Acting Locally to Protect Our Legendary Lands and Waters

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Emerald Ash Borer: Status in North America and Activities in Minnesota

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Emerald ash borer (Agrilus planipennis) is an invasive beetle native to eastern Asia that infests and kills ash trees. Emerald ash borer was accidentally introduced into North America near Detroit, Michigan in the early 1990’s but remained undetected until 2002. Since then this pest has been discovered in a number of surrounding states and is known to be the cause of death for an estimated 50+ million ash trees throughout the region. Minnesota has conducted detection surveys for emerald ash borer since 2003 and has drafted the Minnesota Emerald Ash Borer Readiness Plan to guide interagency efforts in preparing for the arrival of this pest in Minnesota. This presentation will provide an update on emerald ash borer and activities underway in Minnesota.
When emerald ash borer (Agrilus planipennis) is eventually detected in Minnesota a regulatory response will be triggered involving multiple agencies and actions. The Minnesota Emerald Ash Borer Response Plan was written to establish agency roles and guide their actions during this regulatory response. Multiple events were held to evaluate this plan including a multi-agency table top exercise and a full, field response mock exercise. This presentation will describe the Minnesota Emerald Ash Borer Response Plan as well as the methods and results from the exercises held to evaluate it.
Site-specific detection surveys for emerald ash borer (Agrilus planipennis) have been implemented in Minnesota since 2003. Following the detection of established populations of emerald ash borer in Illinois in 2006, funding became available for Minnesota to do a broader area survey. However, there was still a need to concentrate survey efforts on areas most likely to have emerald ash borer introduced to them. To that end, a model was written to describe the risk of emerald ash borer introduction to a given area. GIS layers for sites that might receive emerald ash borer infested materials (campgrounds, nurseries, firewood dealers, etc.) were constructed and fed into the model to create an introduction risk map. The risk map has been used since 2006 to scale emerald ash borer sampling efforts throughout the state.
Factors Responsible for Increasing Invasive Species Spread by the Horticultural Trade

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In 2008, >103,857 horticultural cultivars are available for sale in North America, representing a diversity of high-value edible (fruits, nuts, vegetables, herbs) and non-edible (ornamental flowers, trees, shrubs, grasses) taxa. An increasing number of these crops are invasive. When applying Williamson’s ‘tens rule’ to horticulture, the high propagule pressure of the 2008 introductions increases the likelihood that as many as 100 taxa/year could become invasive. Sources for plant materials include >2,297 plant collectors, breeders, producers, distributors, brokers, growers, retailers, and service-related businesses. Most or all of these firms sell plants in MN—where the horticulture industry is valued at $2.1 million (r). We examine the horticultural trade as a vector for invasive species. The complexity of the distribution channel is not well understood or characterized. Numerous factors within the industry have contributed to the recent expansion in marketed cultivars, including the plastics revolution (plug culture), greenhouse and field mechanization, large retailers (box stores), ‘the rush to market’, enhanced post-harvest, long-distance shipping, off-shore propagation (coupled with on-shore rooting stations), and marketing gurus. As Americans and Minnesotans have matured into lifetime—rather than hobby—gardeners, demand for product diversity has also increased. This has resulted in aggressive scouring of all countries for new crops, many of which are introduced into the market without extensive breeding, selection, and domestication—particularly if the crop can be vegetatively (asexually) propagated. This has resulted in an increase of reported invasive horticultural crops, as well as numerous invasive tag-alongs, with devastating and costly consequences. Approaches to invasive horticultural crop control target players in the distribution channel before and/or after cultivar release with limited effectiveness and buy-in. The reasons for this will be examined along with new approaches.
Invasive Macroinvertebrates in the Upper Mississippi River System: Recent Findings

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Zoobenthos surveys of the great rivers of the Upper Mississippi River basin (Missouri, Upper Mississippi, and Ohio Rivers) in 2004-2006 revealed new invasions by marine and estuarine amphipods. The gammarid amphipods, Echinogammarus ischnus and Gammarus tigrinus, were discovered in the Ohio and Upper Mississippi Rivers in 2004. The corophiid amphipod, Apocorophium lacustre, was first found in the Ohio River in 1996, and first detected in the Upper Mississippi River in 2005. None of these invaders was collected in the Missouri River. The presence of breeding adults of all three species suggests they are permanently established in the Ohio and Upper Mississippi. The range and occurrence of all three species increased in the basin from 2004 through 2006. The quagga mussel, Dreissena bugensis, was first found in the Ohio and Upper Mississippi Rivers in the mid-1990s. It has since gone unreported in the Mississippi River system possibly due in part to its phenotypic variability and close morphological resemblance to the more commonly occurring zebra mussel, Dreissena polymorpha. Sampling of the great rivers during 2004-2006 revealed that the quagga mussel occurs at several localities outside its previously reported distribution in the Ohio and Upper Mississippi Rivers. Few zebra and no quagga mussels were found in the Missouri River. Quagga were nowhere abundant in our survey, comprising less than 1% of identifiable Dreissena specimens. Further monitoring is necessary to determine whether the quagga mussel will become established in the Mississippi River system. This abstract does not reflect EPA policy.
Cow Vetch (Vicia cracca) Infestation on Sand Prairie

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Introduced as a green manure, cow vetch (Vicia cracca) has come to dominate significant portions of sand prairies in eastern Wabasha County, Minnesota. The expansion and increased density of cow vetch infestations is currently a serious concern on restored prairies and threatens to invade adjacent native prairies. Little guidance exists on best practices for controlling the spread of cow vetch. Cow vetch control is a key component to a newly formed Cooperative Weed Management Area in Wabasha County. The group has developed a two-pronged approach to addressing the threat of cow vetch invasion, including 1) control of established infestations and 2) mapping the current extent of cow vetch in the landscape. Land managers examined available information in the published literature and designed a comparative study to evaluate the efficacy of multiple control methods including: hand pulling, prescribed fire and application of multiple herbicides at various times. Applications were evaluated within study plots for speed of implementation, cow vetch mortality, degree of herbicide effect, and non-target plant mortality using Stinger (clopyralid) and Milestone (aminopyralid). Infestations of cow vetch throughout The Nature Conservancy’s Weaver Dunes Preserve have been mapped using the Weed Information Management System (WIMS). Cow vetch infestations will be mapped using WIMS on adjacent conservation lands and tracked over time for treatment methods, density and area of infestation.
Wisconsin Wises Up to Aquatic Invasive Species

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Wisconsin’s story of success will be presented including recent changes in laws, administrative codes and regulations. Wisconsin is making great advances in regulation and enforcement, especially with the new "Water Guard". These approaches will be put in the context of Wisconsin's overall strategy for AIS prevention, containment and control. The Wisconsin Lakes Partnership is taking super strides forward to heighten public awareness and change boater behavior thanks in large part to our "Clean Boats/Clean Waters" watercraft inspection network. We are investing in county-based prevention and in lake organization sponsored projects to control pioneer colonies and in some cases large-scale control of Eurasian watermilfoil and other invasive species. Prevention investments are slowing the rate of new invasions in Wisconsin waters. Enhanced research and monitoring enables earlier detection and more responsive AIS control projects in individual lakes.
Rusty Crayfish Distribution on the Superior National Forest, Minnesota

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The Superior National Forest (SNF), located in Northeastern Minnesota, began surveys for aquatic crayfish in 2003. The primary goal for these efforts was to monitor and assess the distributions of the invasive rusty crayfish (Orconectes rusticus). Since 2003, approximately 500 baited minnow traps have been deployed in 60 lakes within the SNF. Water bodies infested with rusty crayfish have increased from 18 lakes in 2003 to 34 lakes in 2007. Survey data indicate that the presence of rusty crayfish within and adjacent to the Boundary Waters Canoe Area Wilderness is more common in lakes with motorized access. Lake-intensive surveys suggest rusty crayfish abundance, relative to other native crayfish, increases rapidly once an invasion occurs; sites with lower rusty crayfish relative abundance indicate a more recent invasion. Rusty crayfish distribution timelines and trends will be discussed along with future monitoring efforts and management.
The Great Ships Initiative (GSI) is a collaborative effort to end the problem of ship-mediated invasive species in the Great Lakes-St. Lawrence Seaway System through independent research and demonstration of environmental technology, financial incentives and consistent basin-wide harbor monitoring. Launched in 2006, the GSI’s first priority is to incubate/evaluate operational and biological performance of prospective ballast water treatment systems at three testing scales: bench, land-based, and shipboard. GSI’s Research, Development and Technology Evaluation facility in Duluth/Superior Harbor of Lake Superior provides state-of-the-art land-based testing services. Laboratory space within the University of Wisconsin-Superior and University of Minnesota-Duluth is utilized for bench-scale tests and analyses. Developers of ballast water treatment systems apply for GSI research services online, and awards are offered based on an objective review process. GSI testing protocols will be consistent with applicable regulatory requirements. Infrastructure and protocol validation tests were conducted in 2007 at both the bench-scale and land-based scale. Findings from those experiments and the first treatment tests in 2008 will be summarized. GSI testing will allow meritorious ballast treatment systems to progress as rapidly as possible to an approval-ready and market-ready condition.
Cooperative, Large-Scale Invasive Plant Management in Minnesota

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Invasive plants are a challenge to manage. Statewide invasive plant distribution data are increasingly available. These data show gross scale trends such as centers of infestation, invasion fronts, and satellite populations. This information can aid management decisions such as how to slow the spread of infestations and issues of resource allocation. Implementation of these practices will require cooperation from local to state levels. The invasive plant spotted knapweed (Centaurea biebersteinii DC) is a good candidate for gross level management and will be presented as a case study.
The Northwoods Cooperative Weed Management Area is a cooperative relationship for effective management, coordination and implementation of invasive terrestrial and aquatic plant species in northern Wisconsin. Invasive non-native plants can have devastating impacts on native plant communities, fish and wildlife habitat, agricultural yields, recreational and subsistence opportunities, and ultimately, local economies. Purple loosestrife (Lythrum salicaria), leafy spurge (Euphorbia esula), reed canary grass (Phalaris arundinacea), spotted knapweed (Centaurea biebersteinii), and common buckthorn (Rhamnus carthartica) are examples of invasive non-native plants that negatively impact local natural areas and agricultural lands. Because these plants disperse widely across the landscape and administrative boundaries, it is advantageous to work cooperatively towards management and control objectives. In addition, the number of new exotics being introduced into local ecosystems continues to out-pace control activities, and is too much for any one agency to manage alone. The Northwoods Cooperative Weed Management Area provides a forum to share information, collaborate on planning and cooperate on management activities in northern Wisconsin.
Genetic Diversity Among and Between Populations of Common Tansy (*Tanacetum vulgare*)

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Common tansy (*Tanacetum vulgare*) is an herbaceous perennial member of the Asteraceae family and is a non-native invasive weed in North America. Common tansy typically invades disturbed areas and is able to reproduce rhizomatically as well as sexually, with seeds numbering in the hundreds of thousands per plant. Tansy was likely introduced deliberately because of its traditional uses as medicine, preservative, and as an animal and insect repellent. The goal of this research is to understand the genetic structure of common tansy populations in order to integrate genetic diversity and invasiveness data to better manage its spread. Genetic diversity of individuals within and among populations of invasive *T. vulgare* from different regions in Europe and North America including Minnesota, Washington, Montana, Canada and South Dakota was determined using Inter Simple Sequence Repeat markers. Two North American native species (*T. huronense* and *T. camphoratum*) and a European native (*T. balsamita*) were also analyzed and compared to *T. vulgare* from invasive North American and native Eurasian populations. The diversity among and between populations was measured by using the unweighted pair group method with arithmetic mean (UPGMA). Understanding the genetic structure of invasive populations and comparisons of genetic diversity to native and related species may help to identify evolutionary events that occurred within this species and how genetic diversity among and between populations contributes to the invasiveness of this species.
Controlling Leafy Spurge: Interaction of Flea Beetle (Apthona spp.) Effectiveness and Soil Type at Four Sites within the Northern Tallgrass Prairie

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Leafy spurge (Euphorbia esula) has emerged as a major threat to grasslands over the last 50 years. Anecdotal reports suggest that flea beetles (Apthona spp.) are a promising biological control for leafy spurge throughout the Northern Tallgrass Prairie Ecoregion. The purpose of our study was three-fold: to evaluate the efficacy of flea beetles in controlling leafy spurge across a variety of site conditions; identify the soil conditions under which biocontrol for leafy spurge is most effective; and assess the response of native vegetation. We sampled at 40 locations across four sites in Minnesota, North Dakota, South Dakota and Iowa. The study was established in 2001, and results will be reported for the last three years. Leafy spurge stem density decreased by as much as 65% over the three-year study period for sites at which fine-textured soils predominated (t=2.25, df=10, p=0.05), but appeared to increase over time in settings with coarse-grained soils (+15%, not significant). We did not detect differences in native plant species richness over the five year study period. Flea beetles appear to be an effective biological control in grasslands infested by leafy spurge where biophysical conditions are conducive to survival of the biocontrol agent.
Mapping Weeds in Minnesota: Three Examples of Technology
and Implementation

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Mapping of invasive species in Minnesota has become an important tool for managing these highly adaptable plants across a diversity of landscapes. Understanding where populations of invasive plants are located is a first step to making sound professional management decisions. Furthermore, annual mapping programs create opportunities to discover new species of concern that were not previously known to be in the state. This type of early detection can lead to faster reaction times by government agencies and local land managers to isolate newly emerging species and begin prompt treatment of those populations. The Minnesota Department’s of Agriculture, Natural Resources, and The Nature Conservancy all utilize GPS/GIS technology to map invasive species populations on the ground. Although each respective program was engineered separately, they all work to accomplish the same end result: georeferencing data for invasive plant species. This presentation will give an overview of the basic concepts of these mapping programs including equipment, software, data management, and how each system works in the field.
In Minnesota, curly-leaf pondweed (*Potamogeton crispus*) is a non-native, invasive aquatic plant that can interfere with recreational and other uses of lakes by producing dense mats at the water's surface. These mats also can displace native plants. In addition, curlyleaf usually dies back in mid-summer, after which undesirable algal blooms often develop. The majority of curlyleaf pondweed management efforts in Minnesota are spot treatments intended to reduce nuisances using either herbicides or mechanical methods. Past research indicates that endothall herbicide used at low rates (0.75 – 1.5 ppm) early in the spring can control the plant and reduce or prevent production of turions, which are vegetative propagules. As a result, many of the spot treatments with herbicides are now done with a low rate of endothall herbicide in early spring. The Minnesota DNR has supported 14 lake-wide (or bay-wide) pilot projects to control curlyleaf pondweed in order to learn from them and to potentially achieve ecological benefits from them. Ecological benefits include increases in native submersed plants and reductions in levels of phosphorus and algae, which should increase water clarity. Results of lake-wide treatments to date indicate that early-season lake-wide treatment with low rates of endothall or fluridone, another herbicide, can control curly-leaf pondweed in the year of treatment and may be associated with increases in native plants or water clarity or both in some cases, but not others. As these projects continue, the DNR will continue to evaluate the benefits and risks associated with lake-wide herbicide treatment.
Overview of the Cooperative Agricultural Pest Survey Program

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An overview of the CAPS program in the US and how it is designed to detect introduction of agricultural pests will be presented. Specific details concerning criteria to create lists of pests of "national priority" for survey, as well as "state-level" discretionary pest surveys will be discussed.
Curlyleaf Pondweed Abundance in South Central Minnesota Lakes

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Curlyleaf pondweed (Potamogeton crispus) surveys were conducted at the time of peak abundance, about June 1, 2004-2007. A GPS was used to encircle stands of curlyleaf pondweed where it was growing at or near the surface. Maps were produced in ArcView/ArcMap showing exact locations of curlyleaf pondweed beds; and acreage was calculated for each stand and expressed as a total for the lake. Curlyleaf pondweed occupied a range of 1 – 95% of the surface acreage in 68 investigations. The median value was 5% of surface acreage. Curlyleaf pondweed was more abundant in shallow lakes with poor water quality. These surveys have been useful in the development of curlyleaf pondweed control plans and have provided perspective on the extent of the invasive exotic in south central Minnesota lakes.
In an effort to curb species invasions, the California State Lands Commission (Commission) Marine Invasive Species Program (MISP) has recently established performance standards for the discharge of ballast water. The performance standards set limits for organism concentration as a function of organism size class. The standards will be implemented on a graduated time schedule beginning January 1, 2010, with a final standard of zero detectable living organisms in ballast water discharge by 2020.

A critical step associated with the implementation of performance standards has been the evaluation of available treatment technologies to meet those standards. In December 2007, the MISP completed a report for the California Legislature assessing the efficacy, availability and environmental impacts of existing ballast water treatment systems for use in California waters. The report summarizes MISP findings after an extensive review of 28 ballast water treatment systems. The MISP determined that no single technology was yet able to meet California’s performance standards. Of the 28 treatment systems reviewed, 20 had reportable results from performance verification testing, but only 11 systems had results based upon tests conducted onboard vessels.

Hindering the review of treatment system efficacy was a lack of standardized methods to verify system performance. MISP has thus developed a standardized set of testing guidelines for use by technology developers in assessing compliance with California’s performance standards. MISP is also developing protocols to verify vessel compliance with the standards. The testing guidelines and verification protocols will work in tandem, to educate technology developers about California’s standards and ensure that discharging vessels meet the required standards. California’s proactive approach to ballast water management will limit the introduction and spread of nonindigenous species in California waterways, and serves as a model for the effective science-based management of a global challenge.
Overview of the Great Lake Indian Fish and Wildlife Commission's Invasive Species Program in the Ceded Territory

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The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) is an organization exercising delegated authority from eleven Ojibwe tribes in Minnesota, Wisconsin, and Michigan. These tribes retain hunting, fishing and gathering rights on over 45,000 square miles of territory that was ceded to the United States through various treaties. The degradation of native ecosystems by invasive species threatens the continued exercise of these rights and the traditional lifeways they sustain.

To reduce the impacts of invasive species, GLIFWC conducts education outreach, inventory and monitoring, control, and evaluation efforts. These activities are routinely coordinated with tribes, state and federal agencies, local groups, and private landowners. This presentation will provide a brief overview of GLIFWC's invasive species program.
Modeling Invasive Species Population Growth in Response to Variable Temperatures

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A minimum number of individuals of an invasive species are required to establish self-sustaining populations. Below this threshold, populations have a high probability of becoming extinct on their own without the need of eradication efforts. For many invasive species, the minimum population size threshold can be affected by factors such as temperature. For example, barring extreme cold and heat, insects have shorter lifespan, develop faster and produce more offspring at warmer than at cooler temperatures. Under these conditions, population growth models would predict thresholds that might prompt us to direct management efforts towards small populations that require our immediate attention. Under extreme temperature conditions, however, the relationship between temperature and vital rates degenerates; insects experience abnormal development and accelerated death. Population growth models for these scenarios would predict larger minimum population thresholds and, consequently, a reduction in the risk associated with small populations. Although daily and seasonal temperature fluctuations are the norm in invaded habitats, population growth models for invasive species rarely account explicitly for temperature variations. For organisms whose vital rates vary with temperature, variable temperature models may estimate minimum population size more accurately than constant temperature models, allowing us to weight risk and management alternatives relative to population size.
EPA’s Endangered Species Protection Program for Pesticides - An Overview

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The United States Environmental Protection Agency’s Endangered Species Protection Program for pesticides will be described. A brief review of the Endangered Species Act mandate to protect endangered species from the harmful effects of pesticides will be described, followed by an overview of what pesticide users will need to know to protect listed species in their area. The endangered species Bulletins Live! system that will be linked to pesticide labels will be described, as will the process for accessing Bulletins and other information about the program. http://www.epa.gov/espp/
Controlling Invasive Buckthorn While Protecting the Endangered Minnesota Trout Lily

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The Minnesota dwarf trout lily (Erythronium propullans) is a federally listed endangered species found only on 600 acres of Minnesota woodland. It, along with the closely related but not endangered white and yellow trout lilies, often is associated with the invasive European buckthorn (Rhamnus cathartica). In 2006, the Minnesota Department of Agriculture and partners utilized an EPA grant to study the impact of herbicidal stump treatment of buckthorn on the white trout lily, used as a surrogate for the Minnesota dwarf trout lily. Fosamine (Krenite), glyphosate (Roundup) and triclopyr (Garlon) were compared. The study concluded spring 2007 and showed all three herbicides effectively controlled buckthorn resprouting without adverse effect to the white trout lily, with fossamine being most cost effective. The study also noted prolific propagation of buckthorn seedlings where mature buckthorn was removed. It was concluded that complete control of buckthorn needs to include both the elimination of established plants and the suppression of new seedlings. A follow-up herbicidal control study of buckthorn seedlings in white trout lily habitat has been proposed but not funded. The proposed study would foliar treat buckthorn seedlings with triclopyr in late summer when trout lilies are dormant.
"Defending Favorite Places" How Hunters and Anglers Can Stop the Spread of Invasive Species

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During this time a new DVD, which is being released this fall, will be premiered in Minnesota. The 26-minute DVD highlights what hunters and anglers can do to help prevent the spread of invasive species. This project is a component of the National Invasive Species Threat Campaign spearheaded by Wildlife Forever, in partnership with many State and Federal organizations and the National Fish and Wildlife Foundation.
Stop Aquatic Hitchhikers! (SAH) - Threat Campaign: Prevent Introduction of Aquatic Invasive Species

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Minnesota’s boaters and anglers must be engaged in the aquatic invasive species (AIS) issue. If users are unaware and do not know what to do, they pose great threats for spreading invasive fish, plants and organisms. Research shows boaters are part of the problem; the good news is they can be part of the solution. They will take action. SAH partners teamed up with the Threat Campaign, led by Wildlife Forever, to expand the prevention message across Minnesota enlisting an army of support in the battle against aquatic hitchhikers. Combined efforts effectively used multi-media targeting using television, radio, print ads, billboards, airport dioramas, rest area displays, retail kiosks, gas pumps ads, regulation booklets, watercraft inspectors, signage at water accesses, stickers and print materials. Through marketing and media buys, combined efforts generated amazing results. 2006: 125 million people were exposed to the messages; 2007: 137 million people were reached. Partnerships included: U.S. Forest Service, U.S. Fish and Wildlife Service, Minnesota DNR, Minnesota Sea Grant and two lake associations. Question: are the messages reaching the target audiences and does it work? 2006 survey results, led by Minnesota Sea Grant, shows not only is the campaign reaching the target audience, it is raising awareness and empowering users to take precautionary action. Based on exposure to the campaign, 86% said it raised their awareness. Importantly, 97% said it WILL influence them to take action! Through this expanding partnership, we feel it’s making a difference to protect our waters from the spread of harmful AIS.
Hubbard County COLA Countywide Citizen Action to Stop Aquatic Hitchhikers

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Hubbard County Coalition of Lake Associations (COLA) represents 30 lake associations with a total of 40 lakes and over 2,000 citizen members. In 2004 and 2005, eleven lake associations in the COLA completed the Healthy Lakes and Rivers Partnership (HLRP) Lake Management Planning process (LMP). The Initiative Foundation and the Northwest Minnesota Foundation sponsored the LMP program. All eleven LMP’s identified the threat of aquatic invasive species (AIS) as one of the top three strategic priorities. The COLA Board organized an AIS Task Force in 2006 to coordinate the countywide effort to prevent the spread of AIS in Hubbard County. A focused program was started in 2007 and continued in 2008 with additional funding support from a DNR AIS prevention grant. The presenter will discuss how the AIS program in Hubbard County got started, the initiatives in 2007 and 2008, results to date, lessons learned and thoughts on future work. Detailed information on Hubbard COLA’s awareness/Education signage program, the resort education/communications package, volunteer inspection training and launch inspection events, partnerships with local and state agencies, and partnerships with local government units will be presented.
USDA Insect/Plant Disease Pest Quarantine Situations/Regulations Affecting Minnesota

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The presentation will discuss United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine Service insect/disease pest quarantine situations/regulations and the significance the pests as invasive species affecting Minnesota forest, agricultural, and urban interests. Discussed will be the present quarantine area for each pest, a description of the pest, the significance of the pest to Minnesota interests, prognosis for spread of the pest to Minnesota and articles covered by the quarantine or regulations. Pests discussed will include: Asian longhorned beetle (Anoplophora glabripennis), emerald ash borer (Agrilus planipennis), gypsy moth (Lymantia dispar), Japanese beetle (Popillia japonica), pine shoot beetle (Tomicus piniperda), sirex woodwasp (Sirex noctilio), karnal bunt (Tilletia indica), plum pox, Phytophthora ramorum, potato cyst nematode (Globodera pallida), and soybean rust (Phakopsora pachyrhizi). Additionally, a program to discover new pests of significance which have been introduced into the United States will be discussed.
Canada Thistle Wind Dispersal

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Canada thistle (Cirsium arvense) is a noxious weed in Minnesota and control is mandatory for state agencies and private land-owners. Weed laws, complaints of violation and subsequent enforcement are based upon the premise that wind blown achenes are an important means of Canada thistle dispersal and new infestations. It is not clear to what extent this premise is valid. The objective of this research was to characterize the potential for Canada thistle to spread by wind by studying the quantity, quality and movement of Canada thistle achenes. Traps were constructed of wire mesh, coated with adhesive, and arranged at different distances and heights around a patch of Canada thistle measuring 0.9 m in diameter. Wind blown achenes and free pappi were collected over a one to two week period during the peak time of achene dispersal at six Minnesota locations in years 2006 and 2007. Estimates of seed rain within a 6 m radius of the Canada thistle patch averaged approximately 2,000 achenes and ranged from around 400 to 4,000 achenes among sites. The contribution of wind dispersal to the spread of Canada thistle appears to be largely local. Most achenes fell near the parent plants and a relatively small number of seed traveled a distance of 6 m. More than 90% of the trapped pappi were not associated with a viable seed and the percentage of pappi without an attached achene increased with distance from the parent plants. Dispersal was directional along prevailing winds and pappi with viable seed attached tended to travel closer to the ground compared to free pappi. The relative amount of seed distributed long distances by wind appears to be small but may be an important part of a strategy for discovering new sites.
Management Recommendations to Limit the Continued Spread of Exotic Earthworms in Working Forests

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European earthworms are invading previously earthworm-free hardwood forests in the northern US and Canada. A cascade of changes affecting soil structure, chemistry, regeneration and native plant and animal communities follows, leading to concerns about the potential loss of native forest species and the sustainability of northern hardwood forests. The scale of these invasions suggests that a substantial portion of these forests could be impacted within the next few decades. Nevertheless, findings also suggest that local control of invasions into currently earthworm-free or minimally impacted may be possible. A growing body of research into the patterns, mechanisms, and impacts of earthworm invasion can inform potential responses to target efforts in ecosystem and soil types that are most threatened. Earthworm spread continues via human activities such as dumping fishing bait, transporting compost or soil from earthworm-infested areas, or all-terrain vehicles (ATVs) and logging equipment that can transport earthworm cocoons on tires and underbodies. No mechanisms to remove earthworms or to reverse their impacts exist, therefore, prevention of future introductions is key to the protection of northern forests and the resources they provide. Actions to limit the ecological impact of earthworms could affect a variety of stakeholders including natural resource managers, timber harvesters, anglers, recreational visitors, and residents. Using a combination of literature review, risk assessment, expert opinion, and focus groups with a wide range of potential stakeholders, we have developed a set of recommended actions to minimize the continued spread of earthworms in the working forest landscape.
Potential Non-Target Impacts in Prairies From Biocontrol of the Soybean Aphid

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Since its discovery in 2000, the soybean aphid, *Aphis glycines* Matsumura, has become a major pest of Midwest soybean production, and classical biological control is being attempted throughout the region to manage this exotic pest. Concerns over non-target effects in classical biological control prompted field investigation of potential non-target impacts from an introduced parasitoid of the soybean aphid. Pre-release studies of non-target aphid species and associated parasitoids were conducted at six Indiana prairies in 2006-07. The purpose of this study is to determine if the stability of the aphid-parasitoid community is at risk from non-target effects. Ecological surveys using transect sampling were used to assess potential non-target impacts. Information on host plant abundance, aphid species richness and diversity, and parasitoid species richness and diversity was obtained. Results indicate that a rich and dynamic aphid-parasitoid community exists in the Indiana prairies. Overall 67 aphid species and 10 primary parasitoid species were found during the 2-year survey. Fifteen of the aphid species collected were in the genus *k*. Aphid abundance and species richness of aphids and parasitoids varied widely on both spatial and temporal scales. The nature of this complexity may allow the community to withstand non-target effects from the introduction of a soybean aphid biological control agent.
Minnesota's Invasive Regulations and Enforcement Related to Aquatic Plants and Wild Animals

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Minnesota has some of the nation’s most comprehensive regulations to prevent the introduction and spread of aquatic invasive species and wild animals. State regulations focus on both species and pathways. Species are classified into “prohibited invasive species”, “regulated invasive species”, “unregulated nonnative species” and other nonnative species that are not classified are considered “unlisted nonnative species”. Transport of all aquatic plants and prohibited invasive species on public roads is prohibited. Launching a boat or trailer, or attempting to launch, with aquatic plants or prohibited invasive species is also illegal. Activities such as harvest of bait and the transport of water at infested waters are also regulated. These regulations are enforced by state conservation officers and may also be enforced by local peace officers after training by DNR. Minnesota’s enforcement capacity has been expanded recently with the addition of nine DNR Water Resources Officers who work fifty percent of their time on invasive species enforcement. Examples of more regulations and some enforcement efforts will be described during this presentation.
Gypsy Moth in Minnesota: Rapid Response Through Treatment

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Gypsy moths are an increasing concern in Minnesota because the population front is moving steadily closer from the east as is the federally quarantined area. The implications for our state are that 1) low level “outlier” populations are being detected more frequently, 2) quarantine issues are becoming more prominent, and 3) treatments to eliminate or reduce gypsy moth populations are more common. The Minnesota Department of Agriculture has been eradicating gypsy moths since 1980 and became a partner in the federal Slow the Spread project in 2004. In 2008, nearly 85,000 acres in Cook and Lake Counties were treated for gypsy moth. In addition, two eradication treatments were conducted. Past treatments have all been considered successful, and the MDA is committed to the ongoing effort required to maintain Minnesota’s gypsy moth free-status for as long as possible.
Release of unwanted aquarium fish, plants, snails, and crayfish could harm Minnesota’s waters. Once released, non-native organisms can displace native species, harm habitats, upset ecosystem function, and negatively impact recreational and economic values of our lakes and property. Recent releases in waters across Minnesota include: piranha, pacu, water hyacinth, Amazonian catfish, koi, goldfish, rusty crayfish, yellow iris, even a cayman! Habitattitude™ is a proactive campaign that encourages aquarists, water gardeners, and educators not to release live organisms into the environment. Designed and implemented by the pet industry, NOAA-National Sea Grant (led by Minnesota) and the U.S. Fish and Wildlife Service, this national campaign educates people on alternatives to releasing pets and non-native organisms through a strategic multimedia effort. Results of a 2004 pre-campaign mail survey conducted in two communities each in Minnesota and Pennsylvania show that over the last three years, aquarists and water gardeners released unwanted organisms a total of 50 times! Importantly, most viewed the releases as preventable and an environmental problem. Congruent with these attitudes, over 90% agreed that the Habitattitude campaign's logo and messages were acceptable, easy to understand, attractive, positive and clear. Campaign materials and information on how to become a campaign partner will be provided. For more information, visit: www.dnr.state.mn.us/Habitattitude or www.Habitattitude.net.
Overland transport of harmful aquatic invasive species (AIS) by recreational boaters and anglers has been recognized as a priority in Minnesota for nearly two decades. Today, about 830,000 registered boaters and 2.1 million anglers recreate each year. If unaware, they could spread harmful AIS to our 11,842 lakes, 69,200 miles of rivers and streams, plus wetlands, posing risks to our tradition of boating, fishing and outdoor recreation valued at $10 billion annually. Research shows that boaters and anglers will take action if they know what to do. Minnesota Sea Grant has lead several surveys of boaters and anglers over the years in multiple states. Based on those surveys, we know more about boaters and anglers with regard to AIS than any other audiences. We know how to reach them, their risks for spreading AIS, including their awareness, knowledge, attitudes, motivations, knowledge and behavior. In 2006, Stop Aquatic Hitchhikers\textsuperscript{TM}, a national campaign targeting boaters and anglers, was extended and evaluated in Minnesota, Wisconsin and Iowa. This presentation will be a synthesis of the results of efforts to reach boaters and anglers revealing the success story in public education in Minnesota and elsewhere.
Assessment of Whole-Lake Herbicide Treatments for Management of Curlyleaf Pondweed

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Curlyleaf pondweed (Potamogeton crispus L.) occurs in over 800 Minnesota lakes. Its early season growth, propensity to form dense surface matting, and ability to out-compete many native aquatic plants allow it to degrade the ecological and recreational quality of infested lakes. Management strategies such as harvesting and localized herbicide treatment can effectively reduce local nuisance growth, but do not generally provide effective long-term control of curlyleaf in heavily infested lakes. To address this need for improved long-term control strategies, we collaborated with the Minnesota Department of Natural Resources in 2006-2008 to evaluate the use of early-season whole-lake herbicide treatments as a new management tool. Six infested lakes were treated annually with endothall (0.75-1.00 ppm) or fluridone (2-4 ppb). To assess the impacts of these treatments on curlyleaf and native plants, we conducted three comprehensive point-intercept aquatic vegetation surveys each year (May, June, August) to assess aquatic plant frequency and distribution in six treated lakes and three additional untreated control lakes. We also assessed plant biomass to track density of individual plant taxa, and in the fall of each year sampled sediment to track the distribution and density of curlyleaf turions (vegetative propagules). In 2007, after two or three consecutive years of treatment, we observed reduced curlyleaf growth, moderate increases in the density and distribution of some native plants, and reduced turion density in treated lakes. However, viable turions remained in the treated lakes, and native plants had not fully reestablished in previously infested areas.
Asian Mosquitoes in Minnesota: An Approach to Monitoring and Control

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Two Asian mosquito species, *Aedes albopictus* and *Aedes japonicus*, were accidentally imported into the United States in 1985 and 1998 respectively. Both mosquito species use water-holding man-made containers such as used vehicle tires as breeding habitat; mosquito eggs and larvae have been moved around the country in these containers. Both species have spread rapidly and have become significant pests in many states. They are also potential vectors of West Nile virus and many other mosquito-transmitted disease agents. In 1987, the Metropolitan Mosquito Control District initiated a surveillance effort for *Ae. albopictus*, and have continued the effort to the present. Seven infestations of *Ae. albopictus* have been identified within the Twin Cities metropolitan area since 1991; five infestations were found at tire recycling facilities, one at an unlicensed tire storage facility, and the last at rural home. A single infestation of *Ae. japonicus* was identified at a tire recycling facility in 2007. The response to each infestation has included intense monitoring, tire recycling, larval mosquito control in tires, and adult mosquito treatments targeted to mosquito resting habitat. There is no evidence that any of the infestations has persisted. However, the continued interstate movement of used and waste tires will require this effort to continue indefinitely into the future.
Managing the Monitoring of the Menace-Zebra Mussels in the St. Croix River

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Zebra mussels (*Dreissena polymorpha*) have been a threat to the St. Croix watershed since the early 1990s. In 1992, the first mussels were discovered in the Mississippi above the confluence with the St. Croix River. The first boat discovered with attached zebra mussels was in 1994 and reproduction was indentified in 2000. There is a critical need to understand the implications of an ever expanding and increasing number of zebra mussels in the river. This is a high priority for the National Park Service, the DNRs, Fish and Wildlife Service, Army Corps of Engineers, etc. Over the years, we have gather presence/absence and density data, as well as information about the age structure of extant populations to determine recruitment, growth rates, and mortality. This information aids in determining the affects of this animal on native fauna, including freshwater mussels. During the past decade, anecdotal accounts of periodic, but substantial zebra mussel die-offs in large river systems in the Midwestern U.S. have been noted. Details suggest an early season recruitment followed by a late season population crash. However, these observations have been casual and not systematic or well documented. In order to predict impacts to river biota, an organized assessment of seasonal population dynamics of zebra mussels in a large river system was necessary. The presentation will cover the monitoring efforts of St. Croix Aquatic Invasive Species Task Force, from initial attempts to find mussels throughout the river, to current projects focusing on fixed location densities and the population dynamics noted above.
Secondary Effects of Fungicides on Fungi Infecting the Invasive Soybean Aphid

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Soybean aphid, Aphis glycines Matsumura, is an invasive arthropod pest native to Asia that causes significant economic losses in soybean production (>50% yield reduction). Asian soybean rust is a devastating soybean disease caused by the invasive fungus Phakopsora pachyrhizi Sydow, also native to Asia. Both invasive organisms require crop protection chemicals to mitigate yield losses. Our objectives were to determine how the likely increase in fungicide use for soybean rust control might impact soybean aphid populations – specifically the entomopathogenic fungi that are key regulators of soybean aphid populations. We utilized replicated field plots over four location-years to study how different fungicide regimes impacted both aphid disease prevalence and aphid populations. In Lamberton, MN, in 2005 three of four fungicide treatment regimes significantly lowered soybean aphid disease prevalence compared to an untreated control. In Becker, MN in 2007, microplots were employed to study the effect of fungicide and timing of application on a common fungal pathogen of soybean aphid, Pandora neoaphidis (Rem. & Henn.) Humber. We found that when a mixture of two fungicides, a strobilurin and triazole, was applied to early reproductive stage soybeans, this treatment significantly reduced disease prevalence. Although we observed little aphid population response to fungicide applications, we hypothesize that beneficial fungi are more important in limiting aphid populations on the primary host, common buckthorn, Rhamnus cathartica L. Healthier aphids returning to buckthorn in the fall could lead to larger overwintering populations and earlier colonization in the spring. In 2008, studies were conducted to test this hypothesis.
Multicolored Asian Lady Beetle: A Beneficial Insect with Adverse Impacts

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The multicolored Asian lady beetle (Harmonia axyridis) is a generalist predatory insect native to eastern Asia. Because of its predatory capabilities, this beetle has been widely used as a classical biological control agent for aphids and other pests. Unfortunately, the benefits associated with H. axyridis in pest control also come with adverse impacts. Since its establishment in Minnesota, H. axyridis has been documented preying on various native insects including other predators, feeding on fall ripening fruits and contaminating wine, and invading homes and other buildings. This presentation will provide an overview of the biology and impacts of this species as it relates to Minnesota. The global status of H. axyridis will also be addressed with reference to an ongoing molecular study to retrace its invasion history around the world.
Sirex Wood Wasp: A Potential Threat to Minnesota’s Pine Resources

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The sirex wood wasp (Sirex noctilio) is an exotic wood boring pest native to Europe, Asia and northern Africa. Through the international movement of wood and wood products, S. noctilio has invaded parts of New Zealand, Australia, Africa and South America where it has become a devastating pest of pines. Sirex noctilio recently invaded the eastern Great Lakes Region of North America. This presentation will provide an overview of the biology and potential impacts of this pest, as well as strategies including prevention, early detection, and management.
Overseeing Oak Wilt: A Study of Risk Management Through In-Depth Interviews

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Risk management reduces the harm caused by invasive species through prevention, detection, management and restoration measures. Although it is essential to study the ecological and technical aspects of invasive species management, examining the effect of social and institutional factors can increase understanding and effectiveness of management programs. These factors are context-dependent and lend themselves well to in-depth interviewing, a method not frequently utilized in risk management work. For this project, we studied how social and institutional factors affected the management of the exotic invasive oak wilt fungus (Ceratocystis fagacearum) in Minnesota by performing 13 in-depth, semi-structured interviews with foresters and private contractors involved with its management at the city and county level. These interviews provided information on 16 city and 3 county oak wilt management programs. Uniquely situated between expert and lay systems of knowledge, and governmental policy and the public, these foresters and private contractors provided key insights into the dynamics of, challenges to, and opportunities facing oak wilt management programs. Key results include that management programs and their effectiveness vary extensively for reasons such as the existence and enforcement of potential spore producing tree (PSPT) removal ordinances, and resources availability at the state, local, and homeowner level. One issue that reduced the enforcement of existing ordinances was the perceived economic burden enforcement placed on landowners. After providing recommendations for oak wilt management, we end by arguing for the utility of both in-depth interviews and the study of social and institutional factors in invasive species risk management.
Potato Cyst Nematodes: What are They, Where are They, and Why Do We Care?

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Potato cyst nematodes are microscopic worms that feed on the roots of potatoes. In high numbers they can cause up to 80% reductions in yield. There are two species, both thought to have originated in the Andes Mountains in South America. Neither species has been found in Minnesota, but both species are now found in other potato growing areas around the world. One species, Globodera rostochiensis (golden nematode), was discovered in the U.S. for the first time in 1941 in a potato field on Long Island NY. Because of an effective state-federal quarantine, this pest has been confined to 9 counties within NY. In 2006, the other species, Globodera pallida (pale cyst nematode) was found for the first time in the U.S. in several potato fields in Idaho. These detections resulted in the immediate halt of potato movement from that state until the extent of the infestation was delimited. Minnesota is a major producer of both seed and commercial potatoes and could be severely impacted if these nematodes were to establish in fields in our state. This presentation reviews the biology and means of spread of these species, along with highlights of strategies that are in place in Minnesota, the US and Canada to prevent their spread.
Firewood Movement - Does It Really Spread Invasive Species? (The Inside Story)

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Movement of firewood, along with a variety of other articles, is regulated within and from states that have infestations of certain invasive pest species to prevent their spread to uninfested areas. Recently, firewood restrictions have been established for many parks and campgrounds in Minnesota. Since the discovery of emerald ash borer (EAB) in Michigan in 2002, there have been several cases of new EAB infestations in states as far away as West Virginia that have been blamed on firewood movement. While this seems very likely given the biology of the insect and the frequencies and distances that people move firewood, it is difficult to find data to actually support these claims. A critical review of the variety of information on which these claims are based, including anecdotes, surveys, and research, provides some interesting results.
A Juvenile Aggregation Pheromone in the Common Carp

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Pheromones, chemical signals that pass between members of the same species, have great promise for managing invasive fish because of their high specificity and potency. This is especially true for the common carp (Cyprinus carpio), which relies heavily on odorous cues to find food and mates. In this study, the behavior of common carp was tested in mazes to determine whether it uses an aggregation pheromone (a cue released by all individuals of a species irrespective of reproductive state) to locate/identify conspecifics. Our study focused on juvenile and female carp, important groups to remove for control (see Sorensen & Bajer, this conference session). Initial tests discovered that juvenile common carp are strongly attracted to the odor of juvenile conspecifics but not juveniles of other species. Next, we found that sexually-mature, non-ovulated female carp are also attracted to this odor and do not distinguish between the odor of juvenile and adult fish: carp use an aggregation pheromone. More recently, we have discovered that this pheromone has several components, some of which and can be isolated, recovered and concentrated from carp holding water using C18 resins. Ongoing work is focused on chemical characterization and further elucidating function so that larger-scale tests directed towards control might be possible in the field. (Funded by the Minnesota Environmental Trust Fund).
Sex Pheromonal Attractants for Common Carp Appear Useful for Control

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The common carp (Cyprinus carpio) is one of the most damaging invasive fishes found in both North American and Australian small lakes, wetlands and shallow rivers. Present efforts to control this species focus on draining and poisoning with rotenone, an expensive and unsustainable technique -- new, targeted approaches are needed. Pheromones, chemical signals that mediate behavioral interactions between conspecifics, have special promise for use in targeted trapping of this olfactory-driven species. Our ongoing studies demonstrate that the common carp discerns conspecific using species-specific body odors (see Levesque et al., this conference session), which are complimented by potent hormone-driven cues released by mature individuals. Specifically, we have discovered that sexually receptive mature female carp (which are especially important targets for removal) are highly attracted to the odor of sexually mature male conspecifics and that this odor is partially comprised of androstenedione. Additionally, we find that sexually mature male carp are attracted to the odor of sexually receptive female conspecifics. Both cues can be extracted, concentrated and purified using diverse resins, so chemical identification and large-scale application should eventually be possible. In the meantime, and as a first step in developing protocols for testing attractants in the field, we have shown that we can attract wild carp using a potent food attractant, cracked corn, in a small local lake. Ongoing studies now focus on using these procedures as part of an IPM program (see Sorensen and Bajer, this conference session). (Funded by the Invasive Animals Cooperative Research Centre, Australia)
Impacts of the Exotic Zooplankton *Bythotrephes longimanus* on Island Lake Reservoir

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The spiny water flea (*Bythotrephes longimanus* leydig) was first reported in North America from Lake Ontario in 1982 and was subsequently identified in Lake Superior in 1987 and Island Lake Reservoir in 1990. In this paper, I examined the long-term impacts of *Bythotrephes* on the zooplankton and fish communities of Island Lake Reservoir and compared them to data collected concurrently on Whiteface Reservoir, which is not infested with *Bythotrephes*. Zooplankton samples were collected every two weeks during the open-water season of sampling years with a conical plankton net, while fisheries data were collected as part of regularly scheduled Minnesota DNR lake investigations. Similar to other North American lakes infested with *Bythotrephes*, total biomass, abundance and mean length of all plankter groups sampled in Island Lake Reservoir were significantly less than Whiteface Reservoir on a predominance of sample dates. Incremental growth of age two through five walleye (*Stizostedion zander*) and yellow perch (*Perca flavescens*) in Island Lake Reservoir was significantly greater than Whiteface Reservoir. Conversely, mean condition for walleye and yellow perch from Island Lake Reservoir declined significantly compared to Whiteface Reservoir. Spottail shiner disappeared from Island Lake Reservoir seine samples collected between 1989 and 1994. Range expansion of *Bythotrephes* from Island Lake Reservoir to other inland waters of Minnesota had not occurred until the 2004 documentation of their presence in the border waters between Minnesota and Canada. The favorable physical and biological condition of lakes within this region, coupled with their high connectivity has resulted in rapid range expansion. This expansion has exacerbated the need for collection of baseline data on high priority lakes near known infestations.
Preventing the Spread of AIS from Water Gardening

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The water garden industry is a billion dollar a year enterprise in the US and has been identified as a vector for introducing aquatic invasive species (AIS). Aquatic plants are increasingly available locally and over the Internet, few people recognize the risks of releasing them into natural waters, and invasive “hitchhikers” often accompany plant shipments. A comprehensive educational strategy for suppliers and gardeners is critical. To investigate the potential for introducing AIS through water garden horticulture, we surveyed consumers and nursery professionals. Survey tools measured awareness and knowledge, identified sources of plants and information, characterized sales and gardening practices, investigated willingness to pay, and assessed opportunities for education.

Respondents indicated the threat from aquatic invasive species is of serious concern (91% consumers, 57% professionals), but most were unable to correctly identify non-native, invasive species of concern. Few consumers (7%) purchase plants or animals over the Internet; 56% choose plants at local retail outlets. Most consumers (86%) expressed a willingness to pay more for hitchhiker-free plants. Two thirds of nurseries had received unintended plants or animals in shipments. Fewer than 15% had a process in place to eliminate hitchhikers in plant receipts; only 25% had a process to prevent unintended plants in sales. Nearly all retailers (95%) were willing to provide their customers with education about AIS. Point of sale educational materials were developed in conjunction with nursery professionals, Minnesota Water Garden Society members, and agency staff. Materials include posters, tip cards, and plant sticks customized for MN and available for adaptation in other states. End-of-season evaluations indicated that nurseries found the materials very effective in raising awareness and providing valuable information for customers. Minnesota Master Gardeners were provided a power point presentation and table top display to use with garden clubs, county fairs, and festivals; reaching thousands of gardeners across the state. PDFs of the posters, tip cards, and plant sticks are available at: www.seagrant.umn.edu/exotics.
Noxious weeds are weed species that are particularly objectionable due to difficulty of control or eradication and that have adverse effects on human, animal, or environmental health. Not all are necessarily considered invasive, but it is important to limit the spread of these species through seed. The Minnesota Seed Law addresses the sale of seed containing noxious weed seeds. Eleven species are designated as prohibited noxious weeds. These are not allowed in any amount. Ten species are designated as restricted noxious weeds. Up to 25 restricted noxious weed seed per pound are allowed but their presence must be identified on the seed label. Noxious weed seeds are most frequently found as contaminants in native seed mixtures, lawn grass seed, forage mixtures, and wildlife food plot seed. Typically, noxious weed seeds are harvested with the desirable species but are not adequately removed during the conditioning process. They are rarely found in seed lots of major agricultural crops. As seed producers in the state continue to improve their operations, equipment, expertise, and quality control, noxious weed seed contamination frequency and amounts are reduced even in traditionally problem kinds. The unit also assists counties with enforcement of local primary noxious weed restrictions by identifying noxious weed seed found in bird food samples and verifying identification of noxious weeds in enforcement situations.
Integrated Use of Herbicides and Insects to Control Eurasian Watermilfoil

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Current management options for Myriophyllum spicatum are plagued by shortcomings, such as damage to non-target species, high cost, potential herbicide resistance of the weed, and overall ineffectiveness. The native milfoil weevil, Euhrychiopsis lecontei, has been shown to control Eurasian watermilfoil in experimental and certain natural settings. We applied herbicides and weevils individually and in combination to Eurasian watermilfoil grown in 378-L tanks to determine whether insects and herbicides could be integrated in space and time to provide a cost-effective, environmentally-friendly, and long-term control for Eurasian watermilfoil. Individual treatments were applied at recommended dosages: 1.5 ppm 2,4-D (Navigate™), 40 ppb Fluridone (SONAR ASTM), 2-4 weevils per stem, and control. At two-weeks, 2,4-D-treated plants were dead, fluridone-treated plants experienced an increase in shoot length (120% of controls) along with meristem whitening, and weevil-treated plants exhibited larval damage and were significantly smaller than control plants (64% of controls). At seven weeks, 2,4-D-treated plants were largely decomposed, fluridone and weevil-treated plants had similar biomasses and shootlengths that were significantly reduced from the control plants. Carbohydrate allocation to above and below-ground tissue differed among treatments. Control plants had the highest concentrations of carbohydrates and starch followed by weevil-treated plants, fluridone-treated plants, and 2,4-D-treated plants. Despite similarities in the biomass of fluridone- and weevil-treated plants, the observed differences in carbohydrate and starch content have important implications for long-term survival of the milfoil weevil and long-term control of the milfoil plant.
The Need for Regional Pest Risk Assessment

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Many new pests are arriving in the United States because of expanded world trade. Attempting to address all possible pests is an impossibility given limited resources. A science-based assessment of the risks of pests being introduced and established is needed to crystallize priorities. Pest Risk Assessments (PRAs) are done at the national level, but these are too broad for regions like the upper Midwest. In 2006 to 2008, a regional PRA developed by Dr. Rob Vennette of the USDA Forest Service was used by Minnesota Department of Agriculture staff to rank several species for their likelihood of being introduced and establishing in Minnesota. Information on four pests that are not yet found in Minnesota was evaluated, and the results were surprising. The first pest evaluated was the Siberian moth (Dendrolimus superans Butler) and was assigned a score of 63. To determine the range of possible scores, a known serious pest, emerald ash borer (Agrilus planipennis Fairmaire), was evaluated, yielding a score of 170. Another serious pest, Sirex woodwasp (Sirex noctilio) was ranked at a score of 121. In an attempt to find the lower range of the scoring system, the Swede midge (Contarinia nasturtii) was ranked, but the score was a surprising 121—equal to the threat of the Sirex woodwasp. Each PRA took about two months to complete, and although very helpful, the time could not be justified. Hopefully a more streamlined method could be developed.
Competitive Interactions Between the Round Goby
(\textit{Neogobius melanostomus}) and the Native Benthic Fish

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The invasive round goby (\textit{Neogobius melanostomus}) has negatively impacted benthic fish communities throughout the Great Lakes. This study compared the sensory physiology and behavior of three native species, slimy sculpin (\textit{Cottus cognatus}), spoonhead sculpin (\textit{C. ricei}), and logperch (\textit{Percina caprodes}) with the invasive round goby (\textit{Neogobius melanostomus}) to determine the mechanism(s) which allow the round goby to dominate native fish. The mechanosensory lateral line and vision of the four species were examined during predator-prey trials using natural prey (\textit{Gammarus sp}) under varying light intensities (0-130 lx). The trials in the dark (0 lux) indicated that the sculpins and the round goby had similar lateral line sensitivity. However, all three native species had a significance advantage in reaction and strike distance over the round goby at higher light intensities. Interspecific resource competition was assessed by pairing a round goby with a native fish in an artificial stream. Round gobies gained significant weight during all trials, and although the slimy sculpin was able to maintain weight in the presence of the round goby, spoonhead sculpins and logperch lost significant amount of weight during the trials. The experiments indicate that the round gobies’ behavior and not inherent sensory advantages, allow it to dominate resources and out-compete native fish. The results indicate that a wide variety of native benthic fish are at risk to the round goby.
Regulating Ballast Water: Minnesota’s New Permit

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Ballast water discharges from ships may contain aquatic invasive species that could survive in their new location, upsetting the local aquatic ecosystem. In 2007, the Minnesota Pollution Control Agency initiated development of a vessel discharge regulatory program and expects to have a ballast water discharge permit process in place as of September 30, 2008 (pending approval of the agency’s September Citizens’ Board vote). Throughout 2008, agency staff engaged stakeholders in a transparent process to develop a technologically-achievable permit for vessels that discharge ballast water into Lake Superior and its harbors. This presentation will describe the MPCA’s involvement in ballast water control, permit development efforts, the challenges, implications and impacts of developing a state permit program, and the vessel discharge program’s future.
The Extent of Selected Non-Native Invasive Plants on Minnesota Forestland

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The Northern Research Station’s Forest Inventory and Analysis (FIA) Program collects forestland related data throughout a 24-state region in the northeastern United States, ranging from North Dakota to Maryland and Kansas to Maine. Based on discussions with our stakeholders and others, we found that the impact of non-native invasive plants’ impact may be known at the local level but their abundance, regional impact, range, and rate of spread are not well understood. Accordingly, in 2005 and 2006, we sampled for the presence and abundance of 25 selected non-native invasive plant species (NNIP) on all forested FIA plots in several Midwestern states. These plant species were selected based on several criteria, including level of interest by our stakeholders, the threat posed to our forested ecosystems, the extent of their range and the ability to reasonably detect these species throughout the year.

This paper summarizes our findings from the data collection in Minnesota. We summarize the data by forest type and examine the relationship between forest age, disturbance history, and the impact of human influences, such as distance to roads. We also examine the relationship between regeneration of major tree species and the predominance of selected invasive plants. We use geographic information systems (GIS) along with FIA data to map out hot spots for invasive species and potential problem areas associated with invasive species. Compared to other states in the region, Minnesota plots had a relatively low percentage of NNIP. The most common species found was common buckthorn (Rhamnus cathartica). An earlier regional analysis suggested that early successional forest types appear to have a higher percentage of plots with NNIP. Grasses were prominent in low-density or fragmented forestland. Regeneration of selected tree species was impacted by only a few NNIP. Analyses such as these provide valuable information to our cooperators. We conclude with some lessons learned from both methodological and ecological viewpoints.
Use of Herbicides for Management of Non-Native Invasive Aquatic Plants

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Use of aquatic herbicides in Minnesota for control of non-native submersed plants such as Eurasian watermilfoil (Myriophyllum spicatum) and curlyleaf pondweed (Potamogeton crispus) can elicit a broad range of reactions from various stakeholders, regulators, and resource managers. While aquatic herbicides typically provide relief from the nuisance plant, applications can elicit concerns regarding potential for non-target plant impacts, off-target plant impacts, and impacts to fisheries. Moreover, there has been some debate as to whether herbicide use over time is providing a long-term reduction of target plant populations. This presentation will focus on historical and current use patterns of the registered herbicides diquat, endothall, 2,4-D, triclopyr, and fluridone. Although several new herbicides have been registered in the aquatic market, for the foreseeable future it is likely that the five herbicides listed above will be the main products used for control of submersed invasive plants in Minnesota waters. Operational applications and strategies will be discussed in relation to recent research efforts that have evaluated treatment scale and timing, herbicide residue patterns, and biology of the target and non-target plant species. Differences in management philosophies for curlyleaf pondweed and Eurasian watermilfoil will also be discussed.
Curlyleaf Pondweed Turion Distribution, Viability, and Longevity: Implications for Management

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Curlyleaf pondweed (Potamogeton crispus L.) is a problematic invasive aquatic macrophyte in North America. It reproduces primarily via vegetative propagules called turions. Control efforts have focused on eliminating turion production and thus it is important to know the distribution of turions in lakes and lake sediments, their viability, and longevity. To determine turion longevity, we collected mature turions and buried them in mesh bags in the sediment and sampled annually for viability. Buried turions were viable for at least 3 years and continued sampling will determine longevity. To determine turion distribution and viability, we collected sediment cores from 3 depths in 4 lakes over two years. Turions were enumerated from the top 5cm, 5-10cm, 10-20cm and 20-30cm of each core and then tested for sprouting. Turion densities in depths ≤3m were variable among lakes, ranging from an average of 41/m² in Round Lake to 939/m² in Lake Sarah. Turion densities were highest at 1 to 2-m depth (382 to 2003/m²), and were always lower at 3-m depth (25 to 340/m²). Most turions (50 to 75%) were in the top 5cm of sediment, but were common in the next 5cm (30%) and were found as deep as 30cm in two lakes at densities ranging from 14 to 74/m². The buried turions were viable (generally 50% sprouted) and represent a potential source of recruitment. Management efforts will need to control turion production for at least three years to prevent recruitment and the importance of buried turions to recruitment deserves more consideration.
Prospects for the Biological Control of Eurasian Watermilfoil with Aquatic Insects

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Eurasian watermilfoil (Myriophyllum spicatum) is a major nuisance aquatic plant in Minnesota and there is considerable interest in biological control despite availability of effective chemical controls. The native milfoil weevil, Euhrychiopsis lecontei, appears to be the best candidate control agent in Minnesota. The weevil can cause milfoil declines and control the plant when it attains adequate densities that persist throughout the summer. The weevil has been associated with milfoil declines in four Minnesota lakes; declines persisted (≥ 4yrs) in two lakes (Cenaiko and Otter) and in the shallow portion of Smith's Bay. These lakes had adequate herbivore densities and a positive native plant response, resulting in effective control. At other lakes and times, weevil densities were too low to control milfoil. In-lake factors appear more limiting to weevil populations than overwinter conditions. Because the weevil lays 2-5 eggs per day, adult reproductive longevity is critical to summer-long density. Enclosure/exclosure experiments indicate that sunfish (Lepomis spp.) can limit control agents. On a larger scale, among lakes and years, we found significant negative relationships of sunfish and herbivore densities. Sunfish can limit herbivore densities and thus milfoil control. Comparison of herbivore densities among bays in Lake Minnetonka showed significant negative relationships of herbivore density with percentage of the bay harvested, suggesting that large-scale harvesting can also reduce herbivore densities. Low sunfish densities and limited milfoil harvesting, will likely be required for successful biocontrol. Approaches to reduce sunfish density must be developed for biocontrol to be feasible in many lakes.
This presentation will give current information about soybean aphid (Aphis glycines) biological control using the parasitoid, Binodoxys communis. These tiny wasps are reared in MN at the University of Minnesota and the Minnesota Department of Agriculture. The first releases were made in the field season of 2007 after years of research at the Quarantine Facility (located at the U of MN, St. Paul Campus) led to obtaining the TAG permit necessary for releasing these foreign parasitoids. More experimental releases will be taking place in 2008, and the focus will be on monitoring and best release practices for parasitoid establishment. Using biological control, the aim is to reduce or eliminate economic losses due to soybean aphid damages and control costs. The aim is also to curb environmental impacts by reducing or eliminating the need for insecticide use against soybean aphid using this sustainable method of control. A brief overview of other MDA Biolab rearing projects will be mentioned.
The Effects of *Bythotrephes longimanus* on Fish Diets and Mercury Levels

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The spiny waterflea (*Bythotrephes longimanus*) is an invasive zooplankter originating from Eurasia that invaded the Laurentian Great Lakes in the 1980s and has since established in several inland Minnesota lakes and reservoirs. Once established, the spiny waterflea can become a dominant food source for planktivorous fishes. It is hypothesized that the addition of the spiny waterflea to the food web of Island Lake Reservoir in 1990 increased the trophic position of fishes that eat the zooplankter and correspondingly increased their methyl mercury (CH$_3$Hg) levels. Water chemistry data as well as fish and zooplankton specimens were collected from Island Lake Reservoir (spiny waterflea present) in 2006 and Whiteface Reservoir (spiny waterflea absent) in 2007. The stomach contents, age, length, weight, stable isotope (13C and 15N) levels, and total mercury concentrations were determined for walleye (*Stizostedion vitreum*), northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and yellow perch (*Perca flavescens*) from each reservoir. Zooplankton stable isotope levels and mercury concentrations for animals from both reservoirs were also measured. Here we present a preliminary analysis of the data set.
Policies to Prevent or Control Aquatic Invasive Species

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Policies to prevent or control aquatic invasive species (AIS) are largely permissive, meaning they rely on voluntary actions and minimal enforcement. Furthermore, there is a patchwork of regulatory oversight and control at multiple levels. As a result of a lack of clarity regarding legal frameworks and priorities, the resulting system of prevention and control is limited in its effect and scope. Positive steps have been taken and significant improvements have occurred, especially with respect education, awareness and voluntary action. However, other more direct prevention measures are needed to complement these initiatives. To effectively reduce the risk of AIS introductions, individual water bodies must take initiatives at this last line of defense. For many AIS, control measures are not technically feasible. Where feasible, controls need to be as aggressive as the pest being controlled.
Early Detection Monitoring for Invasive Fish: St. Louis River (SLR) Pilot Study

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Early detection of aquatic invasive species is necessary to develop and implement timely management responses. Predicting species introductions, however, is difficult and resources are typically limited. Therefore, monitoring strategies should be designed to effectively and efficiently address a suite of potential invaders. Strategies must consider life histories, spatial and temporal distributions, gear selectivity, habitat diversity and modes of invasion. To develop early detection strategies, we sampled fish in the Duluth-Superior harbor/SLR. Our extensive and comprehensive sampling (2006-2007) provides data on the distribution and abundance of known invasive, and other “rare” but native fish species, and was designed to evaluate different sampling strategies. The study used two site allocation designs (spatially balanced and targeted) and four gears (electrofishing, fyke net, bottom trawl, and beach seine). Both designs performed similarly, suggesting that targeted sampling at fewer sites may achieve the same results as spatially broader random sampling, provided the range of available habitats is included. Individual species detection probabilities and the rate of additional species acquisition varied among gears, and no single gear captured all species. Electrofishing was most efficient in terms of new species per number of fish captured, while “rare” species were captured most frequently by electrofishing or fyke netting. Total richness was generally highest in electrofishing or fyke nets, but varied spatially. Our research indicates that a complex system such as SLR could be effectively sampled with approximately 30 sampling events given appropriate allocation of effort among habitats, sites and gears. This abstract does not necessarily reflect EPA policy.
**Impacts of Garlic Mustard on Oak Woodland Plants: Implications for Restoration**

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With the impending release of biological control agents in Minnesota, it becomes critically important that we understand the nature and duration of the effect of garlic mustard (*Alliaria petiolata*) on native understory plants. This invasive herb has been shown to displace native herbs and reduce growth and mycorrhizal colonization of tree seedlings; an effect that persists for at least two years after garlic mustard removal. Because garlic mustard is a biennial, the result of successful biological control will be constantly-shifting, low-density populations of garlic mustard. An important management question is: can native plants be restored given garlic mustard's potential long-term damage to soil biota? My study addresses the effect of garlic mustard density and removal on the growth of native herbs in two oak woodlands in the Twin Cities metro area. In summer 2006, I removed different amounts of garlic mustard from plots within an existing infestation: 100% removal; partial removal (in which I removed all but 5 garlic mustard rosettes), and no removal. I then planted 10 species of native herbs into these plots, and into uninvaded control plots. I am using ANOVA to analyze plant survival, growth, and flowering rates, which were assessed monthly throughout the summer of 2007. In this presentation, I will share results of first-year plant performance compared across garlic mustard removal treatments.
Control and spread prevention of terrestrial invasive plant species has been the main stay of most land managers invasive species toolboxes. This can be affective to a degree however, other techniques can aid in our overall management of invasive species. Natural resource management is key to reducing the dominance of invasive species on the landscape especially in high quality native plant communities. Changes in a resource (increase sun, nitrogen, water, etc.) can provide a competitive advantage (or simply disrupts the native species that are present) to the non-native species present and can alter the site making it vulnerable to relatively rapid invasion of other non-native plant species. The ecophysiology of the non-native plant species is similar to many of our fire-adapted species making management for these natives even more difficult. Our management decisions can either act to decrease or increase the dominance of terrestrial invasive plant species on a site. Therefore thoughtful planning and site management is essential to the overall management of our state’s natural resources and the invasive species that are impacting these resources.
The Three Year Efficacy of Oak Wilt Management Programs in Minnesota

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Purple loosestrife (*Lythrum salicaria*) is an invasive perennial wetland plant introduced to the US in the early 1800’s from southern Europe. Originally introduced through ship ballast and horticultural trade, purple loosestrife is now a prohibited noxious weed in Minnesota. In 1992, a classical biological control program was initiated to manage purple loosestrife. As a result of this program, two species of leaf feeding beetles, *Galerucella calmariensis* and *G. pusilla*, have established in Minnesota. Variable success has been achieved in wetlands throughout the state with some populations routinely subject to 90-100% defoliation of purple loosestrife and others with little to no observed effect of the biocontrol agents. In this study, three sites were examined that consistently experienced high levels of biological control as well as three sites where agents have failed to establish. Sites were located within the greater Twin Cities metro area and southeastern Minnesota. Beetle number, plant height, above ground biomass and inflorescence development were examined to quantify the variation within and between the two classes of wetlands. Additionally five native populations in the Czech Republic were measured and compared to the invasive populations. Future studies of the evolutionary consequences of the biological control of purple loosestrife will address the long term sustainability of the program.
New Ballast Water Treatment Technologies: Killing Potentially Invasive Algae

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Ballast water discharge from ocean going and laker vessels has been identified as a significant source for the introduction and spread of aquatic invasive species. A new research facility in Duluth Harbor is the first in the Great Lakes region designed to focus on developing technologies to prevent the introduction of nuisance species into the Great Lakes by ships. This pilot-scale facility is part of the collaborative Great Ships Initiative (GSI), and simulates a ship’s complete ballast water system. Various candidate treatments, including physical and chemical methods, are being applied during the simulated ballast water holding periods. Efficiency of these candidate procedures are evaluated by comparing numbers of surviving organisms in treatment and control (no-treatment) tests. Determining organism viability is a fairly established process for vertebrates and invertebrates (e.g., Are they moving?). Algae are more difficult; even under a microscope, living and dead algae can look identical following treatment. I present a method for determining algae viability following test treatments at the GSI facility using a fluorescing stain. Findings from this work will support the development of a ship-board treatment system that meets International Maritime Organization (IMO) standards for species introductions.
Emerald Ash Borer First Detector Training in Minnesota

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A critical component in preparing for the arrival of emerald ash borer (Agrilus planipennis) in Minnesota is establishing early detection networks to enable quick discovery of new infestations. First Detector training is a program administered by the National Plant Diagnostics Network with the goal of providing early detection of exotic pests by training individuals who may encounter them. During spring 2007-2008, the University of Minnesota, University of Minnesota Extension, Department of Agriculture and Department of Natural Resources collaboratively designed and offered a course to train individuals as Emerald Ash Borer First Detectors in Minnesota. The course covered the basic tenants of the First Detector program as well as emerald ash borer biology / identification and how to work with the public to evaluate reports of suspected emerald ash borer infestations. The target audience for the training was forestry and or arboriculture professionals as well as Master Gardeners and other volunteer groups with the goal of tapping into the public through them to help detect emerald ash borer infestations. Six workshops were held around the state during March and April, 2007 2008 and nearly 200 180 individuals attended the sessions in total.
Invasive Aquatic Animals in Minnesota and on the Way

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Several invasive aquatic species of fish, snails, mussels, crayfish, and zooplankton have become established in Minnesota's lakes, rivers and wetlands and have harmful impacts on water recreation and aquatic ecosystems. Additional aquatic animal invaders are headed toward the state via natural movement (e.g., Mississippi River and tributaries) and through human mediated pathways. This presentation will provide an overview of impacts and distributions of aquatic animal invaders established in the state and of those that are future threats to Minnesota. Zebra mussels (Dreissena polymorpha), round gobies (Neogobius melanostomus), spiny waterfleas (Bythotrephes longimanus), rusty crayfish (Orconectes rusticus), and Chinese mystery snails (Bellamya chinensis) are examples of species that have been in Minnesota for many years. Faucet snails (Bithynia tentaculata), present in the Mississippi River south of Winona, were recently found in Lake Winnibigoshish. New Zealand mudsnails (Potamopyrgus antipodarum) and quagga mussels (Dreissena bugensis) are more recent invaders to the Duluth harbor. Bighead (Hypophthalmichthys nobilis), silver (Hypophthalmichthys molitrix), and black carp (Mylopharyngodon piceus), as well as northern snakehead fish (Channa argus) are some of the species that could invade the state’s waters in the future.
A Review of *Phytophthora ramorum* and the Risk of Establishment in Minnesota

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A number of factors influence the establishment of *Phytophthora ramorum*. Some of those factors are climate-host interaction, host range, dispersal potential, economic impact, environmental impact, and pest opportunity. Our climate in Minnesota makes it unlikely that *P. ramorum* could establish in naturalized areas. However, short-term infestations are possible since we have weather patterns in the summer that are conducive to infection, as are most nursery climates. The pathway of introduction will most likely be nursery stock and our risk for introduction increases with the amount of nursery stock we receive from west coast nurseries. A concern related to the establishment of *P. ramorum* in Minnesota is interspecific hybridization of Phytophora species. New hybrids can have expanded host ranges and the ability to move into different niches. *P. ramorum* is a quarantined organism and the movement of plants out of quarantined areas is regulated. This makes nursery finds in Minnesota a regulatory issue. Minnesota needs to continue surveying for *P. ramorum* in nursery stock from quarantined areas for early detection of this organism.
Relating Manager Priorities to Management Policy:  
The Case of Oak Wilt in Minnesota

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Forest and urban tree managers must operate in a complex biological and social environment, and bring different values and perceptions of risk to their problems. The complexity inherent in the different situations can complicate policy maker’s design and implementation of tree pest risk management programs, leading to less than ideal levels of efficacy. We investigate one such complex situation using the case of oak wilt in Minnesota, aiming to inform future state and federal management actions. We started by investigating the on-the-ground priorities of municipal and state land managers, to understand how oak wilt (caused by Ceratocystis fagacearum) is perceived compared to other threats (which include other invasive species). We then explored which tree attributes and services managers are most concerned with protecting, and whether oak wilt threatens them. Invasive species are a critical concern, and oak wilt is considered a high priority invasive species. Perceptions of the threat level vary, however. Managers identified aesthetics and ecosystem resilience as the most important tree attributes, in municipal and state lands respectively, and they affirmed that oak wilt threatens these attributes. Our results contextualize oak wilt as a management priority, and suggest that linking damage caused by oak wilt to attributes that specific managers value may be a useful strategy.
Minnesota Grant Program for Cooperative Weed Management Areas

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Through collaborative efforts with many agencies and organizations in the state, the Minnesota Board of Water and Soils Resources has been developing and implementing a new grant program focused on the creation of Cooperative Weed Management Areas and the control of invasive species. This presentation summarizes the design of the grant program, the process used to select grant recipients and results over the first growing season. The presentation will also focus on lessons learned to date and future plans to streamline the process and continue the establishment of Cooperative Weed Management Areas across the state.
How to Manage Invasive Species at the County Level

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The role of the County Agricultural Inspector (CAI) has evolved over time from the County Weed Inspector to the current day Invasive Species Manager. Along with the changes have come an understanding it’s not just terrestrial species. As a result of our global economy, we must deal with all invasive species. Because of the many hats we wear as Agricultural Inspectors it’s quite easy for most inspectors to become involved in Species Biology/Ecology, Invasive Species Prevention and Containment, Early Detection and Rapid Response along with Invasive Species Control and Management, and then Restoration. As a result of our great working relationship with the staff of Minnesota Department of Agriculture, Department of Natural Resources, and other state and federal agencies, we are able to network with our local levels and better serve the wants and needs of Invasive Species Management. This allows us the ability to get the resources to the ground more efficiently than any other organizations. The Executive Board of the Minnesota Association of County Agricultural Inspectors (MACAI) works hard to promote partnering with all state and federal agencies to further the cause and help fight the battle against invasive species. With the commitment and local contacts each County Agricultural Inspector has within their area, it makes perfect sense to include the County Agricultural Inspector in your arsenal of weapons to wage war on invasive species.
Overview of Minnesota DNR's Invasive Species Operational Order

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The Minnesota Department of Natural Resources (DNR) protects and manages many of the diverse natural resources of Minnesota. Because invasive species have the potential to adversely affect these natural resources, the DNR has developed an operational order that provides policies and procedures to limit the introduction of invasive species onto DNR managed lands and waters, limit their rate of geographical spread, and reduce their impact on high value natural resources. The operational order applies to all DNR resource management activities by employees and non-DNR individuals/organizations on DNR-administered lands, public waters; and actions that DNR regulates, permits, or funds. This operational order addresses prevention and management of invasive species including: 1) intentional movement of equipment, 2) intentional movement of organisms, organic and inorganic materials, 3) identifying invasive species and implement management strategies to reduce their impact at the site level, and 4) monitoring and reporting new invasive species infestations. The operational order is also designed to ensure that DNR resource management activities comply with existing statutes and rules governing invasive species. The author will discuss the key points of the operational order and how it is being implemented throughout the DNR.
Curlyleaf pondweed (Potamogeton crispus) and Eurasian watermilfoil (Myriophyllum spicatum) have become wide spread problems in many northern lakes. Both plants begin growing in early spring when ice cover first disappears from lakes, forming dense canopies before many native aquatic plants begin to grow later in the spring. Previous mesocosm and greenhouse studies demonstrated that applying 1 mg active ingredient [ai]/L endothall combined with 0.5 mg ai/L 2,4-D, when water temperatures were 12 to 18°C, resulted in better control of Eurasian watermilfoil and curlyleaf pondweed with less post treatment re-growth and recovery. Based on these small-scale results, a multi-year field study was initiated to verify selective, long-term control of curlyleaf pondweed and Eurasian watermilfoil using early spring applications of endothall combined with 2,4-D. Four lakes infested with curlyleaf pondweed and Eurasian watermilfoil in the Minneapolis/St. Paul, MN, area were selected for the field study sites. Pretreatment plant surveys were conducted in June and August of 2003. All Eurasian watermilfoil and curlyleaf pondweed populations in two lakes were treated with the combination of endothall (1 mg ai/L) and 2,4-D (0.5 mg ai/L) in April 2004, 2005, and 2006. The two lakes that were not treated served as references. Post treatment evaluations were conducted in June and August, 2004 through 2006. Herbicide applications were successful at reducing curlyleaf pondweed and Eurasian watermilfoil densities by more than 95% throughout the lakes. Herbicide treatments resulted in no significant changes in native plant abundance or diversity during the first year post treatment, but native plant diversity and abundance did increase in treated lakes during the second and third year post treatment. Water clarity was not reduced following removal of Eurasian watermilfoil and curlyleaf pondweed. Populations of curlyleaf pondweed, Eurasian watermilfoil, and native plants did not significantly change in untreated reference lakes. Early spring applications of endothall combined with 2,4-D effectively controlled both curlyleaf pondweed and Eurasian watermilfoil allowing native plants to increase in diversity and abundance. These methods are being further tested in operational herbicide treatments in MN and WI.
Elimination of Invasiveness in Horticultural Crops Through Biotechnology

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Invasive species are a primary threat to biodiversity on the planet, second only to habitat destruction and are one of the least reversible of all human impacts on the environment. Unfortunately, horticulturists have been a major source for the spread of invasive plant species. Invasive plants can spread via sexual (seed) or asexual (vegetative) propagules. A large number of the terrestrial species of horticultural interest spread predominantly by seed. The goal of this project is to introduce sterility genes into horticultural crops with invasive potential to eliminate invasiveness while maintaining other desirable characteristics. We use a biotechnology strategy where genes inhibit the growth of essential reproductive tissues resulting in sterility. This approach relies on the specificity of a sterility gene to target expression to essential reproductive tissues and inhibit their growth. For male sterility, tissue within the anther is inhibited and for female sterility tissue within the style is inhibited. Plants carrying the sterility genes do not produce pollen and have greatly reduced ability to set seed with normal pollination. Plants carrying both male and female sterility genes failed to produce seed over several years of cultivation. Using biotechnology to produce non-invasive plant cultivars is a novel and efficient approach. When a crop has limited variation or means for selection of desirable traits, gene introduction can provide a diverse set of genes to apply toward a problem. The introduction of the sterility genes is a broadly applicable strategy that should only change flower fertility and invasiveness.
Valuing the Effects of Invasive Species: The Case of Oak Wilt

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The magnitude and nature of the economic damages caused by invasive species depend on their environmental impacts. These impacts are often difficult to identify and quantify. However, management and policy decisions hinge upon sound analysis of both the environmental and economic effects of these invasive species. Few studies explicitly quantify these impacts based on both the economic and ecological relationships. We present a framework for evaluating the economic impacts of oak wilt Ceratocystis fagacearum, an exotic invasive fungus and the most significant disease of oaks (Quercus spp.) in Anoka County, Minnesota by 1) quantifying the time dependent spread of oak wilt in a heterogeneous landscape and 2) accounting for economic damages associated with the spread of the invasive species.

The framework captures the spatial spread of oak wilt without management. To illustrate the model, the analysis focuses on Anoka County over a 5-year time horizon. The simulation results indicate that oak wilt could kill approximately 3,700-180,000 oaks trees in the county over the next 5 years. The predicted discounted damages would range from $1.2 million to $49 million. Our current estimates use removal costs since they are straightforward and provide a reasonable, though incomplete, metric of the damages caused by this pathogen. Our results suggest that there are considerable potential benefits from an effective management plan. The model can be expanded to incorporate data from a much larger spatial scale such as the entire state of Minnesota.
Integrated Pest Management of the Common Carp

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Within several decades of its introduction in the 1880’s, the common carp, Cyprinus carpio, had established itself as one the most abundant and damaging invasive fishes in North America. This species voraciously feeds in the benthos, removing valuable plants, liberating sediments, and pumping nutrients into open waters often making them highly eutrophic. Using mark-and-recapture approach we have determined that carp populations often exceed 300 lbs per acre in mid-western lakes, a level considered highly damaging. Ageing analysis has also revealed that carp recruitment (survival of young) is often sporadic and spikes only during years when shallow marshy regions winterkill, possibly reducing the influence of predatory game-fish in these spawning areas. Other work shows that carp aggregate in winter or in response to pheromonal cues (Lim et al., this session). Integrated pest management schemes are now being pursued to explore carp control by simultaneously: 1) suppressing recruitment by enhancing predator abundance; 2) removing adult carp by targeting their aggregations, and 3) restricting immigration of carp into lakes by using barriers which exploit sounds and other sensory cues specific to carp. The process is being guided by a population dynamics model. Recent progress and thoughts on this, the first IPM scheme for a teleost fish, will be discussed. (Fund by the Minnesota Environmental Trust Fund, Riley Purgatory Bluff Creek Watershed District, and the Minnesota DNR.)
Testing Relationships Between Ballast Water Discharge Standards and the Establishment Success of Non-Native Species

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During the past century the use of ballast water by commercial ships has inadvertently created a highly efficient, global transfer mechanism for non-native species. In an effort to eliminate ballast water as a viable vector, the US Congress passed and reauthorized legislation in the 1990s that requires vessels to manage their ballast water in one of two ways. Ships are required either to carryout Ballast Water Exchange (BWE) by flushing ballast tanks in the open ocean or to perform Ballast Water Treatment (BWT) by proactive decontamination. There has been no systematic evaluation of the relationships between permissible post-treatment concentration limits (propagule pressure) and the colonization success of non-native species. This project evaluates the quantitative relationship between the size and frequency of founding populations of zooplankton and their colonization success. Experiments will be conducted in land-based mesocosms. Associated surveys of the density and diversity of zooplankton in the Duluth-Superior Harbor will define the natural communities used to seed mesocosms. Coupling the survey results with information on ship traffic and ballast discharge [volume, port of origin] will provide an in-situ test of the relationship between propagule pressure and colonization success of zooplankton in the Duluth-Superior Harbor.
Gypsy moth is soon to become one of the most destructive tree pests established in the state of Minnesota. Early population detections through the Minnesota Department of Agriculture’s Gypsy Moth Survey Program are key in keeping this pest at bay for as long as possible. However these efforts alone are not the only way in which we can keep this pest at bay. Understanding gypsy moth biology and life cycle development of this insect will aid in understanding how it moves and is transported to new locals across our beautiful state. This session will focus on why we should be concerned with this pest, what efforts are currently being conducted to monitor for their populations, and most importantly the biology of the insect and what stages are mostly likely transported to new locals via human activities.
Grassland management goals in Minnesota often include preservation or restoration of the historical native condition and providing habitat for wildlife. As endangered or declining ecosystems, remnants of tallgrass prairie are also intrinsically important to preserve. Remnant and restored prairies in Minnesota are threatened by encroaching invasive species, particularly cool-season introduced grasses and woody vegetation. The main focus of grassland management efforts is on protecting or enhancing the competitive ability of native plants. However, because we typically operate without clear objectives for prairie management and with little or no evaluation of management effects, we could be missing crucial information that would substantially improve our success rate. In 2007, a multi-agency group of grassland managers and scientists developed and tested standardized grassland monitoring methods for western Minnesota. Our goal is to determine broad plant composition and structural changes over time in response to a suite of land management techniques including grazing, burning, and haying. During the pilot season, all remnant prairies sampled (~15 sites) were significantly invaded by non-native species. The most common weeds included smooth brome grass (Bromus inermis), Kentucky bluegrass (Poa pratensis), quack grass (Elymus repens), red top (Agrostis gigantea), and sweet clover (Melilotus sp.). New results from 2008, the first full field season, and management implications will be discussed.
Impacts of Buckthorn and Garlic Mustard and Potential for Biocontrol

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This presentation will provide an overview of impacts and management of European buckthorn, Rhamnus cathartica, and garlic mustard, Alliaria petiolata, two invasive species of forests. The presentation will also provide details of the development and status of biological control for each species.
What is Pest Risk Assessment for Invasive Species?

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Pest risk assessments provide a systematic way to measure and compare the potential harm that exotic species may cause. These assessments are particularly important for potential pests that are not yet in the state and/or country. Assessments for Minnesota rely on several predictions about the likelihood that a species will arrive in a state, survive the winter, thrive during the growing season, and drive (i.e., spread) to new areas. In areas where invasions might be successful, attention turns to predictions of how severe the impacts might be, particularly in economic, environmental, or social terms. These assessments serve several purposes. First, they can help state and federal agencies develop policies to keep unwanted species out of the state or to restrict the movement of species within the state. Second, they can help managers determine which species are the most important to search for. Finally, if pest risk assessments include maps, they can be used to determine where to begin searching. Consequently, pest risk assessments play a strategic role in preventing unwanted species from becoming a problem in Minnesota.
The Mediterranean pine engraver (Orthotomicus erosus) is an exotic bark beetle that is established in California and considered a high risk for the rest of North America. We have been studying this insect under quarantine conditions to determine which North American trees are likely to be attacked and where the beetle might survive the winter. By studying the effect of tree species on larval development and adult behavior, we have found that some Minnesotan conifers, especially pines and spruces, seem likely to be suitable hosts for the beetle. However, other native tree species, such as hemlock, are attractive to adults but do not support larval development. The presence of these attractive non-hosts in the landscape may affect the ability of the beetle to invade. Through simulation models, we have explored how the proportion of attractive hosts, attractive non-hosts, and unattractive non-hosts affect the establishment potential of the beetle. We have also shown that O. erosus is capable of cold acclimation. However, assays of the supercooling points and lower lethal temperatures of cold acclimated O. erosus suggest that the beetle may persist only in extremely sheltered environments in Minnesota, although it might overwinter in other areas of the Midwest. In addition to informing management decisions about O. erosus, this work addresses general questions about invasive species management, including the utility of laboratory studies of a pest insect prior to invasion.
Becker County Weed Management Area

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The purpose of the invasive plant grants is to address the conservation of grasslands by forming a Weed Management Area (WMA) in Becker County. The Pulling Together Initiative and Minnesota Board of Water and Soil Resources Cooperative Weed Management Area Grants are designed to target resources and achieve gains in invasive species management. The Integrated Plant Management treatment area is located within the focus area in Becker County, isolating existing and emerging weed locations and preventing the continued spread into uninfected grasslands. The control of invasive/noxious weeds such as crown vetch (Coronilla varia), leafy spurge (Euphorbia esula), spotted knapweed (Centaurea maculosa), common tansy (Tanacetum vulgare), and wild parsnip (Pastinaca sativa) is through assembling existing data, and begin to gather new data to form an invasive species baseline inventory/GIS spatial dataset, which will be used to measure future success. Many of these treatments will target the successful isolation/possible elimination of emerging weed threats in the County. Public outreach is done to share the results and management of treating invasive sites through field tours, media events, articles, website, pamphlets and township trainings. Two test site areas were treated in the fall of 2007, wild parsnip was one area and spotted knapweed the other area. Through the partnership, data, goals set for the WMA and the achievement of a control area, we will be able to prioritize the management and development of Becker County WMA on a long term basis.
Aquatic Plant Invaders in Minnesota and on the Way

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Aquatic plant invaders in Minnesota include submersed, floating-leaf, and emergent species. Two familiar submersed invasives are Eurasian watermilfoil (*Myriophyllum spicatum*) and curlyleaf pondweed (*Potamogeton crispus*). Both have high rates of vegetative reproduction and begin growth early in spring before many native plants initiate growth. These invaders can produce mats at the water’s surface that interfere with use of lakes. Mats also can displace native submersed plants and alter environmental conditions in lakes. Eurasian watermilfoil is known to have been in the state since 1987 and occurs in a little more than 200 bodies of water. In contrast, curlyleaf pondweed is believed to have first reached the state 100 years ago and occurs in at least 750 lakes. At present, non-native floating-leaf plants are not causing extensive or severe problems in Minnesota. One non-native species that might cause extensive or severe problems, but has not yet been found in Minnesota, is water chestnut (*Trapa natans*). Two familiar invasive emergent plants are purple loosestrife (*Lythrum salicaria*) and hybrid cattail (*Typha x glauca*). Both have been in Minnesota for many years and are widely distributed in the state. Both have high rates of reproduction and can grow abundantly, which enables them to displace native plants. In addition, hybrid cattail can grow in water deeper than that tolerated by native cattail (*Typha latifolia*), which has resulted in significant changes in the vegetation of many wetlands. The ecology and distribution of other invasive aquatic plants will also be discussed.
Comparison of Four Sampling Gears in Detecting Invasive Invertebrates in the Duluth-Superior Harbor

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It is important to conduct non-indigenous species assessments in areas at risk, such as ecosystems associated with Great Lakes harbors, both for the detection of new species and to determine the spread of existing ones. In addition to direct impacts on harbor ecosystems, additional risks are associated with possible establishment of invasives into near by pristine systems, via a number of transport vectors. In conducting surveys to document and detect the possible spread of new and known invasives, it is important to know what kind of sampling gear is effective and efficient at detecting invaders of interest. New invasives, such as New Zealand mud snails, Potamopyrgus antipodarum, and quagga mussels, Dreissena bugensis (which were recently found by our research in the harbor), are prime examples. As part of an invasive species project to develop early detection methodology for at risk harbors throughout the Great Lakes, four distinct gear types were investigated in the collection of benthic samples. Samples collected with petite PONARs, benthic sleds, vegetation sweep nets and Hester-Dendys were compared for their ability to collect invasive invertebrates. Benthic sleds produced more invasive taxa per deployment, and Hester-Dendys collected more invasive individuals per deployment. Results indicate that by using a combination of gears, such as benthic sleds and Hester-Dendys, the probability of collecting invasive invertebrates improves. This abstract does not necessarily reflect EPA policy.
Overview of Invasive Plant Early Detection Program in Minnesota

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An overview of current efforts to find, delimit and evaluate for best management options newly invading plants in Minnesota. MDA is working with county agricultural inspectors and other agencies and groups in MN to find new plant invasions before they become widespread when eradication is still a management option. This report will include current activities to develop a cooperative network for detection and follow-up of reports of new invasive plants and the web-based invasive plant reporting tool currently deployed. There will also be current information on the status of the six early detection weeds that are the focus of our educational efforts and information on occurrence is being requested on including Grecian foxglove delimiting surveys and efforts to locate, delimit, and eradicate cut leaved teasel including eradication and follow-up plans to ensure elimination of this weed from these sites. There will also be some information on what other invasive plants have been sighted in neighboring states.
DNR Watercraft Inspections and Opportunities for Local Prevention Action

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Lake associations and local governments can take advantage of several opportunities to help prevent the spread of aquatic invasive species in Minnesota. Often these activities can be done in partnerships with the Minnesota Department of Natural Resources. Examples of opportunities and activities will be presented, including posting Stop Aquatic Hitchhikers signs provided by the DNR, being trained to do volunteer watercraft inspections at water accesses on your lake, and DNR training of local peace officers for enforcement of state invasive species laws. Participants will also learn how local groups and governments can cooperatively hire watercraft inspectors with the DNR and apply for prevention grants that will be available from the DNR Invasive Species Program in 2009.
The Effects of University of Minnesota Educational Programming on Efforts by Minnesotans to Reduce Invasive Species

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The University of Minnesota has been conducting vegetative invasive species educational programming for several years through Woodland Advisor, Tree Care Advisor, Master Naturalist and Master Gardener trainings and workshops. Through these programs, participants are shown how to identify and control and manage invasive species in their landscapes. The purpose of this survey program (conducted this summer 2008) is to evaluate the effects of educational programming on specie control or management in private and public areas in Minnesota. Invasive species programming in the future relies on effective educational practices and activities that lead to changes in the way people manage invasive species on their own property and/or give leadership to community management programs on public lands. This project will assess the degree to which educational programming has led to practices that reduce invasive species and identify methods of educational programming that have been particularly effective in increasing these practices.
Poster Abstracts
Tracking Gypsy Moth with Technology - The STS Method

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Minnesota has been using GPS to mark Gypsy Moth trap locations since 2001, however with the state entering STS several new options became available. Seven years ago we draw target circles on pre-printed paper maps and data correction was only possible when the field notebooks came into the office at the end of the season. Now we use GIS to produce over 500 field maps, some on water proof paper, with pre-generated target locations which GPS data can be compared against so inconsistencies are brought to our attention within a week of the trap being placed.

Many of the steps in spatially correlating the trap placements to the target database have been automated and the most recent survey data is always available for download from the STS database which is updated three times each day. Additionally, in 2008 Minnesota is deploying over 20 trapper “gadgets” or PDA computers equipped with GPS and running a custom trapping software which virtually eliminates data entry error while streamlining navigation to target sites.
Regulating Gypsy Moth Using GIS Technology

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The daily use of hand held GPS units in the field by seasonal staff is of great value when combined into an active database that is geographically referenced known as a geospatial database. For over 20 years, the Minnesota Department of Agriculture has been sending out 20-50 seasonal staff to set, check and remove gypsy moth traps. These staff members are also asked to document details on any businesses they find that have a high risk of gypsy moth introduction. These high risk sites include nurseries, mills, and campgrounds that may receive traffic or products from states within the federal gypsy moth quarantine. Our goal is to incorporate many sources of information into one geospatial database so that each year our program has the most accurate information on our priority industries' location and business practices. Our program managers and state, federal and private cooperators are able to use the information in this geospatial database to create work plans that focus on specific areas of interest. We are able to show if there is a gypsy moth presence at any high risk industry site and are also able to show if there were moths caught in proximity to the industry’s property. This allows for a more focused effort and more efficient use of available resources to trap and monitor the highest priority sites.
Biological Control of Invasive Plants in Minnesota

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Biological control, the use of natural enemies to control non-native pests, can be an effective tool in managing invasive plants. Non-native plants can become invasive because they lack the insects and diseases that control them in their native environments. Biological control reunites natural enemies, such as herbivores and pathogens, with their host (invasive plant) to reduce impacts caused by the pest. Frequently, this involves the use of specialized insects that were tested extensively for host specificity (safety) and efficacy. The goal of biological control is not to eradicate the invasive plant, but to reduce its impact to an acceptable level. The Minnesota Departments of Agriculture and Natural Resources have implemented successful biological control programs for leafy spurge (Euphorbia esula), spotted knapweed (Centaurea biebersteinii), and purple loosestrife (Lythrum salicaria, L. virgatum, hybrids, and cultivars) statewide. Development of new biological control efforts for garlic mustard (Alliaria petiolata) and buckthorn (Rhamnus cathartica and Frangula alnus) are underway.
A Biological Control Program for Common Tansy (Tanacetum vulgare) in Canada and the United States

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Common tansy (Tanacetum vulgare L., Asteraceae) is an aromatic herbaceous perennial native to Europe, which was introduced into North America as a culinary and medicinal herb. Now widely naturalized in pastures, roadsides, waste places, and riparian areas across Canada and the northern USA, tansy is also spreading in forested areas. It contains several compounds toxic to humans and livestock, such as α-thujone. Tansy reduces the productivity of pastures, displaces native vegetation in natural areas, and can be a problem in regeneration of logged areas. It is listed as a noxious weed in several states and provinces. Common tansy is a good target for biological control, as it is a perennial plant growing in stable habitats, and has few native North American congeners. A biological control program for common tansy is being funded and coordinated by a Canadian-US consortium led by the Alberta Invasive Plants Council and the Minnesota Department of Agriculture. CABI Europe - Switzerland is identifying and testing potential agents for efficacy and host specificity, including the stem-mining weevil Microplontus millefolii, the leaf-feeding beetle Cassida stigmatica, the rhizome-mining moths Isophrictis striatella and Dichrorampha spp., and the root-feeding flea beetle Longitarsus noricus. Several of these species are now in culture at CABI, and preliminary host specificity testing is under way. A test plant list has been developed and is under review by the Canadian Biological Control Review Committee and the US Technical Advisory Group.

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Spiny waterflea surveys have occurred on the Superior National Forest since 2004. In 2004, surveys occurred in Sea Gull Lake and Lac La Croix in the Boundary Waters Canoe Area Wilderness (BWCAW). Spiny waterflea was not detected in either lake. In 2005, surveys occurred in 10 lakes across the Forest. Of the 10 lakes surveyed, spiny waterflea was observed in 4 lakes that were previously identified as infested including Greenwood, Pine, McFarland, and Saganaga. In 2006, surveys occurred in six lakes including Snowbank, Crane, Burntside, Echo, Vermillion, and Sea Gull Lakes. Spiny waterflea was detected for the first time in Crane Lake. In 2007, surveys occurred in Basswood Lake, a border lake between the United States and Canada and within the BWCAW and Quetico Provincial Park. Spiny waterflea was not detected in Basswood Lake in 2007. Recent surveys and monitoring efforts indicate that this species has the potential to spread to additional lakes within the Superior National Forest. There remains a concern that lakes within the BWCAW, including those along the US-Canadian border, may also become infested. Future survey efforts within the BWCAW and Border Lakes Area will be important for identifying and monitoring new invasions and identifying vectors for invasion. Best Management Practices are currently being developed for the Superior National Forest to help reduce the spread of spiny waterflea.
Non-Native Invasive Plant Control in the BWCAW: What Next?

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The Superior National Forest has inventoried high priority sites (old resorts, old cabin sites, old logging camps) in the Boundary Waters Canoe Area Wilderness (BWCAW) for non-native invasive plants (NNIP). In general, the BWCAW has a lower level of infestation relative to the rest of the Superior National Forest. Some NNIP, such as orange hawkweed (Hieracium auranticum) and oxeye daisy (Leucanthemum vulgare) are somewhat common, while other species such as garlic mustard (Alliaria petiolata) or Tatar honeysuckle (Lonicera tatarica) are much less abundant with only one or two known occurrences. In between these two extremes are species like purple loosestrife (Lythrum salicaria) and Canada thistle (Cirsium arvense) with an intermediate number of occurrences. The only treatment method available in the BWCAW currently is hand-pulling, and we have been treating all the sites of all the highest priority species (like purple loosestrife and garlic mustard) annually over the last several years. As we move forward over the next decade, we need to consider alternate treatment methods such as herbicide spraying, and whether there are NNIP that are so widespread that we will no longer attempt to control them. Formulating a weed treatment strategy for the BWCAW will involve a variety of considerations including weed life history, weed abundance, use of the minimum tool to get the job done, and public input.
Toxic Cyanobacteria in Lake St. Croix

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It is well documented that noxious and sometimes toxic cyanobacteria (blue green algae) dominate summer phytoplankton communities in phosphorus enriched lakes. Recently, however the exotic invasive zebra and quagga dreissenid mussels have altered the paradigm that enables water managers to predict cyanobacteria biomass from phosphorus concentrations. In this study, we report on the seasonal dynamics of cyanobacteria in Lake St. Croix, Wisconsin. The goal of this study was to identify environmental factors associated with cyanobacteria dynamics and toxin production in a local waterbody unimpacted by dreissenid mussels. We measured total chlorophyll, cyanobacterial chlorophyll and estimated total cyanobacteria colonies and filaments from microscopic counts. We took samples for total phosphorus and we made measurements in the lab to quantify the photosynthetic capacity of the phytoplankton. To date we observed that total and cyanobacterial chlorophyll and counts increased by an order of magnitude from July to late August 2008. The hepatotoxin, microcystin (within cells and dissolved in the water) was detectable in all samples but highest (> 3 μg L-1) in the late August surface sample which also had the highest concentration of cyanobacterial chlorophyll and cell counts. Photosynthetic capacity was highest when the cyanobacterial biomass was lowest.
Invasive Species-HACCP: A Preventative System to Control the Spread of Terrestrial and Aquatic Invasive Species

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Invasive Species-Hazard Analysis and Critical Control Point (IS-HACCP, pronounced has-sip) is a self-inspection program to help natural resource managers, aquaculturists, wild baitfish harvesters, hatchery operators, fisheries managers, botanists, researchers and conservation officers to prevent the spread of invasive species. Without controls, operations can spread invasive terrestrial and aquatic plants, fish, invertebrates, and pathogens. The public must be assured that natural resource professionals are also doing their part to prevent the spread of invasive species via their operations. Adapted from the seafood industry by the Great Lakes Sea Grant Network, IS-HACCP is a practical approach that focuses on applying controls at critical control points. It provides a risk assessment tool for consistent use of methods, reporting, and verification to ensure compliance. Sea Grant's collaborative HACCP training workshops have results in more than 200 HACCP plans nationwide. The program includes a comprehensive collection of training materials, document templates, forms, worksheets, PowerPoint presentations and training videos – all available on a CD. A new pocket guide, A Field Guide to Fish Invaders of the Great Lakes Region, is available, which compares harmful invasive fish with native look-a-likes. It is intended to assist private and public resource professionals in identifying and reporting invasive fish during harvest, stocking, fishery and law enforcement operations. For more information, visit http://www.seagrant.umn.edu/ais/haccp. Training workshops are available upon request.
Spatial Relationships Between Buckthorn and Earthworms at Fort Snelling State Park, Eagan, MN: A Four Year Study

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Students and teacher from the School of Environmental Studies in Apple Valley, MN, have collected buckthorn and worm data from an old Civilian Conservation Corps site overlooking the Minnesota River on the southern border of Fort Snelling State Park. Data has been gathered for four years. Spatial relationships have been plotted using a geographic information system (GIS). WORMWATCH protocol was used to collect/identify worms and a buckthorn data sheet and protocol from Afton State Park in Minnesota was used to census buckthorn characteristics.
Volunteer Monitors Patrol River Corridors for Invasive Species

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The River Alliance of Wisconsin and the Wisconsin DNR are partnering with local citizen groups to implement a pilot project training canoeist and kayakers to assist in the early detection of four invasive species (Japanese knotweed, common reed grass, Japanese hops, and purple loosestrife) along riverbanks throughout southern Wisconsin. We will share the variety of approaches we have attempted, what we found to be successful or unsuccessful and our future plans.
The Clay County Cooperative Weed Management Area (CCCWMA) is a cooperative effort to compile resources, partners and private landowners to map, treat and stop the spread of current and emerging invasive species in Clay County. The overarching goal for the project is to develop a model of multi-agency and landowner cooperation that can be used throughout Minnesota and the Midwest. Funded in part by the Pulling Together Initiative (PTI), there are twelve partners involved in the project. Specific activities include: 1) Development of a baseline inventory/GIS dataset, 2) Containment and targeted IPM treatments in four township focus areas, 3) Aggressive treatments of emerging weed threats, and 4) Public education/field tours. The CCCWMA is in its early stages, but significant accomplishments include: 1) Sharing of information (e.g., spatial data and maps), 2) Identification of the top five current and four emerging weed threats throughout the county, 3) Successful public education/field tours, and 4) Identification of priority weed/treatment areas in and implementation of treatments throughout the county. Cooperative weed treatments today have included both chemical and biocontrol methods (e.g., sharing of staff for the distribution of flea beetles (Aphthona sp.) for leafy spurge control). The CCCWMA has also realized financial benefits, including: Matching In–Kind Partnership Dollars for both the 2005 Grant ($100,174) and 2006 grant ($177,678) and pesticides from Dow, DuPont, and BASF worth ~$10,148. Further, some of the money listed above has been used to hire an intern to work the summer field season implementing different parts of the project.
Bark beetles (Scolytidae) are among the most destructive pests impacting North American forests. Minnesota is particularly interested in the early detection of exotic bark beetles, because they have the potential to greatly impact the forest resources of the state; according to the 2005 Minnesota Forest Industries figures, Minnesota forest products have an annual value of nearly $7 billion. A detection network consisting of semiochemical-baited Lindgren funnel traps has been established and maintained in pine stands in the northwestern Twin Cities metropolitan area extending to Saint Cloud and also in the greater Duluth area for the past three years. Over stocked pine stands near high-risk introduction sites were set up as trapping locations, and maintained over a seven month period each year. Each trapping location consisted of two bark beetle specific traps along with three additional wood borer traps. Nine species of exotic bark beetles were targeted for the survey. Approximately 40 species of native or established bark beetles were identified. None of the target species were detected, except for the banded elm bark beetle, *Scolytus schevyrewi*, which was already known to occur in Minnesota. This presentation will give a brief overview of the biology and potential impacts exotic bark beetles may have on Minnesota’s forests along with the basic design and implementation of the survey with a comparison of results spanning the three years of data collected.
Variation Among Purple Loosestrife Populations in Response to Biocontrol

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Purple loosestrife (Lythrum salicaria) is an invasive perennial wetland plant introduced to the US in the early 1800’s from southern Europe. Originally introduced through ship ballast and horticultural trade, purple loosestrife is now a prohibited noxious weed in Minnesota. In 1992, a classical biological control program was initiated to control purple loosestrife. As a result of this program, two species of leaf feeding beetles, Galerucella calmariensis and G. pusilla, have established in Minnesota. Variable success has been achieved in wetlands throughout the state with some populations routinely subject to 90-100% defoliation of purple loosestrife and others with little to no observed effect of the biocontrol agents. In this study, three sites were examined that consistently experienced high levels of biological control as well as three sites where agents have failed to establish. Sites were located within the greater Twin Cities metro area and southeastern Minnesota. Beetle number, plant height, branch number, branch length, above ground biomass, leaf tannin levels, inflorescence length and number of flowers were examined to quantify the variation within and between the two classes of wetlands. Additional studies of the evolutionary consequences of the biological control of purple loosestrife and will address the long term sustainability of the program.
Non-Native Invasive Terrestrial Plants Threaten the Woodland Ecosystem of Minnesota's Arrowhead Region

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The spread of non-native invasive plant and animal species is thought to be one of the largest ecological problems we face today. In Minnesota, evidence has shown the impact on our lakes and wetlands due to aquatic invasive species, an impact that has proven to be detrimental to many native aquatic plants and animals. Minnesota forests are facing a similar threat, one that is not receiving as much attention of the public as aquatic invasive species, but one that is of equal importance. Non-native invasive terrestrial plants already established in other areas of the state and along our borders have the capability to encroach and alter our diverse northern woodland ecosystems. This project examines the role recreational trails, secondary roads and highway corridors are playing in the transmission of non-native terrestrial invasive plant species into the northern forests of the Arrowhead Region of Minnesota. A map created using ArcGIS illustrates the locations of five invasive plant species that are threatening forest diversity in the region. Highlighted, along with the areas of known infestation and their proximity to roads or trails, are the native forest communities that are at the highest risk of invasion. Raising public awareness will be an important element to controlling the spread of non-native invasive plant species into the pristine wilderness areas of the Arrowhead region.
What Are the Alien Plants in Minnesota?

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There is no standard complete list of the non-native plants that have been documented outside of cultivation in Minnesota. Any one compilation fails to include some plants or mistakenly includes others. In addition, other non-natives could be growing in Minnesota but have not been documented as such. “Alien” is a category with less room for ambiguity than “invasive”. Alien plants that are not widely known may nevertheless have localized effects or may be in the early phase of a possible range expansion. Knowing about their limited occurrence provides opportunity for eradication, seldom an option for the problem plants that are abundant. I am trying to improve this basic knowledge for Minnesota by combining information sources and critically evaluating them, while at the same time conducting field searches for new alien members of the flora. Typically, a few aliens are documented in the state for the first time each year. Minnesota has several alien plants that have seldom or never been documented outside of cultivation elsewhere in the United States or Canada. A current working list of alien plants is provided.

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The Perpetuation of *Bythotrephes longimanus* in Lakes After Initial Invasion

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There is evidence from oligotrophic North American lakes that the spiny waterflea, (*Bythotrephes longimanus*), has adapted to local habitats through modifying its morphology, phenology, and life history. In this study, core body and caudal spine morphology, life history, and diel vertical migration traits of *Bythotrephes* were compared across a set of nine inland lakes in northern Minnesota, Wisconsin, Michigan (USA) and Lake Superior that ranged widely in trophic state and water clarity. Habitat characteristics were used in combination with estimates of fish species composition to interpret variation in *Bythotrephes* traits. Selection for longer tail spines and a smaller eyespot to body size ratio were consistent with a fish driven mortality hypothesis. Resting eggs and males were produced in most lakes throughout the summer which may be an establishment strategy. Migration amplitude did not differ between lakes of high water clarity and lakes of low water clarity. Evidence suggests that *Bythotrephes* can inhabit a wide variety of lake types in the region. Management of this invasive species should thus consider a wide variety of lake types, particularly glacial scour lakes and reservoirs.
Minnesota: Land of 3,400 (and Counting) Gypsy Moth Males

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Sporadic introductions of the gypsy moth in Minnesota date back to at least 1983 when roughly 340 hectares were treated under gypsy moth eradication programs. However, since 2000, populations have been detected with increasing frequency and at higher densities, especially in St. Louis, Lake, and Cook counties. The total male moth catch in these three counties has increased from 31 in 2000, to 3,111 in 2007, or approximately 88% of the total 2007 statewide trap catch of 3,536. In addition, we have also observed prolonged male moth flight periods that extend from mid July to early October. Some of the variation in peak male moth flight can be explained by year-to-year variability in temperature. However, the within-year length of male moth flight suggests a mix of both locally established populations developing according to local climatic conditions, and immigrating male moths whose phenology corresponds to climatic conditions outside of the Minnesota North Shore. Preliminary data on the characteristics of male moth wings likewise support the notion of a blend of resident and immigrating gypsy moth populations along the North Shore. The prospect of increasing low-density resident populations with immigrating males has critical implications in gypsy moth management because it could enhance mate-location success and consequent establishment success, which tend to be very poor in low-density populations. In this poster, we will present a historical summary of gypsy moth in the North Shore, and our recent data that suggests that the North Shore contains a mix of locally-established and immigrating populations.
Garlic mustard (Alliaria petiolata) is an invasive biennial forb that is native to Europe and has become abundant in forested regions in the US. Garlic mustard can form dense populations in the forest understory and crowd out native species. In anticipation of future releases of garlic mustard biological control agents, a garlic mustard population monitoring program was initiated in Minnesota in 2005. In 2008, a proposal to approve the release of the weevil Ceutorhynchus scrobicollis was submitted to the USDA Technical Advisory Group. Three years of monitoring data from 12 sites show that garlic mustard is currently experiencing very little herbivory in Minnesota and that garlic mustard populations can vary considerably from year to year. Overall, garlic mustard plants had an average of 1.8% of their leaf area removed by herbivores. At about half of the sites, population changes in garlic mustard from year to year are due to the biennial nature of garlic mustard. These sites tend to be dominated by either the 1st or 2nd year plants in any given year. Other sites had more stable or increasing garlic mustard populations. Sites with greater garlic mustard cover had lower native species richness and cover than sites with lower garlic mustard cover. After biological control release, we will be able to determine if garlic mustard is reduced, and if so, whether native species populations recover. Pre-release monitoring is necessary for assessing the success of biocontrol releases.