing the spread of invasive species or recognizing localized populations before they spread and using BMPs to manage such species. A complete discussion of this topic is available in Section I. Education and Outreach of this document.

Goal 3. Develop standard criteria for the evaluation of management options on a per-species basis.

The actions used for invasive species control are dependent upon many factors, with the most important being the species involved. A standard policy for the evaluation of available management options is not currently available. Control methods should be effective and have minimal impact on non-target species. An appropriate management action can be determined by utilizing a standard risk assessment evaluation on both the target species and available control methods. In many cases, BMPs may be readily available for chemical, biological, or mechanical control. Viability of total eradication, managed control, or spot treatments of isolated populations should be an inherent part of the evaluation of appropriate management actions.

Goal 4. Evaluate the need for restoration efforts by habitat, establish BMPs and provide coordination of a statewide plan.

Control programs for invasive species should include an evaluation of the need for restoration efforts. In some habitat types and locations, this type of effort may be cost prohibitive or technically infeasible. For example, in marsh habitats where *Phragmites* has been controlled, restoration efforts have been used infrequently due to difficulties inherent in such habitats. In impoundment situations, the native seed bank is robust and native plants quickly colonize the area, followed by successional species. The same habitat in a tidal area, however, requires a longer time period for growth of native plant species due to the limited seed bank, as most seed produced is flushed from the system. A restoration program in either situation is also difficult due to the large expanse of *Phragmites* (over 100,000 acres according to Robert Meadows, DE DFW), the daily flushing of the tides, and the poor structure (mud flat) of the habitat.

In some situations, restoration should be required. Removal of autumn olive (*Elaeagnus umbellata*) in some locations on Delaware state wildlife areas has been followed by the planting of warm season grasses. The grasses provide habitat for many ground-nesting species and minimize the regrowth of the autumn olive (Wayne Lehman, DE DFW, personal communication). Many invasive species colonize disturbed areas. Those sites where habitats have been restored should be less vulnerable to future invasions by the same or other invasive species (National Invasive Species Management Plan 2001).

A restoration protocol is needed to provide BMPs following the reduction or eradication of invasive species and to provide technical assistance to both the private and public sector.

4. ACTION STEPS AND PARTICIPATING AGENCIES

Goal 1. Develop MOUs between appropriate agencies that deal with invasive species issues as part of their responsibilities and provide coordination of a statewide plan.

DISC may provide technical assistance and focus efforts on an invasive species management plan, but an Executive Director or Coordinator is needed to fulfill the day-to-day responsibilities required by this effort. Such a position should be funded under DISC, DNREC or DDA to provide this coordination. The development of MOUs between the major agencies involved should be pursued. *Agencies: DNREC (DSWC, DFW, DPR), DDA (Plant Industries, Forestry, Poultry and Animal Health), DelDOT, USFWS, and USDA-NRCS .*

Goal 2. Establish landowner incentive programs to effect invasive species control efforts on privately owned lands.

The Phragmites cost-share program provides 50-87% matching funds (through the DFW & NRCS) for control efforts by landowners with more than five-acres coverage of this plant. This program should be expanded to cover other species as funds are made available to the states through the National Invasive Species Plan. Terrestrial plant species such as Spotted Knapweed (*Centaurea biebersteinii*) have cost-share programs available in some states (Westbrooks 1998).

Resources for technical assistance to interested parties should be made available through appropriate web sites, for example the DISC site, with links to useful locations. A directory of available information (web sites, contacts, etc.) should be developed while

taking advantage of "on the ground" programs such as The Nature Conservancy (TNC) and Delaware Nature Society (DNS) and research efforts (University of Delaware, Delaware State University) for programs that have worked. Many pertinent web sites, such as www.invasivespecies.gov, include "tool kits" for managers needing practical information on control methods.

Information about viable alternatives to many landscape (aquatic and terrestrial) species should be provided to the general public for home use and restoration efforts on control sites. The Delaware Native Plant Society (DNPS), the Delaware Nature Society (DNS), and local nursery retailers provide species lists and culture information. DNPS and DNS, as well as regional suppliers also sponsor sales of native plants. Publicizing the use of native species alternatives to invasive species and providing technical assistance on control methods should enhance the availability and profitability of native landscape species for retailers. The need to document propagated native species versus those collected from the wild should be basic to such a program.

Goal 3. Develop standard criteria for the evaluation of management options on a per-species basis.

Management action options should be evaluated according to established criteria. In many cases, where the invasion is widespread, preventing the spread or minimizing the impact on the habitat may be the best that can be achieved. For species like *Multiflora* Rose or *Hydrilla*, treatment for control may only be attempted at specific sites by users

> *Control and management objectives may include: eradication within a local area, population suppression, limiting dispersal, reducing impacts, and other diverse objectives. Control and management of invasive species populations is accomplished using an integrated pest management (IPM) approach. The IPM approach considers best available scientific information, updated target population monitoring data, and the environmental effects of control methods in selecting a range of complementary technologies and methods to implement to achieve a desired objective. These methods may include: 1) cultural practices (e.g. crop rotation, revegetation, grazing, and water level manipulation); 2) physical restraints (e.g. fences, equipment sanitation, and electric dispersal barriers); 3) removal (e.g. hand removal, mechanical harvesting, cultivation, burning, and mowing); 4) the judicious use of chemical and biopesticides; 5) release of selective biological control agents (such as host-specific predator/herbivore organisms); and 6) interference with reproduction (e.g. pheromone-baited traps and release of sterile males). Often several methods are used within an overall integrated strategy. For example, control of purple loosestrife may involve biological control, mechanical removal, and other methods. Consideration of the environmental impacts of control actions requires that environmentally sound methods be available and judiciously deployed, especially in highly vulnerable areas.*
>
> *National Invasive Species Management Plan. 2001.*

most seriously impacted. In other cases, the fire ant for example, small, localized infestations can be easily eradicated through an early detection and rapid response system.

All control programs should use the best available information, but should be revised to reflect updated information and successful methodology. Information about successful programs should be made available (via DISC web site or links) to those who need it.

Goal 4. Evaluate the need for restoration efforts by habitat, establish BMPs and provide coordination of a statewide plan.

Short lists of plant species by habitat type should be made readily accessible for private landowners although more detailed information should be available (e.g. through Delaware Cooperative Extension Master Gardeners). Sources of available materials and BMPs should be available through educational efforts, web sites, and/or printed publications.

5. LITERATURE CITED

Environmental Law Institute. 2002. Halting the Invasion: State Tools for Invasive Species Management. Washington, D.C. 101 pp.

National Invasive Species Council. 2001. Meeting the Invasive Species Challenge: National Invasive Species Management Plan. Washington, D.C. 80 pp.

Westbrooks, R. 1998. Invasive Plants, Changing The Landscape Of America: Fact Book. Federal Interagency Commission for the Management of Noxious and Exotic Weeds (FICMNEW). Washington, D.C. 190 pp.

H. Research

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1. INTRODUCTION

Research is an essential and often first step in addressing the many problems posed by invasive species. The Delaware Invasive Species Council, Inc. (DISC) provides a forum through which interested parties can collaborate to identify areas of concern that could benefit from additional information, formal hypothesis testing, or other forms of research activity.

2. CURRENT STATUS OF RESEARCH ON INVASIVE SPECIES

There has been a good deal of research on invasive species in the past decade. Much of it has focused on the impact of invasives on the biotic and abiotic components of various ecosystems (Mooney & Drake 1986, Soule 1990, Goold 1994, Pysek 1995, Duncan 1997, Gandon 1998, Cox 1999, Levin 2002) and on the economics of invaded regions (Pimentel et al. 2000). Other studies have tried to determine what factors enable some nonindigenous plant species to exhibit invasive behavior while others never do (Williamson 1996, Crawley 1997, Keane & Crawley 2002). Although several studies have measured the effect of native insect communities on the fitness of invasive plants, there have been no organized attempts to quantify the impact of invasive plants on native insects.

3. GOALS

Goal 1. Identify all species not indigenous to Delaware that are or are at risk of becoming invasive.

Goal 2. Improve our understanding of the agricultural, economic, ecological and health consequences of invasions by alien species.

Goal 3. Identify and block new and existing pathways of invasion.

Goal 4. Integrate control/eradication programs with restoration programs.

4. GAPS, CHALLENGES, OPPORTUNITIES

There are critical gaps in our knowledge of the impact of invasive species on local biodiversity, energy flow through different ecosystems, water and mineral cycles, threatened or endangered populations of plants and animals, recreational fishing and bird watching and human health. There is also much to learn about life history traits and environmental conditions that encourage invasiveness in particular nonindigenous species. We need to improve our understanding of the many pathways by which alien species invade our ecosystems, and our knowledge of how to meet the daunting challenge of restoring natural areas to their native states is in its infancy. Even our knowledge of which nonindigenous species are already established in Delaware is woefully incomplete. Although research is needed on many fronts, DISC urges that resources be focused on the following priorities.

Goal 1. Identify all species not indigenous to Delaware that are or are at risk of becoming invasive.

Before we can understand the impact of invasive species or discover the most efficient ways to eliminate them we need to know which invasive species are established in Delaware. Because many nonindigenous species become invasive after long periods of relatively benign behavior, it is important to note the presence of all nonindigenous species in Delaware ecosystems.

Goal 2. Improve our understanding of the agricultural, economic, ecological, and health consequences of invasions by alien species.

An important challenge for DISC is to coordinate, encourage and facilitate research on the consequences of alien invasions. Nationwide generalities about the economic, biotic and abiotic effects of aliens are emerging but specifics about the effects of aliens in Delaware are lacking.

Goal 3. Identify and block new and existing pathways of invasion.

Research into identifying and blocking invasion pathways is essential if we are to slow the influx of nonindigenous species into Delaware.

Goal 4. Integrate control/eradication programs with restoration programs.

Removal of invasives, particularly plants, leaves disturbed ground that is then vulnerable to reinvasion by the same alien species or by new ones. Without proper restoration of the disturbed site, the long-term elimination of invasive species is improbable at best. Little is known about the best way to restore areas after the removal of invasives and techniques that work will probably depend upon the species that has been removed and characteristics of the invaded site. This is an area ripe with research potential.

5. ACTION STEPS

DISC Research goals will be facilitated through regularly scheduled meetings of the DISC Research Committee. Representatives of federal and state agencies, academic institutions and other parties conducting research on invasive species will be invited to these meetings to share results and challenges of these projects.

Goal 1. Identify all species not indigenous to Delaware that are or are at risk of becoming invasive.

This goal is elaborated in Section E of the DISC management plan.

Implement the Delaware Invasive Species Tracking System (DISTS) in coordination with data collection by permanently funded surveys of plants, vertebrates, arthropods, and marine invertebrates. *Agencies: DNREC, DDA, and the Delaware Center for Inland Bays.*

Goal 2. Improve our understanding of the agricultural, economic, ecological and health consequences of invasions by alien species.

Sponsor and conduct research by DISC membership on topics relevant to the biotic, abiotic and economic impact of invasive species in Delaware.

Conduct three meetings annually to discuss future research directions and highlight current research initiatives.

Compile and publicize a list of funding agencies and sources that address invasive species research.

Goal 3. Identify and block new and existing pathways of invasion.

Block pathways of invasion by supporting new legislation.

Continue to educate the public about their role in importing invasives.

Goal 4. Integrate control/eradication programs with restoration programs.

Promote the coordination of restoring native flora and fauna in conjunction with eradication programs.

Investigate the ability of various species of native plants to repel the invasion of exotics.

6. REFERENCES CITED

Cox, G. 1999. Alien Species In North America And Hawaii: Impacts On Natural Ecosystems. Island Press, Washington, D.C.

Crawley, M.J. 1997. Plant Ecology. Blackwell Scientific. London.

Duncan, C. 1997. Environmental Benefits of Weed Management. Dow-Elanco, Inc., Washington, D.C.

Gandon, S. 1998. Local Adaptation And Host-Parasite Interactions. Trends in Ecology and Evolution 13:214-216.

Goold, C. 1994. The High Cost Of Weeds. pages 5-6 in Noxious Weeds: Changing the face of Southwestern Colorado. San Juan National Forest Association, Durango, Colorado.

Keane, R.M. and M.J. Crawley. 2002. Exotic Plant Invasions And The Enemy Release Hypothesis. Trends in Ecology and Evolution 17:164-170.

Levin, D.A. 2002. Hybridization and extinction. American Scientist 90:254-261.

Mooney, H.A. and J.A. Drake, eds. 1986. Ecology of Biological Invasions of North America and Hawaii. Ecological Studies 58. Springer-Verlag, New York, New York.

Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2000. Environmental And Economic Costs Of Nonindigenous Species In The United States. Bioscience 50:53-65.

Pysek, P. 1995. Recent Trends In Studies On Plant Invasions (1974-1993). Pages 233-236 in Pysek, P., K. Prach, M. Rejmanek, and M. Wade, eds. Plant Invasions – General Aspects and Special Problems. SPB Academic Publishing, Amsterdam, The Netherlands.

Soule, M.E. 1990. The Onslaught Of Alien Species And Other Challenges In The Coming Decades. Conservation Biology 4:233-239.

Williamson, M. 1996. Biological Invasives. Chapman & Hall. London.

I. Education and Outreach

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1. INTRODUCTION

Because many people, organizations, companies, and agencies are unaware that their actions can result in the introduction and spread of non-native, invasive species, education and outreach programs constitute an important early defense for prevention and control. Everyone has a stake in the management of invasive species and therefore needs to be involved in efforts to address the problem. Education and outreach programs on invasive species will be most effective when they target the information needs and interests of specific audiences, indicate that positive progress can be made, and recommend specific actions. Stakeholder involvement can be expanded by communicating the interrelationships between invasive species and quality of life issues, and by delivering a consistent message through a diversity of messengers and media.

2. GOALS

The goal of this section is to develop an effective and comprehensive management strategy regarding invasive species that integrates information exchange, public education, prevention, and fosters cooperative working relationships. This will be accomplished through the following goals and action steps:

Goal 1. Educate the General Public

Goal 2. Educate Business Owners

Goal 3. Provide Additional Educational Material

Goal 4. Information Exchange

3. GAPS, CHALLENGES, AND NEEDS

People need to be made aware that invasive species can and do:

Have an ecological or economic impact on native species, rare habitats (natural areas), native species habitats such as wetland and riparian areas, and commercial fisheries, industries, outdoor recreation, agriculture and the like;

Have political and economic significance with management of certain species that impacts constituency groups like commercial seed producers or plant nurseries, the pet or fish bait industry, landscapers, gardeners, animal welfare, sportsmen, those seeking outdoor recreation, commercial fishermen, farmers, and others who may oppose certain management activities; and

Have human health significance by being vectors of disease organisms that can affect humans.

The *challenge* is to present this information in such manner as to not alienate a group or to overwhelm or create a sense of despair with individuals who might feel that nothing can be done to halt the spread of invasive species.

Gaps in information for Delaware-specific target audiences appear to be two-fold. General invasive species information appears at the national level, but localized information is too technical for general audiences. In dealing with industry-specific

audiences (i.e. pet and bait trade, landscapers, nurseries, retail outlets, etc), there is little to no targeted information (species or pathway-specific) that can help to inform or cause a change in practices or products being sold or used.

There is a *need* for a consistent message directed at all age, industry, education, and socio-economic levels that informs and seeks to empower the audience to act in a different manner and feel that they can be part of the solution.

4. ACTION STEPS

Goal 1. Educate the General Public.

a. Develop and maintain a Speaker's Bureau list to use prepared slide/overhead/flipchart/PowerPoint presentations.

Initially, core DISC groups including the Delaware Department of Agriculture, the Center for the Inland Bays, the Delaware Department of Natural Resources and Environmental Control, U.S. Department of Agriculture, the U.S. Fish and Wildlife Service, the Delaware Nursery and Landscape Association, the University of Delaware, Delaware State University, the Claude E. Phillips Herbarium and The Nature Conservancy should provide input (slides, images, concepts and ideas to be conveyed) to the Education and Outreach Committee to aid in presentation development. Each DISC member agency and group, depending on speaker qualification and target audience, can use the presentation to further the DISC message.

b. Identify and target non-traditional groups for general invasive species presentations.

The Board and membership of DISC should annually review and modify a list of potential groups. Programs developed under Action step b. (above) could be provided to these groups. Below are examples of groups that may be interested:

Local and State Elected Officials

Delaware Farm Bureau/ Delaware Council of Farm Organizations/Grange

Delaware State Chamber of Commerce/Better Business Bureau

Lion's Club/Rotary/Kiwanis/Ruritan/etc.

Local Home and Garden Clubs.

c. Develop and distribute a general public "FYI" invasive species brochure.

DISC Board member agencies and groups, along with general membership groups that have an interest and key resources at their disposal, should assist the Education and Outreach Committee in the development of this information. Once developed, sources of funding will be solicited to help pay for the cost of printing.

d. Prepare and distribute web-page/internet-ready information for distribution to applicable groups.

The DISC Board will assist the Education and Outreach Committee in the development and distribution of this information. Some information will be made available via the DISC website, http://www.delawareinvasives.org/

e. Develop and distribute regular Public Service Announcements and Press Releases.

The DISC Board will assist the Education and Outreach Committee in the development and distribution of this information. Based on the topic at hand, the Committee or the Board may utilize the assistance of key individuals or groups who may have a particular expertise.

Goal 2. Educate Business Owners.

a. Develop and distribute industry-specific invasive species brochure (i.e. pet and bait trade, landscapers, nurseries, retail outlets, etc.).

DISC Board member agencies and groups, along with general membership groups that have an interest and key resources at their disposal, should assist the Education and Outreach Committee in the development of this information. This brochure will be developed in coordination with the groups that have a vested interest.

b. Identify industry-specific publications for invasive species-related articles, columns, and open letters.

The DISC Board will assist the Education and Outreach Committee in the development and distribution of this information. Based on the topic at hand, the Committee or the Board may utilize the assistance of key individuals or groups who may have a particular expertise.

c. Prepare and distribute web-page/internet-ready information for distribution to applicable groups.

The DISC Board will assist the Education and Outreach Committee in the development and distribution of this information. Some information will be made available via the DISC website, http://www.delawareinvasives.org/

d. Develop and distribute regular Public Service Announcements and Press Releases.

The DISC Board will assist the Education and Outreach Committee in the development and distribution of this information. Based on the topic at hand, the Committee or the Board may utilize the assistance of key individuals or groups who may have a particular expertise.

Goal 3. Provide Additional Educational Material.

a. Develop information that can be utilized by existing public and private education and outreach programs to disseminate general information regarding invasive species.

Core DISC groups including the Delaware Department of Agriculture, the Center for the Inland Bays, the Delaware Department of Natural Resources and Environmental Control, U.S. Department of Agriculture, the U.S. Fish and Wildlife Service, the Delaware Nursery and Landscape Association, the University of Delaware, and The Nature Conservancy should provide input (slides, images, concepts and ideas to be conveyed) to the Education and Outreach Committee to aid in its development. Target Groups for this effort should include:

DNREC Parks & Recreation Naturalists' Programs

Delaware Nature Society/The Nature Conservancy/The Audubon Society/The Sierra Club

Pesticide and Arborist Certification Programs

University of Delaware Cooperative Extension System Master Gardeners

Delaware Envirothon

Future Farmers of America

4-H.

b. Develop information for use by the Delaware Department of Education to educate elementary and high school students about invasive species.

DISC Board member agencies and groups, along with general membership groups that have an interest and key resources at their disposal, should assist the Education and Outreach Committee in the development of this information, all in close coordination with the Delaware Department of Education.

c. Prepare and distribute web-page/internet-ready information for distribution to applicable groups.

The DISC Board will assist the Education and Outreach Committee in the development and distribution of this information. Some information will be made available via the DISC website, http://www.delawareinvasives.org/

Goal 4. Information Exchange.

a. Regularly share invasive species-related information and activities with adjoining states.

Share information with Maryland/Pennsylvania/New Jersey and key partner agencies and organizations such as Delaware-Maryland-Pennsylvania-New Jersey invasive species groups, the Mid-Atlantic Exotic Pest Plant Council, State Natural Resources and Agricultural representatives and Federal agencies with an interest in invasive species such as the National Park Service, the Forest Service, Fish and Wildlife Service, Natural Resources Conservation Service, etc. Some information can be shared via the internet (hosted web sites), listserv distribution, and e-mail. Information to be shared can and should include management plans, ongoing research and projects, and the like. After groups have been identified and relationships have begun to develop, plans to convene a regional meeting should commence.

b. Identify, collect, and distribute existing printed information (i.e. brochure, fact sheets, etc) to appropriate outlets and venues.

Each DISC member group or agency should share any and all information relevant to invasive species. For example:

Links to websites, on-line internet publications, and digital images can be shared with the membership via e-mail;

Maintain a bibliography of publications, journal articles, and books related to invasive species;

Printed publications and articles can be copied and forwarded to the DISC Board for review and possible distribution or routing based on its content and applicability to the state; and

Originals of other printed material (brochures, photographs, fact sheets) should be forwarded to the DISC Board for evaluation and discussion.

c. Prepare and distribute web-page/internet-ready information for distribution to applicable groups.

The DISC Board will assist the Education and Outreach Committee in the development and distribution of this information. Some information will be made available via the DISC website, http://www.delawareinvasives.org/

5. REFERENCES

Handbook for Ranking Exotic Plants for Management and Control

Ronald D. Hiebert, National Park Service and James Stubbendieck, Department of Agronomy, University of Nebraska. Natural Resources Report NPS/NRMWRO/NRR93/08. July 1993

Invasive Species in the Chesapeake Bay Watershed-Final Report to the Chesapeake Bay Program, Invasive Species Working Group. Fredrika Moser, Editor. Publication number UM-SG-TS-2002-03. August 2002

Meeting the Invasive Species Challenge: National Management Plan

National Invasive Species Council. January 2001

"Preserving Our Natural Heritage" The National Park Service. A Strategic Plan for Managing Invasive Nonnative Plants on National Park System Lands. U. S. Department of the Interior, National Park Service. August 1996

Statewide Invasive Species Strategic Plan for Florida. Invasive Species Working Group (Florida). 2002

Wisconsin's Comprehensive Management Plan To Prevent Further Introductions and Control Existing Populations of Nonindigenous Aquatic Nuisance Species. Wisconsin Department of Natural Resources in cooperation with University of Wisconsin Sea Grant. September 2001

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1. INTRODUCTION

It is our vision to develop a process for addressing the problems associated with invasive species. Through the membership of the Delaware Invasive Species Council (DISC), a collective group of interested parties can collaborate on efforts to prevent, mitigate, or eradicate invasive species. This network of experts is a tremendous resource to combat the problems of invasive species.

The interest among Delaware scientists, policy makers, and business owners is growing concerning invasive species. Increased media coverage on national venues has increased awareness. Few people have not heard of fireants, killer bees and the dinoflagellate *Pfiesteria* in Delaware, but connecting these organisms to invasive species prevention programs is still a major challenge. Homeowners are concerned about their landscaping areas and gardens. Farmers are concerned about new weeds and damaging insects. Beach enthusiasts are concerned with harmful algae disrupting fisheries. An educated public could assist DISC in identifying and monitoring invasive species around the state.

2. CURRENT STATUS OF MONITORING/EVALUATION OF INVASIVE SPECIES

The primary invasive species monitoring and evaluation programs are specific to a single species under investigation and conducted under the auspices of the Delaware Department of Agriculture (DDA) and the Delaware Department of Natural Resources and Environmental Control (DNREC). The DISC board and particularly the Invasive Species Inventory Committee is striving to aggregate existing invasive species data to make monitoring and success measures possible. There is only a small fraction of invasive species on the database, most of which are invasive plants.

3. GOALS

The goal of this section of the Delaware Invasive Species Management Plan is to:

Goal 1. Develop a process for assessing our statewide monitoring efforts

Goal 2. Develop a process for evaluating the effectiveness of our management plan on an annual or semi-annual basis.

4. GAPS, CHALLENGES AND NEEDS

Monitoring for invasive species is no easy task. Few state of Delaware scientists are skilled in recognizing invasive species. After an invasive species is identified, often information on that particular species is limited. With little information and limited budgets, invasive species will only get attention when it reaches the crisis level, such as the expansion of *phragmites* in wetland areas. Invasive species monitoring efforts have been mostly informal programs conducted by scientists interested in a particular species or habitat. Developing a process for monitoring invasive species, particularly examining pathways of transmission, represents the major gap to our monitoring efforts.

Goal 1. Develop a process for assessing our statewide monitoring efforts.

The need for a statewide system of monitoring invasive species is a key challenge of DISC. Since the DISC is comprised of state biologists, university scientists, and environmental experts, monitoring of invasive species should be done in a consistent and scientific manner. In addition, our monitoring methodology should be as uniform as possible to aggregate data for reporting and charting progress. Current new tools such as GIS/GPS will be merged with traditional ecological methods for measuring biological diversity and the impacts from invasive species on indigenous communities. Our challenge will be to agree on both qualitative and quantitative methods for collecting data for monitoring and inputting this data into our DISC tracking system.

Goal 2. Develop a process for evaluating the effectiveness of our management plan on an annual or semi-annual basis.

A major feature of evaluating the effectiveness of our management plan is how successful we are after implementation. Currently there is no comprehensive monitoring program of Invasive Species in Delaware. Monitoring efforts are conducted on an individual species level. Although monitoring one species is extremely important, to improve ecological systems, a comprehensive holistic approach is warranted.

5. ACTION STEPS

Goal 1. Develop a process for assessing our statewide monitoring efforts.

The key methods for monitoring and evaluating the effectiveness of this section of the plan is to scientifically assess the reductions of existing invasive species of interest and quantifying the potential impact of those species residing in Delaware. Ecological surveys could be utilized in sample site to statistically assess program impacts. Some of these statistics can be easier to quantify such as the number of acres spayed with a certain pesticide to kill an invasive weed. Measure of ecological diversity will also be used. Other species are extremely mobile and more rigorous methods will be needed to monitor shifts in population growth.

Goal 2. Develop a process for evaluating the effectiveness of our management plan on an annual or semi-annual basis.

A key component to this plan is to evaluate the effectiveness of the DISC program committees of research, education, and inventory. The evaluation of these research programs will include such items as the number of research projects started, the results of the research, the adaptation of the research into statewide management of invasive species. The evaluation of education programs will include such items as the number of educational programs conducted, the number of media pieces on Delaware TV, radio and press, and other criteria. The evaluation of the inventory (data management) committee will include the review of the quality of data included and the utilization of that data by state policy makers and scientists.

A good indicator of the effectiveness of DISC will include, not only our ability to assess the increases and decreases of invasive species, but also establishing a process for managing emerging (unforeseen) invasive species issues, quickly, fairly and effectively.

Finally, another method of evaluating and monitoring our success is to establish a DISC annual report for policy makers and the general public. The published document could

be called “the State of Invasive Species in Delaware.” We can make this report available in a newspaper insert as well as on a PDF file on our DISC website.

Specific measures of the effectiveness of the management plan in monitoring and evaluating invasive species in Delaware could include the following:

Conduct an annual meeting to re-evaluate program, monitoring efforts, short-term goals, and long-term goals and emerging issues.

Re-evaluated Flora and Fauna priority lists on a one to two year basis.

Review quantifiable data such as number of acres sprayed for a specific invasive plant or the number of “hits” on the DISC website.

Conduct annual review of work-plans of standing committees (education, research, etc,)

Establish base line data for individual species

Compare monitoring data to baseline data in subsequent years.

Compare monitoring data to other nearby states.

6. LEAD AGENCY: DE HERITAGE PROGRAM, DE DEPT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL, DISC BOARD OF DIRECTORS

Appendix 1: List of Pests of Plant under Survey

APIARY

Africanized Honeybee – *Apis mellifera*

Small Hive beetle – *Aethina tumida*

Varrora Mite – *Varroa jacobsoni*

COMMODITY CROPS

Boll Weevil – *Anthonomus grandis grandis*

Golden Nematode – *Globodera rostochiensis*

Soybean Aphid – *Aphis glycines*

Karnal Bunt – *Tilletia (Neovossia) indica*

Soybean Rust – *Phakopsora pachyrhizi*

Soybean Pod Borer – *Leguminivora glycinivorella*

TREE FRUIT

Plum Pox Virus

Plum Curculio – *Conotrachelus nenuphar*

Apple Maggot – *Phagoletis pomonella*

NURSERY

Daylily Rust – *Puccinia hemerocallidis*

Chrysanthemum White Rust – *Puccinia horiana*

Giant Salvinia – *Salvinia molesta*

RESIDENTIAL/PUBLIC LANDS

Hydrilla – Hydrilla verticillata

Purple Loosestrife – *Lythrum salicaria*

Mile-a-minute – *Polygonum perfoliatum*

Gypsy Moth – *Lymantria dispar* spp.

Asian Longhorned Beetle – *Anoplophora glabripennis*

Imported Fire Ant - *Solenopsis invicta*

Tropical Soda Apple – *Solanum viarum*

Japanese Cedar Longhorn Beetle – *Callidiellum rufipenne*

Japanese Beetle – *Popillila japonica*

Pine Shoot Beetle – *Tomicus piniperda*

Exotic Bark Beetles (multiple species)

Giant Hogweed – *Heracleum mantegazzianum*

Cogongrass – *Imperata cylindrica*

Kudzu – *Pueraria montana* (previously known as *P. lobata*)

Goatsrue – *Galega officianlis*

Exotic snails (multiple species)

Appendix II: Delaware Invasive Plants List

Widespread and Invasive

		Life Form
Multiflora rose	*Rosa multiflora*	S
Japanese honeysuckle	*Lonicera japonica*	V
Oriental bittersweet	*Celastrus orbiculata*	V
Japanese stilt grass	*Microstegium vimineum*	H
Japanese knotweed	*Polygonum cuspidatum*	H
Autumn olive	*Elaeagnus umbellata*	S
Norway maple	*Acer platanoides*	T
Common reed	*Phragmites australis*	H
Morrow's honeysuckle	*Lonicera morrowii*	S
Mile-a-minute	*Polygonum perfoliatum*	V
Wineberry	*Rubus phoenicolasius*	S

Restricted and Invasive

Periwinkle	*Vinca minor*	V
Garlic mustard	*Alliaria petiolata*	H
Winged euonymus	*Euonymus alata*	S
Lesser celandine	*Ranunculus ficaria*	H
Purple loosestrife	*Lythrum salicaria*	H
Amur honeysuckle	*Lonicera maackii*	S
Tartarian honeysuckle	*Lonicera tartarica*	S

Life Form: S=shrub, V=vine, H=herbaceous, T=tree
REVISED: August 6, 2003

THE LIST*

- Plants on The List are non-native to Delaware, have the potential for widespread dispersal and establishment, can out-compete other species in the same area, and have the potential for rapid growth, high seed or propagule production, and establishment in natural areas.
- Plants on Delaware's Invasive Plant List were chosen by a committee of experts in environmental science and botany, as well as representatives of State agencies and the Nursery and Landscape Industry.
- An environmental assessment was conducted on each of the plants listed, and placement on the list results from review of the scientific literature, as well as a consensus of expert opinion. Plants on the list are ordered from highest invasiveness.
- Plants on the list should not be planted, under any circumstances, and should be removed from properties as feasible.
- Listed plants that are currently in the nursery trade should be phased out of inventory and production.
- Homeowners are encouraged to ask nurseries, garden centers, and landscapers for non-invasive plants, preferably natives.
- Widespread and Invasive plants are currently invasive, cause serious management concerns or pose a serious threat to the biological diversity of Delaware.
- Restricted and Invasive plants are equally problematic. However, they have a more localized distribution in Delaware.
- This list will be widely distributed to nurseries, garden centers, landscapers, homeowners, gardeners, and land managers.
- A more complete list can be viewed at: www.dnrec.state.de.us/fw/wildrehe.htm

** These plants are Tier 1 of The List. Additional tiers are under analysis and will be published in 2004.*

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Appendix IV: Acronym Listing

A number of acronyms appear throughout this document. We have tried in every case to give the full name at the first appearance of an acronym. Due to the large number of them throughout the document, we have also provided this list for your convenience.

Acronym	Full Name
ALB	Asian Longhorned Beetle
ANS	Aquatic Nuisance Species Task Force
APHIS-PPQ	Animal Plant Health Inspection Service-

	Plant Protection and Quarantine
BMP(s)	Best Management Practice (s)
CAPS	Cooperative Agricultural Pest Survey
CDC	Centers for Disease Control
DDA	Delaware Department of Agriculture
DelDOT	Delaware Department of Transportation
DF&W	Delaware Division of Fish and Wildlife
DISC	Delaware Invasive Species Council, Inc.
DISTS	Delaware Invasive Species Tracking System
DNPS	Delaware Native Plant Society
DNREC	DE Department of Natural Resources and Environmental Control
DNS	Delaware Nature Society
DPR	Division of Parks and Recreation (part of DNREC)
DSWC	Division of Soil & Water Conservation (part of DNREC)
EEP	Estuarine Enhancement Program
IPM	Integrated Pest Management
MOU	Memorandum of Understanding
NAS	Nonindigenous Aquatic Species
NDWRP	Northern DE Wetland Rehabilitation Program
NGOs	Non-Governmental Organizations
SARS	Severe Acute Respiratory Syndrome
TNC	The Nature Conservancy
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USDA NRCS	United States Department of Agriculture Natural Resources Conservation Service
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WNV	West Nile Virus

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