Proceedings of the Invasive Species Research Strategic Planning Workshop of the Upper Midwest Environmental Sciences Center

U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, Wisconsin 54603

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Executive Summary

Management of the U.S. Geological Survey (USGS) Upper Midwest Environmental Sciences Center (UMESC) launched a research initiative to address growing concerns about aquatic invasive species in the Great Lakes and Mississippi River basins. A draft UMESC Invasive Species Research Strategic Plan was developed by a group of UMESC scientists to help guide Center research. The purpose of this workshop was to present and obtain comments on the draft document, to share UMESC capabilities in this area, to obtain input on the immediate regional research needs on invasive species, and to identify areas of overlap between our Center strategic plan and partner priorities. The workshop was held on June 23, 2004, in La Crosse, Wisconsin, and was attended by 25 participants from Federal, state, and nongovernmental organizations.

During the workshop, participants were oriented to the USGS Invasive Species Program Element, historical and ongoing invasive species research at UMESC, and the draft UMESC Invasive Species Research Strategic Plan. Discussions in breakout sessions led to the development of a list of partner priorities for invasive species research and a thorough analysis of the elements of the draft strategic plan. The relevancy, organization, and utility of the draft UMESC Invasive Species Research Strategic Plan were then discussed in an open forum. The results of this workshop will be used to improve and finalize the UMESC Invasive Species Research Strategic Plan. Sincere thanks go out to the workshop participants who so freely shared their time, thoughtful reflection, and ideas.

Identified Partner Priorities for Invasive Species Research

The top research priorities identified by partners included conducting risk assessments to help prevent new introductions, developing new control methods, assessing impacts of invasive species, preventing new invasions, and developing tools to respond rapidly to new introductions. The need to document the effects of invasive species on habitats and native species in order to justify money spent on control and restoration was mentioned by several groups. The aquatic invasive species of greatest concern were overwhelmingly zebra mussels and Asian carps (bighead and silver carps). Top concerns over these species included preventing their further introduction, establishment and spread, developing control alternatives, management techniques, identifying their ecosystem effects, and understanding their population dynamics.

Strategic Plan Review Breakout Session

Generally, strengths of the draft UMESC Invasive Species Research Strategic Plan identified by participants were assets of the UMESC (e.g., facilities, quantitative and statistical expertise, experience with chemical control, diversity of specializations) and the fact that the plan addressed partner needs. Other than social forces not being in favor of pursuing chemical control and the need to verify models, major weaknesses and blind spots identified were the organization of and language used in the strategic plan. The intention of parts of the strategic plan was misunderstood—language needs to be clearer. The need to better title the plan subsections and to better align section objectives with stated goals was discussed. In addition, there was general agreement that the strategic plan would be better organized using the same sections as in the National Invasive Species Council National Invasive Species Management Plan and State

Management Plans. Timeliness and availability of products and data were seen as a problem with three of the five breakout groups. Some of the identified problems were specific to the bureaucracy within USGS.

Recommendations

*1. Do not lose capacity for chemical control of invasive fishes***.** It was stressed that the UMESC has a reputation for chemical control expertise, is sought to provide technical assistance on this topic, and that this ability should not be lost.

2. Do not lose the ability to conduct regulatory affairs. The importance of having the UMESC, with our unique and extensive experience in regulatory affairs, involved in regulatory aspects of chemical control of invasive species was stressed.

3. Be cognizant of and work to limit bureaucratic time bottlenecks that may affect proposed research when developing strategic plan. Concern over the ability of USGS to 'respond rapidly' and to review and deliver products and data was expressed.

4. Reorganize the strategic plan to mirror management plans developed for invasive species. It was suggested to reorganize the strategic plan in the same manner as similar documents and to remove the primary and secondary research emphases.

5. Focusing on prevention, control, and effects of aquatic invasive species, particularly of zebra mussels and Asian carps is consistent with partner research priorities. These issues were identified as top partner priorities at the workshop.

6. Better define our niche for partners. The specific types of research that the UMESC is capable of conducting should be clearly defined including research methods, taxa studied, and the types of products produced.

7. Improve specificity of language in the strategic plan. Places in the draft plan that were too vague and unclear were identified.

8. Explain how risk assessments can be used for management. It should be made clearer how risk assessments can be to used to guide management decisions.

9. Provide a list of the types of partners that we envision for each section of the plan. This would help potential partners understand how the UMESC envisions potential partnerships.

10. Adopt a 'poster species.' Focusing on one aquatic invasive species, such as bighead or silver carp, would provide a foundation on which to build a reputation for the UMESC.

11. Prioritize research needs to concentrate effort in an area in which the UMESC can make a substantial contribution. Prioritizing research needs will help identify areas in which the UMESC can make the best contribution.

12. Produce a shorter version of the strategic plan for marketing purposes. A fact sheet on the UMESC Invasive Species Research Strategic Plan would be a useful tool for marketing Center capabilities.

13. Plan strategically with other USGS facilities and other governmental agencies. The UMESC should look for opportunities to participate in or to lead strategic planning within and outside USGS.

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Overview of Workshop

In response to concerns about invasive species issues in the Great Lakes and Mississippi River basins, the U.S. Geological Survey's (USGS) Upper Midwest Environmental Sciences Center (UMESC) began an invasive species initiative to better focus Center research efforts on this growing problem. To launch this initiative, Center management assembled a writing team with diverse expertise to draft a strategic plan to help guide Center research on invasive species. Before developing a final document, input was sought from potential partners to determine the relevancy of the proposed research areas identified in the strategic plan. To obtain this valuable partner input, a workshop was held on June 23, 2004, at the Radisson Hotel, in La Crosse, Wisconsin. The workshop was attended by 25 representatives of Federal, state, and nongovernmental organizations and was facilitated by JFK Associates of La Crosse, Wisconsin.

The purpose of the workshop was threefold:

- To present and obtain comments on the draft UMESC Invasive Species Research Strategic Plan and to share our capabilities in this area with workshop participants
- To obtain input on the immediate regional research needs on invasive species
- To identify areas of overlap between our Center strategic plan and partner priorities

Workshop participants were provided with an electronic file of the UMESC Invasive Species Research Strategic Plan and were asked to submit the top three invasive species research priorities before the workshop (Appendix A). Several workshop participants arrived in La Crosse the evening before the workshop to tour the UMESC facilities.

Much of the morning of the workshop was used to educate participants about the USGS Invasive Species Program Element, historical and ongoing research on invasive species at the UMESC, and the recently developed draft UMESC Invasive Species Research Strategic Plan. The remainder of the workshop was spent discussing partner priorities and the draft UMESC Invasive Species Research Strategic Plan in breakout sessions and in an open forum.

After a general introduction to the facility, the agenda, and the purpose of the workshop, all participants introduced themselves to the group. Next, Sharon Gross provided background on the USGS Invasive Species Program Element. Historical and ongoing research on invasive species was then presented by Cindy Kolar, Eileen Kirsch, and Teresa Newton. The last presentation was given by members of the strategic plan writing team (Cindy Kolar, Eileen Kirsch, Mike Boogaard, Kirk Lohman, and Steve Gutreuter). Background on each of the five programmatic areas identified in the plan was presented. All three presentations that were given in the morning are provided in Appendix B.

In the late morning, participants broke into five groups. Each group developed a list of their top three research priorities for invasive species. Participants were provided with the lists of priorities submitted by fellow participants before the workshop to begin discussion (provided in Appendix C). Each group presented their priorities to the group (Appendix D).

In the afternoon, participants again divided into the same breakout groups. Each group was assigned one programmatic area of the strategic plan to assess for strengths, weaknesses, blind

spots, and unanswered questions. After discussion, groups reported their analyses to the rest of the workshop participants.

The last portion of the workshop consisted of an open forum discussion on the relevancy, appropriateness, and organization of the draft UMESC Invasive Species Research Strategic Plan (see Appendix E for notes from this discussion). Throughout the day, ideas were freely exchanged with much useful discussion of invasive species research priorities and the new research initiative at UMESC. Impressions of the workshop from the facilitator can be found in Appendix F.

The results of this workshop will be used to improve and finalize the UMESC Invasive Species Research Strategic Plan. Sincere thanks go out to the workshop participants who so freely shared their time, thoughtful reflection, and ideas. A list of participants and their contact information can be found in Appendix G.

Summaries of Background Presentations

Handouts of the presentation are provided in Appendix B.

U.S. Geological Survey's Invasive Species Program Element
Sharon Gross, Assistant Invasive Species Program Element Coordinator

The Invasive Species Program is one of six program elements in the Biological Resources Discipline of the USGS. The USGS scientists are currently conducting research on invasive species on a variety of taxa and ecosystems. USGS collaborators with more than 120 partners to provide essential support for the National Invasive Species Management Plan. We are also finishing a 5-year strategic plan for implementing the Invasive Species Program to guide project planning, to define science needs, and determine priorities. More than 80 scientists are working at 13 Science Centers around the country on invasive species issues in the USGS. The budget of the Program Element has increased from around $3 million to $10 million in 8 years and the President's 2005 budget calls for a $700K increase to the program. Taxonomically, USGS scientists conduct research predominantly on plants and fishes.

The USGS Invasive Species Program has six focus areas: prevention, early detection and rapid response, monitoring and prediction, effects, control and management, and information systems. The goal of prevention is to conduct research and develop methods and technologies to prevent the introduction of invasive species. Work in this area has focused on assessing treatment technologies for ballast water and to support its regulation. The goal of early detection and rapid response is to identify and report new invaders and assess risks to natural areas and waters. The USGS activities have centered on facilitating the National Early Warning/Rapid Response Strategy and providing information and technical assistance in response to new invaders (e.g., snakeheads, giant salvinia). The goal of monitoring and prediction is to assess changes in populations and distributions of established invaders. Research within USGS on monitoring has included development of multi-scale 'smart monitoring' to maximize efficiency while collecting high quality data, developing models of vulnerable habitats, and examining the utility of remote sensing for monitoring invasive species. The goal of control and management is to provide

approaches to contain, reduce, and eliminate populations of invasive species and restore habitats and native species. Examples of USGS activities in this area include facilitating control of sea lamprey in the Great Lakes, tamarisk in western riparian zones, and nutria in Maryland and Louisiana. The goal of the effects program element is to determine the effects of invasive species and susceptibility of habitats to invasion. Research conducted in this program element by USGS scientists is diverse and is on priority species identified by managers. Lastly, the goal of information management is to provide and coordinate the collection, synthesis, and accessibility of invasive species information. The USGS continues to work to develop information standards and technologies, update and grow the Non-indigenous Aquatic Species Database, and further develop the invasive species information node.

The USGS Invasive Species Program is now developing a National Institute for Invasive Species Science which is a virtual organization linking USGS programs, cooperators, and customers interested in invasive species issues. This virtual network will be a think tank for emerging invasive species issues and will provide technical assistance and decision support for resource managers. This virtual institute is based at the USGS Fort Collins Research Center, Colorado.

Research priorities for the USGS Invasive Species Program in FY 2005, as specified in the President's budget, are twofold. The first emphasis is to develop innovative control strategies for species such as Asian carps in the Mississippi River, the Great Lakes, and the southeastern United States. The second emphasis is to provide more technical assistance to the brown tree snake control program. Other near-term opportunities include examining invasions in inland waters, partnership with U.S. Department of Agriculture on plant pests and diseases in natural systems, applications of molecular and genetic technologies, predicting new invaders for priority action, developing early detection methods and rapid assessment of new invaders, multi-scale monitoring and forecasting of incipient and established invaders, and development of adaptive management strategies for established invaders in complex landscapes.

Historic and Ongoing Research on Invasive Species at the UMESC
Cindy Kolar, Eileen Kirsch, and Teresa Newton

The UMESC has a long history of invasive species research that has led to more than 170 research publications. The chemical control of invasive fishes was fundamental to the initial mission of the laboratory. After early research on the control of several carp and other nuisance fishes, scientists at the Center became involved in the Sea Lamprey Control Program of the Great Lakes Fishery Commission (GLFC). Scientists at the Center cooperated with others to develop and register the lampricides TFM and Bayluscide that are still used as the primary means of managing sea lamprey populations in the Great Lakes. Involvement with the GLFC has since focused on refining lampricide application techniques and formulation development, minimizing impacts to non-target species, acting as the regulatory agent for the registration of the lampricides with U.S. Environmental Protection Agency (USEPA) and Health Canada, and to begin developing data on sea lamprey attractant pheromones for submission to the USEPA for registration. As a result of new invasions and range expansions of invasive species in the Great Lakes and Mississippi River basins, the UMESC expanded its success with sea lamprey and focused its chemical control talents on new Great Lakes invasive species. In 2002, the UMESC

partnered with the Bureau of Reclamation to assess integrated strategies to control invasive fishes in the southwestern United States.

In response to the zebra mussel invasion of the Upper Mississippi River System (UMRS), UMESC scientists also examined food-web effects of zebra mussels on native fishes and birds, their ability to bioaccumulate toxins, and ways to minimize the likelihood of introducing zebra mussels concurrent with native mussel conservation activities. The effect of reed canary grass on arthropods and bird territory placement in riparian wet meadows has also been examined. Also, since the 1990s, the Long Term Resource Monitoring Program (LTRMP) for the UMRS, under the guidance of the UMESC, has documented the introduction and expansion of bighead and silver carps and other fishes, such as white perch, in the system. Current invasive species research at the UMESC includes an analysis of fish introductions in the UMRS since the early 1900s, biological synopsis and risk assessment of the bigheaded carps (Genus *Hypophthalmichthys*) in the United States, and a risk assessment of zebra mussels on native unionid populations in the UMRS. Research will soon begin on the toxicity of piscicides to Asian carps and on potential competition between Asian carps and native fishes.

Invasive Species Research Strategic Plan for the Upper Midwest Environmental Sciences Center

Cindy Kolar, Mike Boogaard, Steve Gutreuter, Eileen Kirsch, Kirk Lohman (and Verdel Dawson and Brian Ickes, *in absentia*)

Management at the UMESC decided to pursue an invasive species initiative because of our historical and ongoing research on invasive species, growing concerns over invasive species in the region, and the proximity of UMESC to the Great Lakes and the Mississippi River—two highly invaded ecosystems. The purpose of the strategic plan is to assess proposals for 'base' funding, encourage proposals for USGS cyclical funding, focus Center activities in regional and national invasive species planning and advisory activities, and to enhance science leadership in current partnerships. In addition, the plan can be provided to potential partners as a marketing device to share UMESC science capabilities. The guiding vision for plan development was to ensure that UMESC will play a vital and cohesive role in the USGS to advance the prevention and management of aquatic invasive species by building on Center strengths, developing and growing current partnerships, and applying our collective talents to provide high quality management tools and scientific products. Among the assets at the UMESC to apply to invasive species research are experience, scientists with diverse specializations, strengths in geospatial, landscape, decision support tool development, risk assessment, quantitative expertise, extensive facilities and infrastructure to conduct field and laboratory studies, and existing partnerships.

The strategic plan is divided into five programmatic areas. Two of which, risk assessment and ecological forecasting and ecology of invasive species, are identified as primary areas of research emphasis. These are areas in which UMESC scientists would actively develop a program and submit proposals to begin work. Three secondary areas of research emphasis are also presented, science support for rapid response, monitoring of invasive species, and the science of management of invasive species and ecological restoration of native habitats and taxa. These are areas in which UMESC has capability and areas in which our expertise has historically been sought by partners.

The goal of the risk assessment and ecological forecasting emphasis area would be to develop high quality and practical tools for use by decision makers to prevent and manage invasive species. Examples of research that might be conducted in this area include determining the potential of an invader to spread to new areas, determining when rapid response should occur after an invasive species is detected early, determining areas or habitats vulnerable to invasion, and modeling the spread of a species through an ecosystem.

The goal of the ecology of invasive species emphasis area would be to identify the effects of harmful invasive species on native ecosystems and their components. Examples of research that might be conducted in this area include identifying stages or areas that are more vulnerable to control, determining life history and habitat requirements of invasive species, quantifying the effect of invasive species on energy pathways, and assessing direct and indirect effects of invasive species on native species and habitats.

The goal of the science support for rapid response emphasis area would be to use current expertise at UMESC to provide science support for partners to control newly established or currently established aquatic invasive species in range expansion. Examples of research that might be conducted in this area include producing a manuscript on the current state of knowledge of chemical control, integrating geospatial and chemical control expertise to aid in rapid response plan development, and providing expertise in developing rapid response plans.

The goal of the monitoring of invasive species emphasis area would be to develop a better understanding of the spread of aquatic invasive species and refine methods for monitoring expanding populations for implementation by partners. Examples of research that might be conducted in this emphasis area include developing sound monitoring techniques to provide multi-scale data optimizing human resources, developing methods to assess populations of bighead and silver carps and round goby, synthesizing existing LTRMP data sources for information on invasive species within the UMRS, and integrating historical records, remote sensing data, and field sampling in Geographic Information Systems to document spatial and temporal spread patterns at landscape and regional scales.

Finally, the goal of the science of management of invasive species and ecological restoration of native habitats and taxa emphasis area would be to work with partners to study and evaluate alternatives for restoration and management of native species and ecosystem functions. Examples of research that might be conducted in this emphasis area include identifying sites and processes in most need of restoration, developing adaptive management frameworks for restoring native species in the face of invaders, developing protocols for rapid response for preventing expansion and restoring native habitats and ecosystems, developing new control methodologies, and providing technical assistance to other agencies.

In addition to the many assets that the UMESC has that can be applied to invasive species research, rearrangement of analytical and wet laboratory space will allow development of a new aquatic invasive species containment and experimental complex at the UMESC. The complex will consist of three wet laboratories and two analytical laboratories. Animals brought into the facility will not need to leave the complex because the wet laboratories are all adjacent. Biosecurity will be further enhanced by the purchase of a variety of recirculating tank systems.

Overview of Breakout Sessions

Two breakout sessions were facilitated during the workshop. For each, workshop participants were divided into five groups. Although group membership was determined by participants, UMESC scientists were spread throughout all groups to ensure that UMESC priorities and views did not overwhelm any one group. The goal of the first breakout session was for each group to develop a list of the three top invasive species research priorities perceived by the group. Before discussion, everyone was provided with the material sent by workshop participants before the workshop. The goal of the second breakout session was for each group to assess the UMESC draft Invasive Species Research Strategic Plan. For this exercise, each group was assigned one of the five programmatic areas of the strategic plan to evaluate the section for strengths, weaknesses, barriers to success, and unanswered questions. Each group was also asked to provide comments on other portions of the strategic plan if time allowed. Group membership was the same between the two breakout sessions. Groups were given more than 30 minutes for the first exercise and more than an hour for the second exercise to develop consensus on the issues. After that time, groups reported their issues and views to the whole workshop. Items written on flip charts by each group for both breakout sessions can be found in Appendix D.

Partner Priorities Breakout Session

Table 1 shows a summary of the invasive species research priorities identified by partners before and during the workshop. Most of the priorities identified were either action-focused in that they focused on processes or actions, or species-focused in that they identified a particular invasive species of concern. The priorities of some individuals and agencies may be represented twice if they were submitted before the workshop and were brought forward as the top priorities of a breakout group during the workshop.

The top research priorities identified by partners included conducting risk assessments to help prevent new introductions, developing new control methods, assessing impacts of invasive species, preventing new invasions, and developing tools to respond rapidly to new introductions (Table 1). Most of the action-based priorities identified before and during the workshop were similar, but submissions before the workshop included more focus on prevention, whereas during the workshop, the need for developing tools to respond rapidly was stressed. The need to document the effects of invasive species on habitats and native species to justify money spent on control and restoration was mentioned by several groups. The need to conduct risk assessments and to develop new methods for species screening to prevent new introductions was the most discussed research priority for invasive species.

The top species-focused priority identified by partners were overwhelmingly zebra mussels and Asian carps (bighead and silver carp). Together these species were cited 21 times by participants before and during the workshop (Table 1). Top concerns over these species included preventing their further introduction, establishment, and spread, developing control alternatives, developing management techniques, identifying their ecosystem effects, and understanding their population dynamics.

Table 1. Summary of invasive species research priorities identified by partners before and during the workshop. Priorities are grouped as being action-focused, species-focused, or other. Complete responses from submissions before the workshop and during breakout groups can be found in Appendixes C and D). AIS = aquatic invasive species

Partner priority	Before workshop	At workshop	Total responses
Action-Focused Priorities			
Risk assessments with the aim of prevention	4	4	8
New control methods (including barriers)	3	3	6
Assessing impacts of AIS (including to support restoration)	2	3	5
Prevention (introduction, establishment, species exchange)	6	0	6
Tool development for responding rapidly to new invasions	0	4	4
Restoration	2	1	3
Integrated Pest Management strategy development	0	2	2
Early detection	1	1	2
Monitoring	1	0	1
Ecology—understanding invasions better	1	0	1
Eradication tool development	1	0	1
Economic assessments of AIS	1	0	1
Species-Focused Priorities			
Zebra mussels (prevent introduction, spread, management, population dynamics)	9	2	11
Asian carps (prevent introduction, spread, effects, control)	8	2	10
Round goby (spread, distribution)	1	1	2
Eurasian water milfoil (spread)	2	0	2
Hydrilla	0	1	1
Earthworms	0	1	1
Smooth cord grass	1	0	1
Purple loosestrife	1	0	1
Salt cedar	1	0	1
Other Focus Priorities			
Leveraging resources to maximize efficiency	1	0	1
Evaluating effectiveness of AIS education, monitoring, prevention, and control programs	1	0	1

Strategic Plan Review Breakout Session

Table 2 provides a summary of the strategic plan review conducted by workshop participants during the second breakout session. Generally, strengths of the draft UMESC Invasive Species Research Strategic Plan identified were assets of the UMESC (e.g., facilities, quantitative and statistical expertise, experience with chemical control, diversity of specializations) and the plan addressed partner needs. Other than social forces not being in favor of pursuing chemical control and the need to verify models, major weaknesses and blind spots identified were the organization of and language used in the strategic plan. Through discussion it became obvious that some groups had misunderstood the intention of the monitoring (4^{th} section of plan) and restoration (5^{th} section of plan) sections of the draft UMESC Invasive Species Research Strategic Plan because of vague language. In both of these cases, some workshop participants thought that the UMESC was proposing to conduct monitoring for invasive species and restoration of native habitats and taxa instead of developing methods and protocols for other agencies to carry out the field work.

The need to better title the plan subsections and to better align section objectives with stated goals was discussed. It was suggested that the last section of the plan, on restoration, be split into two different research areas. In addition, there was general agreement that the strategic plan would be better organized using the same sections as the National Invasive Species Council National Invasive Species Management Plan and state plans. Timeliness and availability of products and data were seen as a problem with three of the five breakout groups. Some of the identified problems were specific to the bureaucratic culture within USGS.

Overall, there seemed to be the impression from the group that the types of research proposed in the draft document were mostly aligned with partner needs and priorities with the caveats identified in the weaknesses and blind spots.

Table 2. Summary of group review of the draft Upper Midwest Environmental Sciences Center (UMESC) Invasive Species Research Strategic Plan.

Section of plan	Strengths	Weaknesses	Blind Spots
Risk Assessment and Ecological Forecasting	(1) Much need for the work; (2) Local expertise and partners; (3) Long Term Resource Monitoring Program (LTRMP) database	Identified problems with language in the draft document in a variety of places	Models and risk assessments should be verifiable
Ecology of Invasive Species	(1) UMESC assets (e.g., Geographic Information Systems, statistics, facilities); (2) Partnerships; (3) Public support	(1) High cost; (2) Need for more field sites; (3) Slow turn around time	(1) Overhead rate may restrict options; (2) Limited personnel available; (3) Competition within U.S. Geological Survey (USGS)
Science Support for Rapid Response	(1) Unique UMESC assets (e.g., expertise in chemical control and regulatory permits, facilities); (2) Current partnerships	(1) Needs to be rapid; (2) Limited number of chemicals; (3) Review time lags in USGS	(1) Social forces may not support; (2) Regulatory permitting problems may prohibit use of plan
Monitoring of Invasive Species	(1) Complements LTRMP	(1) Monitoring should be hypothesis-driven; (2) Expensive	(1) Lag in getting data out; (2) Real-time data needs—USGS Water Resources Discipline as model
Science of Management of Invasive Species and Ecological Restoration of Native Habitats and Taxa	(1) Biological and chemical control; (2) Technical assistance	(1) Suggested changes to organization of document; (2) Change to adaptive management approach	(1) Identified problems with language in the draft document; (2) Suggested splitting section into two

Recommendations from the Workshop and Responses for the UMESC

Below is a list of recommendations that was developed from breakout session group reports, general discussion, and on comments by workshop participants. After each recommendation is an explanation of how the draft UMESC Invasive Species Research Strategic Plan will incorporate it into the final document. If no change will be made, rationale for why the recommendation will not be followed is provided.

1. Do not lose capacity for chemical control of invasive fishes. Concern was expressed over UMESC losing its emphasis on chemical control of aquatic invasive species (fish in particular). Several participants stressed that the UMESC has a reputation for chemical control expertise and is sought to provide technical assistance and research on this topic. The UMESC scientists responded by pointing out that chemical control is part of several programmatic areas in the draft document and that was not given primary emphasis because of concern over a lack of funding and lack of public support for this type of research. Peter Sorensen, in particular, urged reorganization of strategic plan such that chemical control was of primary emphasis. He said that with overseas interest in developing piscicides, funding might not be as static as previously believed.

UMESC: Agreed. An objective in the revised strategic plan will clearly state that the UMESC should maintain and demonstrate capabilities in regard to chemical control of invasive fishes. We believe that the UMESC must consider carefully the type of chemical control studies initiated in the future. Chemical control research at the UMESC should focus on meeting the needs of the Great Lakes Fishery Commission, development of new piscicides (if funding opportunities become available), and should address particular partner needs (e.g., for developing rapid response or other management plans). The UMESC should be careful not to concentrate research efforts figuring out which chemicals, in what strengths, kill organisms, ad infinitum. *Changing political and social pressures against the use of chemicals in the environment is a concern (i.e., the UMESC should not specialize in a defunct technology) and this will be clearly stated in the revised document.*

2. Do not lose the ability to conduct regulatory affairs. The importance of having a governmental agency involved in regulatory affairs for chemical control of invasive species was discussed. There is and will continue to be a role for the UMESC in this area because of the UMESC's unique skill set in this regard. For example, UMESC should maintain their current role in registering pheromones (sea lamprey and others) for use in controlling aquatic invasive species.

UMESC: Agreed. A discussion of the regulatory affairs work that UMESC staff does to support the Great Lakes Fishery Sea Lamprey Control Program will be provided in a new appendix of the revised document. In addition, a bulleted point on regulatory affairs will be added to one of the objectives.

3. Be cognizant of and work to limit bureaucratic time bottlenecks that may affect proposed research when developing strategic plan. Concern over the ability of USGS to 'respond rapidly' to emergent situations was expressed. Similarly, the timely delivery of

products, time lags because of USGS product review policies, and availability of data was discussed.

UMESC: Agreed. Although the strategic plan does not call for 'responding rapidly' to a new invasion (i.e., the rapid response action would be carried out by a partner or client and is beyond the scope of work at the UMESC), time sensitivity is important for many invasive species issues. Government bureaucracies can work to slow time needed to deliver products and services. A bulleted point will be added to the recommendations list that suggests examining whether it is possible to develop ways to streamline product delivery on timely issues while remaining in compliance with Department of the Interior, USGS, Biological Resources Discipline, and UMESC policies. This limitation, however, is largely beyond the scope of the UMESC Invasive Species Research Strategic Plan.

4. Reorganize the strategic plan to mirror the organization of management plans developed for invasive species. It was generally agreed that the UMESC Invasive Species Research Strategic Plan should either be organized into the same subsections as the National and State Invasive Species Management Plans, or use those of the USGS Invasive Species Program Element Five-Year Strategic Plan (Prevention, Early Detection and Rapid Response, Monitoring and Forecasting, Effects, Control and Management, and Information Management). Regardless of the decided upon reorganization of the strategic plan, it was suggested that subdividing the plan into primary and secondary areas of research emphasis was not helpful.

UMESC: Agreed. The revised strategic plan will be reorganized using the Program Goals of the USGS Invasive Species Program Element Five-Year Strategic Plan.

5. Focusing on prevention, control and effects of aquatic invasive species, particularly of zebra mussels and Asian carps, is consistent with partner research priorities. These issues were identified as top partner priorities at the workshop. Prevention priorities included risk assessments to identify invasive species, invasible habitats, and prevention of further introduction, establishment, and spread of invasive species. The dire need for new control methodologies was a recurring theme throughout the workshop. Also identified as important was the need to document effects of invasive species to justify costs associated with control and restoration.

UMESC: Partner priorities identified during the workshop were similar to those that were provided to the Mississippi River Basin Panel on Aquatic Nuisance Species and overall were not a surprise to those developing the strategic plan. Prevention, control, and effects of aquatic invasive species will be the focus of the revised document.

6. Better define our niche for partners. After reading the UMESC Invasive Species Research Strategic Plan, potential partners should be left with a clear indication of UMESC research capabilities and expertise. The specific types of research that the UMESC is capable of conducting should be obvious in terms of research methods, taxa studied, and the types of products produced.

UMESC: Agreed. Throughout the document it will be made clear that the UMESC has an aquatics focus and that those are the taxa with which we want to work primarily with in the near future. In addition, a few sentences will be added that specify the UMESC's current expertise as being in aquatic invasive animals.

7. Improve specificity of language in the strategic plan. Places were identified in the draft plan that were too vague and unclear. Language in the programmatic objectives, for instance, needs to be bounded by the associated programmatic goal. Throughout the document, it should be made clearer whether all invasive species or just aquatic invasive species are being addressed.

UMESC: Agreed. This recommendation is quite similar to the one above (6). The taxa that the UMESC is currently most qualified to address will be better identified throughout the plan. In addition, the phrasings of the goal statements will be more in-line with the objectives falling under them. Generally, the language of the strategic plan will be clarified and made more relevant to the UMESC.

8. Explain how risk assessments can be used for management. Risk assessments are useful for management purposes but do not have a long history of such use. It should be clear from the language of the strategic plan how risk assessments can be used to guide management decisions.

UMESC: This concern seems to be largely beyond the scope of the invasive species strategic plan. A couple of sentences, however, will be modified to better clarify the meaning and applicability of risk assessments and decision support.

9. Provide a list of the types of partners that we envision for each section of the plan. It would be helpful for potential partners reading the document to see a list of potential partners under each section of the strategic plan to better indicate how the UMESC envisions potential partnerships.

UMESC: This information was already provided in the strategic plan but will be better highlighted.

10. Adopt a 'poster species.' Adoption of one aquatic invasive species, such as bighead or silver carp, would help to focus research efforts at UMESC and provide a foundation on which to build a reputation. A UMESC poster invasive species could also be used as a marketing device.

UMESC: We agree that this idea has merit. The purpose of the strategic plan, however, is to identify strategic research directions that could be pursued for the next 5-10 years. Perhaps a poster species would be appropriate at the next level of planning—development of study plans.

11. Prioritize research needs to concentrate effort in an area in which the UMESC can make a substantial contribution. The outlook for funding in the next several years is bleak for environmental issues. Even with a hot topic like invasive species, it is difficult to be optimistic. The UMESC would be best served by developing a strategic plan that focuses on existing resources and personnel. Prioritizing research needs will help to identify areas in which the UMESC can make the best contribution.

UMESC: Agreed. The strategic plan identifies a broad diversity of potential research areas that could be pursued. In order for the UMESC to make strides in aquatic invasive species, and to grow a regional and national reputation in that arena, given the currently small size of the program, efforts must be concentrated into one or two areas. A new section will be added to the revised document that will identify highest priority areas of research.

12. Produce a shorter version of the strategic plan for marketing purposes. A fact sheet on the UMESC Invasive Species Research Strategic Plan would be a useful tool for marketing Center capabilities. This product should be less technical in nature, concise, and made widely available.

UMESC: Agreed. A fact sheet will immediately be developed based on the final document for educating USGS and external partners and clients about the UMESCs invasive species initiative.

13. Acknowledge the need to plan strategically not only within UMESC but also with other USGS facilities and governmental agencies. Although the need for strategic planning in the UMESC is imperative for guiding research at the Center, so is coordination with other USGS facilities and other research entities to ensure leveraging of resources and to eliminate duplicative efforts. The UMESC should look for opportunities to participate in or to lead strategic planning within and outside USGS.

UMESC: Agreed. The need to plan strategically within the Great Lakes and Mississippi River basins in addition to across USGS and even DOI partners regarding aquatic invasive species issues is recognized. The UMESC will take steps to plan strategically with the Columbia Environmental Research Center in Columbia, Missouri, regarding Asian carp research issues. The UMESC will look for other opportunities to participate in and become integrated into larger strategic planning exercises. A recommendation will be edited to this effect in the revised document.

APPENDIX A. Draft Invasive Species Research Strategic Plan for the Upper Midwest Environmental Sciences Center

Draft Invasive Species Research Strategic Plan for the Upper Midwest Environmental Sciences Center[1]

May 2004

The Context

Most nonindigenous species established outside their native range do not cause observable changes in the invaded ecosystem, but a proportionately small number are perceived as a nuisance (Williamson 1996). These invasive species are economically costly (Pimentel et al., 1999, estimated this cost to be $137 billion annually in the United States alone), negatively affect human health (e.g., West Nile virus, malaria, Cholera), and have significant negative environmental effects (e.g., zebra mussels *Dreissena polymorpha*, leafy spurge *Euphorbia esula*, and kudzu *Pueraria montana* var. *lobata*). Each year thousands of species from microbes to mammals are intentionally or accidentally introduced into the United States (Ludke et al. 2002). The introduction and spread of invasive species are perhaps the least reversible human-induced global changes under way (Kolar and Lodge 2002).

Definition of terms (modified from Executive Order 13112)

Nonindigenous (or non-native, or alien) species
With respect to a given ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem

Invasive species
An invasive species is a nonindigenous species whose introduction does or is likely to cause economic or environmental harm or harm to human health

As the primary research agency within the Department of the Interior, the U.S. Geological Survey (USGS) fills an important niche in Federal efforts to combat invasive species in natural and semi-natural areas. The USGS Invasive Species Program Element supports cooperative efforts to document and monitor the introduction and spread of invasive species, study the ecology of invaders and factors in the resistance of habitats to invasion, forecast probabilities and locations of future invasions, and develop methods for minimizing their effects (USGS 2003). The Invasive Species Program Element is developing a virtual National Institute for Invasive Species Science that will include research conducted at other Science Centers in conjunction with the new National Institute for Invasive Species Science facility in Fort Collins, Colorado. In the future, the USGS Invasive Species Program Element will focus on developing predictive understanding of the relationships between invasive species and environmental drivers (e.g., extreme natural events and changes in physical disturbance regimes, climate, physicochemical pollution, and atmospheric conditions) operating at many spatial and temporal scales (USGS 2003).

The USGS Upper Midwest Environmental Sciences Center (UMESC), in La Crosse, Wisconsin, is close to two major North American watersheds that have been highly invaded by aquatic and wetland nonindigenous species, the Great Lakes and Mississippi River Basins (Figure 1). More than 160 nonindigenous aquatic species have arrived via an array of introduction vectors and a variety of physical pathways to become established in each of these ecosystems (Rasmussen 1998; NCRAIS 2004; USGS 2004). Ninety known aquatic and wetland nonindigenous species have been introduced into the Upper Mississippi River System (UMRS) alone (USGS 2004). Recent invaders to the Upper and Middle Mississippi River that have either become very abundant, have threatened native endangered species (e.g., the Higgins' eye pearly mussel, *Lampsilis higginsii*, and winged mapleleaf, *Quadrula fragosa*), or have otherwise negatively altered the ecosystem include the zebra mussel, bighead carp (*Hypophthalmichthys*

[1] This is a draft document that will receive review by participants of a workshop of potential partners that will take place on June 23, 2004. The final document will incorporate perspectives and priorities of workshop participants.

nobilis), silver carp (*H. molitrix*), purple loosestrife (*Lythrum salicaria*), and reed canary grass (*Phalaris arundinacea*). Negative effects from historical invasions of the ecosystem, such as declines in native submersed plants and buffalo fishes caused by common carp (*Cyprinus carpio*), are only now beginning to be understood (Bellrichard 1994). Since the sea lamprey (*Petromyzon marinus*) invaded the Great Lakes in the 1940s, invasive species have shaped and defined the ecology of that ecosystem. The rate of invasion continues to increase in the Great Lakes, even after the institution of mid-water ballast water exchange regulations (Holeck et al. in review). The importance of artificial connecting waterways as corridors for species movement has been highlighted recently since several invasive species (e.g., the zebra mussel and white perch *Morone americana*) have used the Illinois Inland Waterway (IIWW) to spread from the Great Lakes to the Mississippi River Basin and several others (e.g., bighead and silver carps) are poised to spread to the Great Lakes from the other direction. The UMESC is particularly well-positioned to conduct research on aquatic invasive species within the UMRS, the Great Lakes, and the IIWW that artificially connects the two basins.

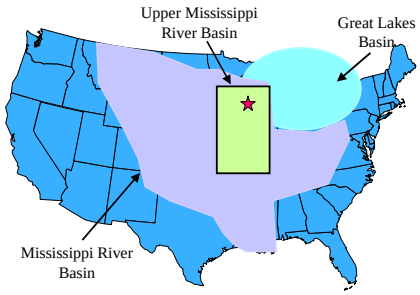

Figure 1. Location on the landscape of the Upper Midwest Environmental Sciences Center (indicated with a star).

The Stage

Research on aquatic invasive species has been an important and productive part of the research program at the UMESC since the inception of the facility in the 1950s and has resulted in over 170 publications (Attachment 1). The vast majority of this research effort has focused on the Effect Stage of the invasion process (after the species becomes established and has negatively affected the invaded ecosystem; Figure 2)—more specifically on the chemical control of invasive fishes. Early efforts to develop chemical control for common carp and other nuisance fishes expanded in the 1960s to a monumental and highly successful effort to control the invasive sea lamprey in the Great Lakes. These two efforts, in cooperation with the Great Lakes Fishery Commission (GLFC), constituted the Center's major research emphasis on invasive species through the early 1990s. After that time, the UMESC extended its chemical control talents to newly established nonindigenous species in the Great Lakes (e.g., Boogaard et al. 1996), and recently, to the use of taxon-specific chemicals and more integrated control of invasive fishes in the southwestern United States (Dawson and Kolar 2004). Other research efforts at the UMESC have examined the effects of invasive species such as zebra mussels and reed canary grass on the UMRS (Attachment 1). Scientists at the UMESC have also conducted more limited research at other stages of the invasion process (Figure 2). For example, UMESC scientists have developed models to predict potential fish invaders in the Great Lakes (Introduction Stage; Kolar and Lodge 2002) and have been involved in the early detection and monitoring of invasive species in the UMRS (Establishment Stage; USGS 1999). The Long-Term Resource Monitoring Program (LTRMP) for the UMRS, under the guidance of the UMESC, for example, documented the introduction and expansion of bighead and silver carps in the UMRS. See Attachment 2 for a more thorough discussion of the history of invasive species research at the UMESC. Although research on aquatic invasive species at the UMESC has been productive, it has become more responsive and less strategic over time.

The purpose of this document is to lay out strategic research directions on invasive species at the UMESC to help Center Management to (1) assess new proposals for "base-funded" research, (2) encourage proposals for cyclical USGS funding, (3) focus Center activities in regional or national invasive species planning and advisory activities, and (4) enhance science leadership within existing partnerships (e.g., GLFC, LTRMP) related to impacts or control of invasive species.

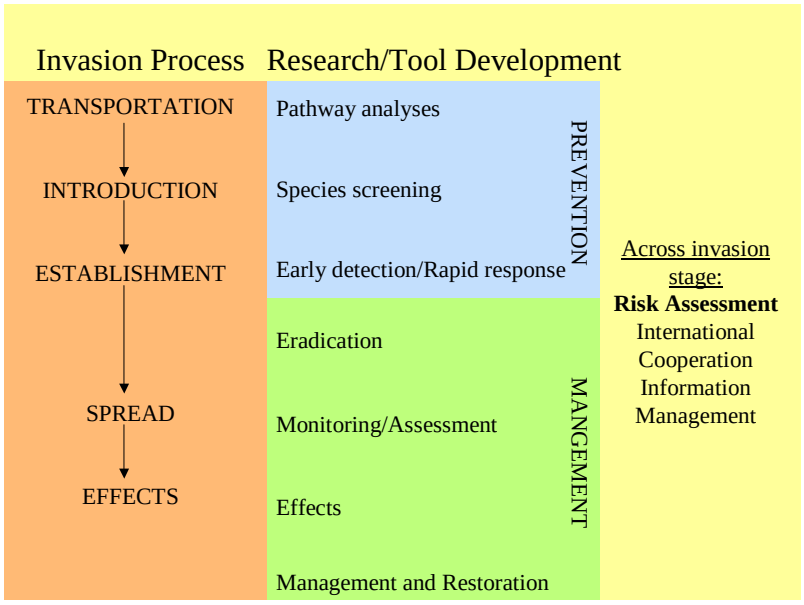

Figure 2. Stages of the invasion process (orange) with the associated research and tool development needs for the prevention (blue) and management (green) of invasive species. Risk assessments, international cooperation, and information management are needed across all invasion stages.

The UMESC has made substantial contributions toward the better understanding of the prevention and control of aquatic invasive species. The culmination of a variety of factors will ensure that the UMESC will be well positioned to become a more visible player in invasive species research in the Upper Midwest and on the national front. These factors include (1) proximity to two highly invaded ecosystems; (2) the Center's extensive history on invasive species research; (3) management of the LTRMP; (4) close association with the GLFC; (5) strong quantitative focus; (6) strengths in geospatial, landscape, decision support tool development, and risk assessments; (7) the increasing awareness and concern of invasive species by partner entities; and (8) the development of a more cohesive and strategic research plan.

This plan was developed by Cindy Kolar (ecology and fisheries, Branch of Chemistry and Physiology), Michael Boogaard (chemistry, Branch of Chemistry and Physiology), Verdel Dawson (toxicology, Branch of Chemistry and Physiology, retired), Steven Gutreuter (ecology and statistics, Branch of Aquatic Sciences), Brian Ickes (ecology and fisheries, Branch of Aquatic Sciences), Eileen Kirsch (ecology and birds, Branch of Terrestrial Sciences), and Kirk Lohman (ecology, Geospatial Sciences and Decision Support Laboratory).

The Plan: Research Directions for the Next Five to Ten Years

> **Vision**
>
> UMESC will play a more vital and cohesive role within the USGS in advancing the prevention and management of aquatic invasive species by building on our Center strengths, developing and growing current partnerships, and applying our collective talents to provide high quality management tools and scientific products

A focused research program at the UMESC on aquatic invasive species should take full advantage of Center facilities and human resources, such as field capabilities and tool development expertise, to meet partner and client needs at the regional and national level. The program, however, should look beyond current strengths at the Center to emerging invasive species issues. The research directions presented here were developed after consulting documents such as the National Invasive Species Management Plan (National Invasive Species Council 2001) and the Invasive Species Program Element Five Year Strategic Plan (USGS 2003), both important at the national level, and several documents regarding research priorities for invasive species at the regional level (see Attachment 3 for a listing of documents that were consulted). Research directions for invasive species at the UMESC are organized into primary and secondary areas of emphasis.

Primary areas of emphasis are those that should be pursued proactively and aggressively. These are areas in which sophisticated and holistic approaches should be taken to increase visibility of the UMESC regarding invasive species issues. They are areas in which the UMESC has existing capabilities and expertise, but that might require more focused development. They are areas that are or may become more important in invasive species research in the next several years. Two primary areas of emphasis are identified in this document: Ecological forecasting and risk assessment of invasive species and the Ecology of invasive species.

Secondary areas of emphasis are those in which UMESC scientists have substantial capabilities and reputation, but for reasons such as lack of potential for substantial funding or current political pressures and public attitudes, are not expected to be areas of growth for invasive species research in the next 5 years. They are areas in which the UMESC should maintain its capability, and perhaps even market its expertise. Research in these areas should proceed largely in response to partners seeking the expertise of the UMESC rather than by providing a basis for program development. Three secondary areas for emphasis are identified in this document: Science support for rapid response, Monitoring of invasive species, and the Science of invasive species management and ecological restoration of native habitats and taxa.

In the following section, each recommended area of emphasis will be discussed and described. For each, the issue, rationale for UMESC involvement (i.e., UMESC assets that can be applied to the problem), approach suggested for UMESC scientists to take, research goal, and objectives for each emphasis area are presented. With each objective are provided bulleted points as examples of the types of research possible at the UMESC given the strengths of the Center, current trends in research on invasive species, and partner needs. These examples are not intended to be a work plan; rather, they exemplify the types of questions envisioned under each objective.

Primary Areas of Emphasis

Ecological Forecasting and Risk Assessment of Invasive Species

Issue. Most research on invasive species has been reactive and occurred after a species is established, is spreading quickly, or is negatively affecting the invaded ecosystem (Kolar and Lodge 2002). In the past decade, however, growing emphasis has been placed on preventing the establishment and spread of invasive species. This change in research emphasis is evident in the published literature, in the stated needs of potential partners, in the National Invasive Species Management Plan (NISC 2001), and in proposed legislation regarding aquatic invasive species (National Aquatic Invasive Species Act). Perhaps the most important and overarching component of preventing invasions is being able to predict the success, distribution, and effects of potential invading species. Similarly, perhaps the most important component of providing viable management alternatives is being able to predict the outcome of such actions. Both of these ends require substantial abilities in ecological forecasting and risk assessment. Ecological forecasting and risk assessment are appropriate at all stages of the invasion process—broadly categorized as Prevention and Management (Figure 2)—and are capabilities needed within the Federal government to further progress in understanding invasive species issues. A substantial niche in ecological forecasting and risk assessment exists, particularly in freshwater and wetland ecosystems and species, within the USGS for the UMESC. These capabilities are also being developed for the more terrestrially focused research at the new USGS National Institute of Invasive Species Science in Fort Collins, Colorado.

Rationale (UMESC Assets). The UMESC has the following human, physical, and informational resources that would be of benefit researching ecological forecasting and risk assessment of invasive species: (1) Geospatial modeling capabilities, (2) Quantitative expertise, (3) Wide range of biological expertise, (4) Some past experience in risk assessments and ecological forecasting, and (5) Access to LTRMP and other relevant databases.

Approach. Increasing the capability of scientists to accurately predict potential invaders, their distribution, and potential effects on invaded ecosystems is central to successfully combating the damaging effects of some invasive species. Risk analysis, risk assessments, and ecological forecasting are important tools that can be used to increase predictive ability. These tools include an array of categorical, qualitative, and quantitative methods, some of which include geospatial applications. Developing a specialization in ecological forecasting and risk assessments, rather than being species or ecosystem focused, would allow the UMESC to apply them to a variety of ecosystems and species as well as to both basic and applied ecological problems. Although the UMESC is strong in quantitative expertise, key personnel may require additional training in risk assessment, risk analysis, and ecological forecasting. Collaboration may also fill some of this need.

Goal. Develop high quality, practical, science-based tools for managers and other decision makers to prevent and manage aquatic invasive species.

Objective 1. Use ecological forecasting and risk assessment information to develop priorities for implementing a program to prevent the introduction of aquatic invasive species.
Priorities in preventing introduction of aquatic invasive species:

- Establish a robust system for ranking risk assessment factors that could be used to determine the most critical pathways of entry, vectors of transport, species most likely to become established, and habitats most at risk
- Conduct risk assessments for individual species (e.g., bighead and silver carp risk assessments funded by FWS)

- Develop species screening tools to assess risk of potential new invaders

Objective 2. Use ecological forecasting and risk assessment information to develop a better understanding of factors that facilitate the spread, ecological effects, and management of aquatic invading species.

Factors associated with the species:

- Conduct risk assessment of the potential for established invaders to invade new areas (e.g., zebra mussels into inland lakes, bighead and silver carps into backwater habitats)
- Use existing life-history databases to identify species that may pose a particularly high risk (e.g., r-selected opportunistic strategists in all systems, periodic strategists in some rivers, etc.)
- Examine life history characteristics of invading species (i.e., Asian carps) in field and laboratory experiments to better determine the potential spread of the species
- Identify high-risk entry points for aquatic invasive species (e.g., ports, aquaculture facilities near highly connected inland waterways) in preparation for rapid response initiative
- Quantify risk of recently discovered invading species to determine appropriate action to take (i.e., in a given situation, should early detection lead to rapid response)
- Identify potential pathways and predict potential distributions of currently established invasive species
- Develop tools to choose appropriate management actions based on ecological forecasting and risk assessments

Factors associated with the vulnerability or sensitivity of ecosystems to invasion:

- Determine whether properties of ecosystems, such as food-web complexity, abundance of predators, potential pathogens and parasites, connectivity, resilience, nutrient enhancement, altered hydrology, altered fire regimes, roads, trails, climate change, and production affect vulnerability to invasion (e.g., are species-rich ecosystems generally more or less vulnerable to invasion than species-poor ecosystems? Does disturbance frequency affect vulnerability?)
- Develop geospatial management tool to determine regions or habitat types of the UMRS most vulnerable to invasion
- Use databases to model the spread of individual species through the UMRS over time to look for patterns—to identify pathways at greater risk of invasion, hindrances to spread (e.g., Lock and Dam 19), taxa that spread the most quickly, or habitats more prone to invasion
- Test theorized causes and correlates of invasibility with case studies

Ecology of Invasive Species

Issue. Once an invasive species is established, it is often necessary to determine the ecological effect, especially when such effects are perceived to be economically detrimental. Thus, determining the effects of an invasive species is critical for developing control strategies, management alternatives, or approaches that otherwise mitigate the negative effect. Additionally, investigation of the effects of invasive species on ecosystems provide an opportunity to learn, producing valuable lessons that can be applied to future invasions.

Ecologically, invasive species can affect the abundance, productivity, and survival of native species directly—by predation and competition—and indirectly—by altering nutrient and energy flow pathways or the physical environment by their presence or actions. Such effects often result in astounding economic and sociological consequences. Decisions concerning how to control invasive species—and where and at what spatial and temporal scales control can be effective in terms of

supporting (restoring) native species and natural ecosystem processes—require an understanding of a full range of effects for some particularly harmful invasive species.

Rationale (UMESC Assets). The UMESC has the following human and physical resources that would benefit research on the ecology of invasive species: (1) Extensive ecological experience—many historical and ongoing studies in terrestrial and aquatic ecosystems, (2) Scientists with diverse specializations, (3) Geospatial capabilities, (4) Statistical expertise, and (5) Extensive facilities, equipment, and infrastructure in place to conduct field and laboratory studies.

Approach. Ecosystems are increasingly under threat from certain invasive species; some invasions can have profound ecological and economic consequences. Comprehensive understanding of the effects of invasive species requires research on the basic biology of the invasive species (autecology) and how it interacts with its environment and the native biotic community (synecology). Experimental and observational studies will be conducted in both field and laboratory settings at scales appropriate for the research question.

Goal. Identify the effects of harmful invasive species on native systems and their components.

Objective 1. Study the physiology, ecology, and population dynamics of aquatic invasive species to develop possible avenues for control and mitigation (Autecology of invasive species).

- Identify areas or stages susceptible to control (chemical, physical, and biological)
- Determine specific life stage habitat requirements of invasive species and use such information to predict effects on native species, constraints to distributional spread, and areas where control could be implemented
- Determine native taxa most likely to be affected by invasive species

Objective 2: Determine the individual and cumulative effects of aquatic invasive species on ecosystem processes (Synecology).

- Investigate the effects of invasive species on energy pathways and food webs
- Investigate the effects of invasive species on the physical environment (e.g., increased suspended sediment resuspension, destruction of vegetation)
- Assess the direct and indirect effects of invasive species on habitats and species of management concern

Objective 3. Study ecosystem level processes and conditions that may control aquatic invasive species or keep them from spreading (Effects of Management).

- Study the efficacy of management techniques in controlling invasive species and reducing their spread such as fire, erosion, and deposition processes, atmospheric and climatological stresses, chemical pollution, land use changes and management practices, chemical applications, habitat manipulation, and habitat restoration
- Assess whether dams alter the rates or extent of effects of invasive species on native species

Secondary Areas of Emphasis

Science Support for Rapid Response

Issue. Growing evidence indicates early control of potentially harmful invasive species can prevent them from attaining nuisance levels. Therefore, detecting such nonindigenous species soon after their introduction may be key to preventing negative consequences from their introduction. Early

detection and rapid response to newly invading species have been the focus of several regional and state management plans. After an invading species is detected and a risk assessment determines that a rapid response (control) effort is called for, a control plan must quickly be developed. Development of these plans requires technical expertise (e.g., of chemical efficacy and application) not widely available.

Rationale (UMESC Assets). The UMESC has the following human resources to benefit research on the science support for rapid response of partner and client agencies: (1) Extensive and unique expertise in chemical control of fishes, (2) Geospatial expertise, and (3) Expertise in developing chemical treatment plans for flowing waters.

Approach. Because of the expertise housed within the UMESC on chemical control and integrated pest management of fishes, partners previously have sought the help of UMESC scientists in developing chemical control plans. The facilities and expertise at the Center have made us the national leader in this field. We therefore expect UMESC personnel to be approached by funding partners to do additional work in this field. Given the importance of developing rapid response plans and the wealth of such knowledge at the Center, UMESC should continue to provide technical assistance in developing rapid response plans. It may be appropriate to market our expertise to potential partners. Developing these plans would be a collaborative effort.

Goal. Use current expertise at the UMESC to provide science support for partner clients to control the newly established or currently established aquatic invasive species with expanding range.

Objective: Maintain and demonstrate capability to develop rapid response plans for the control of invasive aquatic species.

- Produce synthetic paper on the current state of chemical control effectiveness for aquatic vertebrates or produce document for use in marketing the UMESC capabilities in chemical control plan development
- Develop and demonstrate the UMESC capabilities in providing science support for rapid response to invasive species (pilot project integrating geospatial and CAP expertise).
- Maintain existing advisory roles on rapid response committees (e.g., Chicago Rapid Response Committee)
- Provide scientific expertise for interagency rapid response teams
- Participate in multidisciplinary teams to provide assessment of impacts of new invaders and to provide sound scientific advice for biological “SWAT” teams responding to new invasions

Monitoring of Invasive Species

Issue. Accurate monitoring of invasive species is important to understanding their rate of spread, ecology, and population biology, and is important in developing control plans and management strategies. Monitoring of invasive species has been identified as a key area in need of improvement in the National Invasive Species Management Plan (NISC 2001). Standard survey methods used by monitoring programs, however, were not developed to accurately detect rare species (relevant to early detection of invasive species) or particular invasive species due to unique behaviors or areas they inhabit. In addition, the behavior or habitats of some invasive species may make them particularly difficult to detect and monitor. Innovative, accurate, and reliable methods of monitoring invasive species are needed.

Rationale (UMESC Assets). The UMESC has the following human, physical, and informational resources that would benefit research on monitoring of aquatic invasive species: (1) Expertise within the LTRMP, (2) LTRMP data sets, (3) Statistical expertise, and (4) Geospatial capability.

Approach. The UMESC has taken on a national leadership role in the monitoring of riverine aquatic organisms with the administration of the LTRMP. As specialists in monitoring of aquatic organisms, UMESC personnel may be approached to develop methods to accurately monitor invasive species in particular situations.

Goal. Develop a better understanding of the spread of aquatic invasive species and refine methods for monitoring expanding populations for implementation by partner and client.

Objective 1. Develop and improve methods to reliably monitor invasive species.

- Develop scientifically sound monitoring techniques that could provide multi-scale data with less demand on human resources
- Determine the degree to which such methods (developed above) can be applied to a different taxa
- Develop methods to assess populations of bighead and silver carps in the UMRS and round goby in the IIWW

Objective 2. Use existing monitoring expertise at UMESC, particularly in relation to the LTRMP, to develop effective strategies for tracking the status and trend of invading populations.

- Synthesize existing LTRMP data sources for information on nonindigenous species within the UMRS and identify hotspots of invasion
- Evaluate methods developed for native species to monitor invasive species
- Integrate historical records, remote sensing data, and field sampling data in geographic information systems to document spatial and temporal patterns of expanding invasions at landscape and regional scales

Science of Management of Invasive Species Ecological Restoration of Native Habitats and Taxa

Issue. By the time a nonindigenous species is reported to have invaded a new habitat, it is usually already well established and has begun to negatively affect native species and their ecosystem. Managers are then faced with the problem of ecological restoration and management of a highly disrupted system. Options for restoration and management of native species and ecosystem function are limited. Technical expertise is required to evaluate alternatives and assist with development of a viable management plan.

Rationale (UMESC Assets). The UMESC has the following human, physical, and informational resources that would benefit research on managing aquatic invasive species and restoration of native habitats and taxa: (1) Expertise in controlling invasive species (e.g., UMESC involvement with the GLFC); (2) Geospatial expertise; (3) Scientists with diverse backgrounds; and (4) Extensive facilities, equipment, and infrastructure to enable laboratory and field research.

Approach. Involvement by the UMESC in these questions will be driven by client needs. Scientists at the UMESC have a long history of developing tools and operational plans for restoration and management of invasive species. As a result, they often have been approached by funding partners to provide assistance in this area. With the continuing spread of invasive species, the UMESC should expect to be called upon to continue collaborating on research aimed at developing new approaches to controlling invasive species and restoring native habitats.

Goal. Work with partners to study and evaluate alternatives for restoration and management of native species and ecosystem function.

Objective 1. To collaborate on research aimed at understanding the ecological processes most in need of restoration in the Mississippi River System to mitigate the effects of aquatic invasive species.

- Identify sites and processes most in need of restoration
- Develop adaptive management frameworks for restoring native species in the face of invaders
- Evaluate whether floodplain restoration differentially benefit invasive species or native species

Objective 2. To develop scientifically valid procedures to help guide managers in effectively manage aquatic invasive species.

- Develop protocols for rapid response when invasions are first reported, for preventing range expansion, for selecting tools for reducing populations of invasive species, for restoration of habitats altered by invasive species, or for protection and restoration of threatened and endangered species

Objective 3. To collaborate with interdisciplinary teams in developing new approaches to controlling populations of aquatic invasive species.

- Develop new formulations of general or selective chemical toxicants
- Develop new biological control methods
- Develop innovative genetic or transgenic management techniques
- Develop integrated pest management strategies

Objective 4. To provide technical assistance to clients and partner agencies

- Provide technical assistance to agencies responsible for the control of invasive species, for the restoration of native species or critical habitat, or for the restoration of threatened and endangered species

Recommendations

The following recommendations are made to help focus the invasive species research program at the UMESC and to better ensure its success:

1. As stated in the National Invasive Species Management Plan (NISC 2001), "the first line of defense for invasive species is prevention." The invasive species research program at the UMESC should target prevention, in the context of the USGS mission, in a significant portion of research conducted at the Center.

2. Because the resulting ecological and physiological shifts and changes caused by invasive species are intrinsically complex, the most productive and efficient research on invasive species integrates across disciplines and spatial and temporal scales. A significant portion of invasive species research conducted at the UMESC should be interdisciplinary, making full use of the talents of UMESC staff (toxicologists, ecologists, chemists, statisticians, geospatial specialists, and those with mapping capabilities), and including collaborations within the Biological Resources Discipline, the USGS, the Department of the Interior, academic institutions, and other entities as needed.

3. Most of the example research questions listed as bulleted points under objectives in this document are not watershed or taxon focused. Given current and emerging species issues, research focused on species such as the bighead, silver, black (*Mylopharyngodon piceus*), and grass carps

(*Ctenopharyngodon idella*), round goby, ruffe, Eurasian water milfoil, purple loosestrife, and reed canary grass, would be recommended. Also, given the geographic location of the UMESC, research will likely focus on the UMRS and midwestern and eastern river systems for riverine questions, as well as on the Great Lakes and midwestern lakes and wetlands. Specific species and ecosystems or ecosystems studied should be driven by regional concerns, partner and client needs, and USGS research priorities.

4. To optimize both this strategic plan and the ensuing research, it will be important to leverage research done at the UMESC with other efforts under way in the USGS and to foster new collaborations both within the BRD and in the other disciplines of the Bureau. Full advantage of applicable USGS programs such as the Invasive Species Program Element and the focus areas of the Upper Mississippi River and the Great Lakes should also be taken.

5. Foster a relationship with the new National Institute for Invasive Species Science in Fort Collins, Colorado.

6. The UMESC invasive species program should make full use of contacts within the Center for further research on invasive species such as the administration of the LTRMP at UMESC, Pat Heglund as USFWS contact, Kirk Lohman as National Park Service contact, David Kennedy as the Congressional contact, and Cindy Kolar as chair of the Research and Risk Assessment Committee of the Mississippi River Basin Panel on Aquatic Nuisance Species.

7. A UMESC representative should visit field offices in the Great Lakes and UMRS of potential funding partners (e.g., USEPA and USFWS) to keep current on their research needs and interests.

8. Determine the efficacy of economic cost or benefit approaches (e.g., determine when it is beneficial to take action against an invasive species).

9. Progress made by the new and focused research program on invasive species at the UMESC should be reviewed annually during the assessment of other teams at the Center. This strategic plan also should be reexamined periodically through program implementation (mid-FY 2006).

Program Needs

The wealth and diversity of scientific expertise, facilities, equipment, and infrastructure at the UMESC put the Center in a good position to further develop an invasive species research program. Assigning personnel dedicated to implementing the plan is essential. Additional training may be necessary for several UMESC scientists to further develop expertise in risk assessment and ecological forecasting. Hiring an ecosystem modeler could strengthen the risk assessment and environmental effects aspects of the proposed program. Similarly, research conducted at the UMESC on the environmental effects of invasive species are limited by the facilities and equipment currently housed at the Center, particularly for terrestrial species (e.g., lack of greenhouse, laboratory facilities for terrestrial vertebrates). All of these needs can be met through collaboration or contract with state agencies or universities, however. If the focus of invasive species research at UMESC is expected to have a greater focus on terrestrial species, these limitations should be addressed in a long-term plan.

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Glossary

BOR	Bureau of Reclamation
BRD	Biological Resources Discipline
CAP	Branch of Chemistry and Physiology
GLFC	Great Lakes Fishery Commission
IAFWA	International Association of Fish and Wildlife Agencies
IIWW	Illinois Inland Waterway
LTRMP	Long Term Resource Monitoring Program
NASA	National Aeronautics and Space Administration
NCRAIS	National Oceanic and Atmospheric Administration National Center for Research on Aquatic Invasive Species (
NPS	National Park Service
UMESC	Upper Midwest Environmental Sciences Center
UMRS	Upper Mississippi River System
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

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174 publications

Attachment 2. History of Invasive Species Research at the Upper Midwest Environmental Sciences Center

The study of invasive species at the Upper Midwest Environmental Sciences Center (UMESC) dates back to the formation of a federal research presence in La Crosse, Wisconsin in the 1950s. The American Fisheries Society resolved at its 88th annual meeting in 1958 to recommend an expansion of research in fish control to the Secretary of the Interior. In that same year, Congress made the first appropriation for establishment of the Fish Control Laboratory at La Crosse, Wisconsin. The Bureau of Sport Fisheries and Wildlife established the laboratory in 1959. The initial mission of the laboratory was to develop means for efficient manipulation of freshwater fish. In particular, safe and economical controls (chemical, biological, electrical, or mechanical) were sought for undesirable populations in standing and flowing waters. The objectives were sufficiently broad to encompass investigation and development of any new tools that may be useful in fishery management, fish culture, or fishery research. Early recognition was given to the potential of chemical control agents such as general and selective toxicants, attractants, repellants, anesthetics, sterilants, spawning inducers, osmoregulators, marking dyes, medications for diseases, and sedatives and decontaminants for fish distribution. Emphasis was on finding selective toxicants for longnose and shortnose gars, gizzard shad, goldfish, carp, squawfish, white sucker, black bullhead, rock bass, green sunfish, pumpkinseed, yellow perch, and freshwater drum.

Early studies involved evaluations of various chemicals such as toxaphene and antimycin as piscicides. Much of the research focused on development of general toxicants, but the laboratory soon became involved in the effort for selective control of sea lamprey in the Great Lakes. The Fish Control Laboratory at La Crosse and the Hammond Bay Biological Station at Hammond Bay, Michigan, cooperated in the development and registration of the lampricides, TFM and Bayluscide, that are still being used as the primary means of managing sea lamprey populations in the Great Lakes. In the 1960s and 1970s, the laboratory concentrated its invasive species research on the efficacy and environmental safety of the lampricides. These studies included toxicity to target and non-target organisms, analytical methodologies, residue studies, uptake, metabolism, and elimination studies, photolysis studies, and microbial degradation studies. During this time, rotenone was also being developed and registered as a piscicide. New piscicidal candidates were being evaluated such as juglone, isobornyl thiocyanoacetate (Thanite), Salicylanilide I, and the selective toxicants, Squoxin and 2-(digeranylamino)-ethanol (GD-174).

In 1947, Congress passed the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) that regulated the licensing and application of pesticides, primarily for agriculture. Initially, the U.S. Department of Agriculture was given the responsibility of registering pesticides. The responsibility passed to the U.S. Environmental Protection Agency (USEPA) when it was created in 1970. Amendments to FIFRA were made in 1980 and 1988, with the latter amendment requiring that all pesticides registered before 1984 undergo a reregistration process. This was largely done because testing methodology had improved significantly, and Congress felt this necessitated repeating the registration process for older chemicals. Consequently, in the late 1980s and 1990s research effort was once again centered on the previously registered piscicides, antimycin, rotenone, TFM, and Bayluscide. New data, primarily involving safety studies, were collected and submitted to the USEPA in support of the reregistration process.

Thus, development of chemical controls for nuisance fishes such as common carp at the UMESC was expanded in the 1960s to the control of invasive sea lamprey in the Great Lakes. These two efforts constituted the Center's major research emphasis on invasive species through the 1980s. The late 1980s brought a rapid expansion of the number of nonindigenous species in the aquatic systems of the Upper Midwest. New invasive organisms found their way into the Great Lakes, presumably by way of ballast

water discharges from ocean-going vessels. These included the zebra mussel, Eurasian ruffe, and round goby. The range of the zebra mussel expanded considerably in the 1990s, and the species became a serious ecological threat throughout the Great Lakes and the Mississippi River Basin. As a result of these new invasions and range expansions, the UMESC expanded its success with sea lamprey and focused its chemical control talents on new Great Lakes invasive species. In response to the zebra mussel invasion of the Upper Mississippi River System, UMESC scientists also examined food-web effects of zebra mussels on native fishes and birds, their ability to bioaccumulate toxins, and on ways to minimize the likelihood of introducing zebra mussels concurrent with native mussel conservation activities. Also from the 1990s until currently, the Long Term Resource Monitoring Program for the Upper Mississippi River, under the guidance of the UMESC, has documented the introduction and expansion of bighead and silver carps and other fishes, such as white perch, in the system.

In 2002, the UMESC stepped out of its regional focus to partner with the Bureau of Reclamation to assess integrated strategies to control invasive fishes in the southwestern United States. The native fish fauna of the southwestern United States, including that in the Gila River Basin in Arizona and New Mexico, is critically imperiled as a result of the introduction and establishment of nonindigenous fishes. As a result, UMESC scientists assembled a comprehensive review of integrated management techniques to control nonnative fishes.

Attachment 3. Strategic Documents of Other Entities for Invasive Species Research at the National or Regional Scale Consulted in Developing This Strategic Plan

1. Great Lakes Panel on Aquatic Nuisance Species (ANS) Research Committee, ANS Research Priorities for the Great Lakes (draft) July 2003.
2. Species of concern: Midwest Natural Resource Group. Partner Responses for Early Detection and Rapid Response.
3. National Invasive Species Council. 2001. Meeting the invasive species challenge: National Invasive Species Management Plan. 80 pp. Available online at http://www.invasivespecies.gov.
4. U.S. Geological Survey Invasive Species Program Element Five Year Strategic Plan. 2003 (draft). 50 pp.
5. Mississippi River Basin Panel on Aquatic Nuisance Species Risk Assessment and Research Committee ANS Research Priorities for the Mississippi River Basin (draft) January 2004.
6. U.S. Fish and Wildlife Service. 2002. Fish and wildlife resource conservation priorities. Region 3. January 2002. Version 2.0. 34 pp.
7. U.S. Geological Survey Eastern Region Integrated Science Priorities.
8. Research priorities for aquatic invasive species. Hearing before the Subcommittee on Environment, Technology, and Standards Committee on Science. House of Representatives, One hundred seventh Congress, Second Session. June 20, 2002. Serial Number 107-72. Available online at http://www.house.gov/science.
9. Non-Native Invasive Species Framework for Plants and Animals in the U.S. Forest Service, Eastern Region. 2003. R9 Regional Leadership Team, April 11, 2003.
10. Strategic plan for the U.S. Geological Survey Program on the Status and Trends of Biological Resources, 2004-2009.
11. The Nature Conservancy (TNC). 2003. Aquatic invasive species role definition. Information developed during a meeting to discuss the role that the TNC may have for combating aquatic invasive species. Draft.
12. Weitzell, R. E., M. L. Khoury, P. Gagnon, B. Schreurs, D. Grossman, and J. Higgins. 2003. Conservation Priorities for Freshwater Biodiversity in the Upper Mississippi River Basin**.** Nature Serve and The Nature Conservancy. July 2003.
13. International Association of Fish and Wildlife Agencies Strategic Plan. December 15, 2003.

APPENDIX B. Presentation Materials

USGS Invasive Species Program Element
Sharon Gross-Assistant Invasive Species Program Element Coordinator

USGS: Invasive Species Program

Sharon K. Gross
Invasive Species Program, Assistant Coordinator
U.S. Geological Survey

USGS

Biological Resources Discipline

- Ecosystems
- Wildlife and Terrestrial Resources
- Fisheries and Aquatic Resources
- Status and Trends
- Contaminants
- Invasive Species

USGS

Why USGS?

- "Microbes to Mammals"
- All ecological regions – terrestrial, freshwater, marine
- Special capabilities:
  - Integrated research – all disciplines
  - Freshwater and wetland invaders
  - Monitoring and ecological forecasting
  - Information systems
- More than 120 partners!
- Essential support for implementing the National Invasive Species Management Plan

USGS

THE FIVE-YEAR PLAN

- "The heart of the Bureau planning model"
- Basis for annual project planning and decisions
- Customers, cooperators and partners ..

  - help define science needs, emerging issues, and priorities

  - provide external review
- A/D leads development through the PC
- Approved by the Director

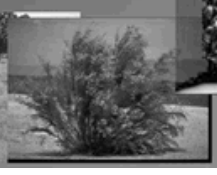
USGS

Invasive Species

Provide reliable information and useful tools for documenting, understanding, predicting, assessing, and addressing threats from invasive species in U.S. ecosystems.

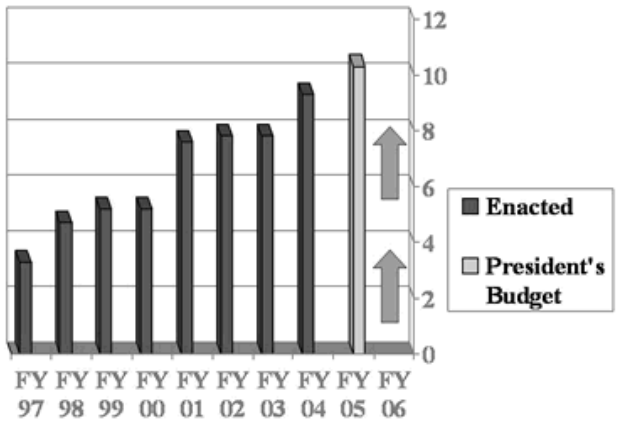
Scope & Scale

- $10 Million Effort (in FY04)
- Research at 13 Science Centers
- More than 80 Scientists

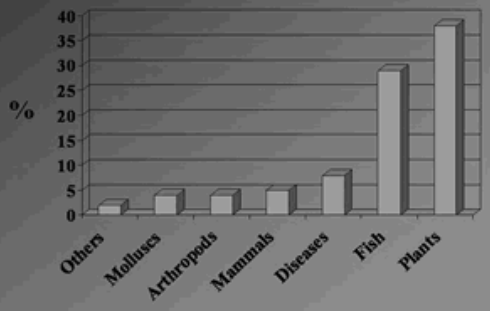


USGS

Invasive Species Budget



USGS research on invasive species



USGS

USGS Invasive Species Program Focus Areas

- Prevention
- Early Detection and Rapid Assessment
- Monitoring and Prediction
- Effects
- Control and Management
- Information Systems (in cooperation with Biological Informatics)

USGS

PREVENTION

Program Goal: Conduct research and develop methods and technologies to prevent the introduction of invasive species

USGS Activities:

- Cooperative research to assess treatment technologies for ballast water and support regulation

USGS

EARLY DETECTION AND RAPID RESPONSE

Program Goal:

Identify and report new invaders and assess risks to natural areas and waters

USGS Activities:

- Facilitating National Early Warning/Rapid Response Strategy
- Information (public alerts, fact sheets, distribution maps) and technical assistance for response to new invaders

USGS

Snakehead

Family Channidae

- Origin: Southeast Asia
- Established populations: Florida, Maryland

USGS
science for a changing world

Early Detection /Rapid Response, continued

Giant Salvinia

(*Salvinia molesta* D.S. Mitchell)

- Origin: Brazil
- First Report: 1995, SC

USGS
science for a changing world

MONITORING AND PREDICTION

Program Goal: Assess changes in populations and distributions of established invaders

USGS Activities:

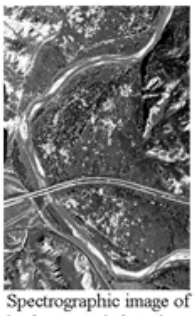
- Multi-scale "smart monitoring"
- Models for mapping vulnerable habitats
- Remote sensing applications

USGS

Monitoring & Prediction, continued

Leafy Spurge

(*Euphorbia esula* L.)



Spectrographic image of leafy spurge infestations (red & yellow) from Theo. Roosevelt NP, ND

USGS science for a changing world

CONTROL AND MANAGEMENT

Program Goal: Provide approaches to contain, reduce, and eliminate populations of invasive species and restore habitats and native species

USGS Activities:

- Examples
  - Sea lamprey (Great Lakes)
  - Tamarisk (western riparian areas)
  - Nutria (MD and LA)

USGS

Asian Carp

Movements and habitat selection characterization
Diet studies
Susceptibility to piscicides
Effectiveness of triploidy

USGS science for a changing world

EFFECTS

Program Goal: Determine effects of invasive species and susceptibility of habitats to invasion

USGS Activities:

- Studies of priority species identified by managers

USGS

INFORMATION MANAGEMENT

Program Goal: Provide and coordinate the collection, synthesis, and accessibility of invasive species information

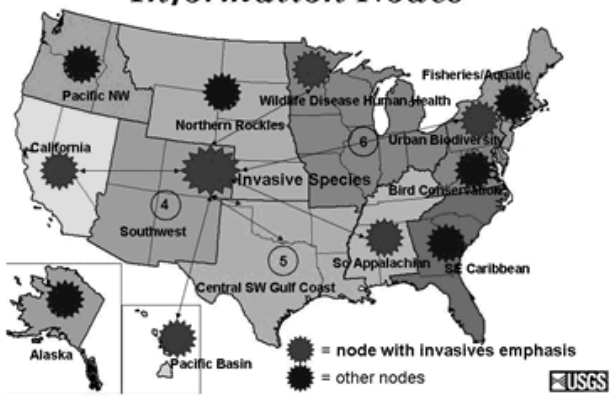
USGS Activities:

- Information standards and technologies
- Non-indigenous Aquatic Species Database
- Invasive species information node

USGS

Information Systems, continued

National Network of Information Nodes



National Institute of Invasive Species Science

- Virtual Organization Linking USGS Programs, Cooperators, and Customers
- Emphasis: Invasions in U.S. Ecosystems
- Think Tank on Emerging Issues
- Invasive Species Information Node
- National Early Detection and Forecasting System and Service
- Technical Assistance and Decision Support for Resource Managers
- Small Staff at FORT

USGS

FY 05 Priorities (President's Budget)

- Develop innovative control methodologies (700K)
  - Asian carp & other aquatic invaders in:
    - Mississippi River Basin
    - Southeastern U.S.
    - Great Lakes
- Technical assistance for Brown Tree Snake control (300K)

USGS

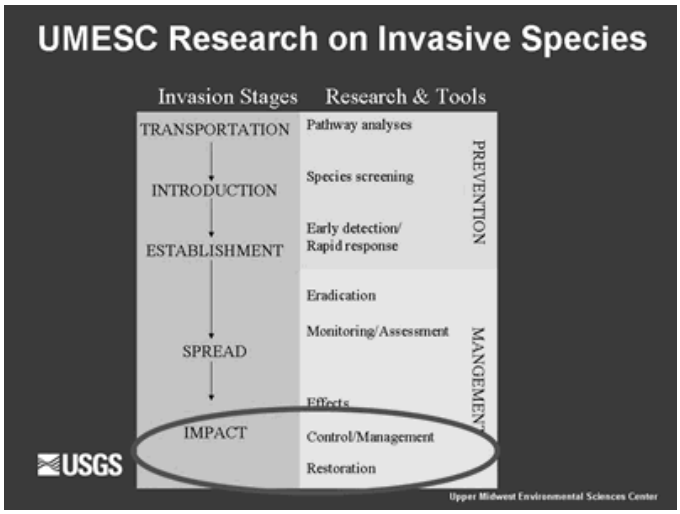
Near-Term Program Opportunities

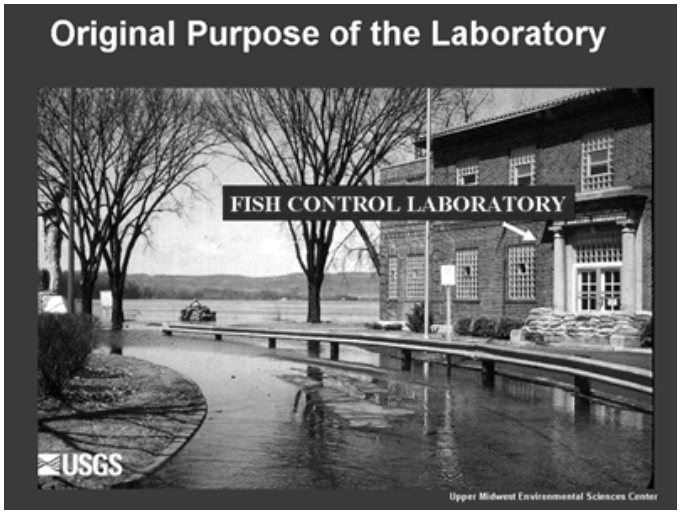
- Invasions in Inland Waters
- Partnership with USDA on plant pests and diseases in natural systems (e.g., cactus moth, lobate lac scale)
- Applications of molecular and genetic technologies
- Predicting new invaders for priority action (i.e., the next Asian carp!)
- Early detection methods
- Rapid assessment of new invaders
- Multi-scale monitoring and forecasting of incipient and established invaders
- Adaptive management of established invaders in complex landscapes – control and management

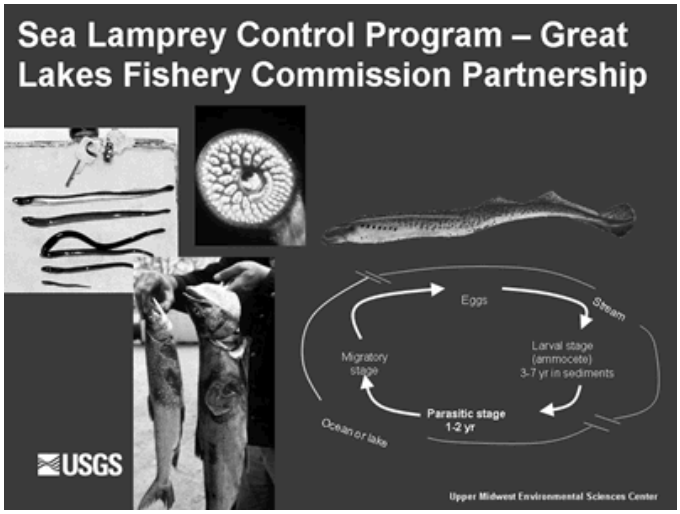
USGS

Historic and Ongoing Research on Invasive Species at the Upper Midwest Environmental Sciences Center

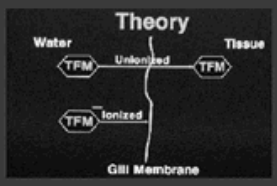
Cindy Kolar, Eileen Kirsch, and Teresa Newton







Refine Lampricide Application Methods



Developed new technique to apply chemicals

Old (alk) Method: 116,281 lbs

New (pH) Method: 93,258 lbs

Savings in 1 year = $644,000

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Lampricide Formulation Development

Old Tool

New Tool

Old 5% granular Bayluscide formulation

New granular Sea Lamprey Larvicide -timed-release; dust-free

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Minimize Impacts on Non-target & Sensitive Species

Freshwater mussels

Lake sturgeon

Hungerford's Crawling Water Beetle

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Regulatory Agent for USEPA & Health Canada

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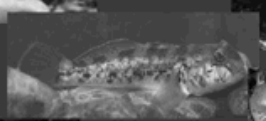
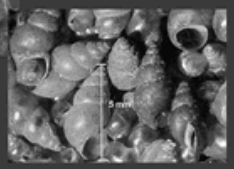
Chemical Control of a Variety of Other Taxa





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Michael Redmer ©

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Using Our 40+yrs of Knowledge on Integrated Management of Invasive Species

- ✓ Bureau of Reclamation effort to address aquatic invasive fish impacts to endangered species
- ✓ UMESC chemists, fishery biologists, ecologists & toxicologists aiding effort

Integrated Management Techniques to Control Nonnative Fishes
Completion Report to Bureau of Reclamation

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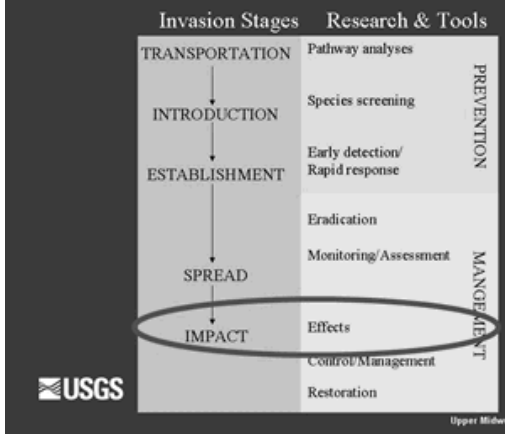
UMESC Research on Invasive Species



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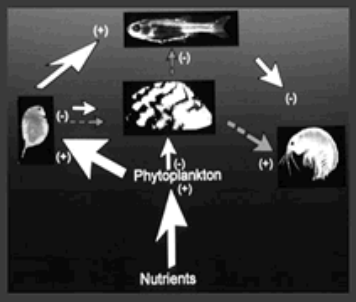
Competition Between Zebra Mussels & Native Larval Fish



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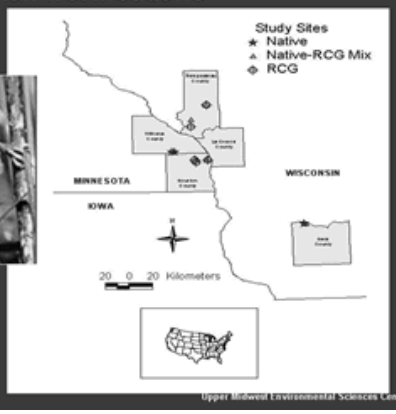
Effects of Reed Canary Grass dominance on bird territory placement and arthropod community composition in riparian wet meadows



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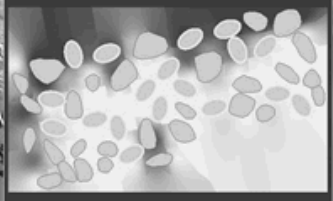
Common Yellowthroat - indifferent to RCG, slight association with shrub cover

Sedge Wren – positive association with RCG dominance

Swamp Sparrow – positive association with the RCG cover and dominance, and negative association with veg. height density and litter depth

Arthropods – Numbers, biomass, and diversity not associated with RCG -- But species composition may shift



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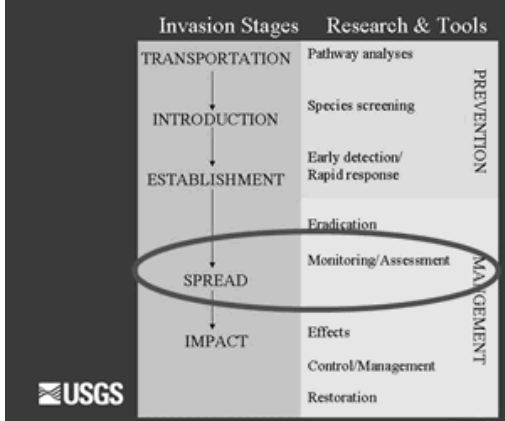
UMESC Research on Invasive Species



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Long-Term Resource Monitoring Program

- ✓ System-wide ecological trends
- ✓ Five reaches - UMR & one reach – IL River (25-30 miles)
- ✓ Scientific guidance provided by an international committee of scientists
- ✓ Significant resource problems such as navigation impacts, sedimentation, & reduced fisheries populations being examined
- ✓ Data collected: fish, vegetation, water quality, and macroinvertebrates

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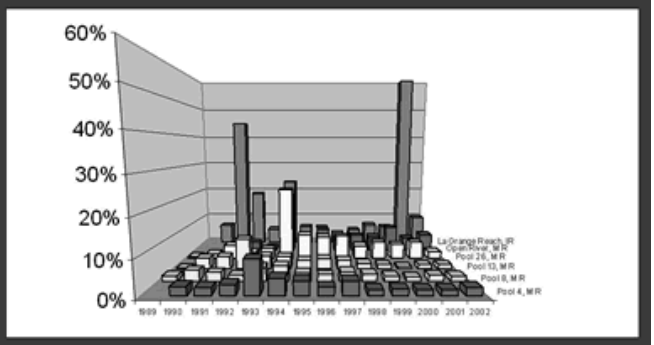
LTRMP – Percent Nonnative Fishes



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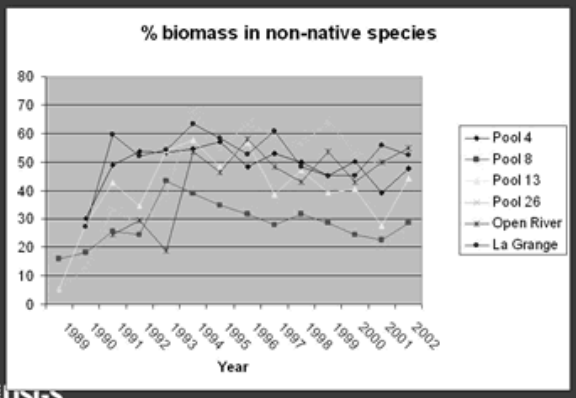
LTRMP – Percent Nonnative Biomass



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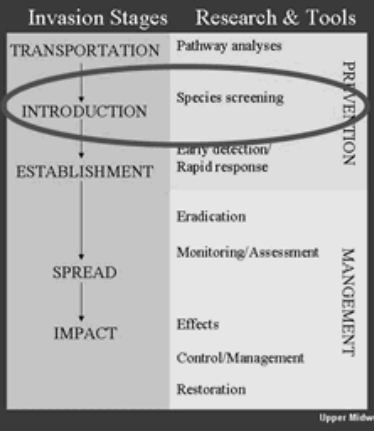
UMESC Research on Invasive Species



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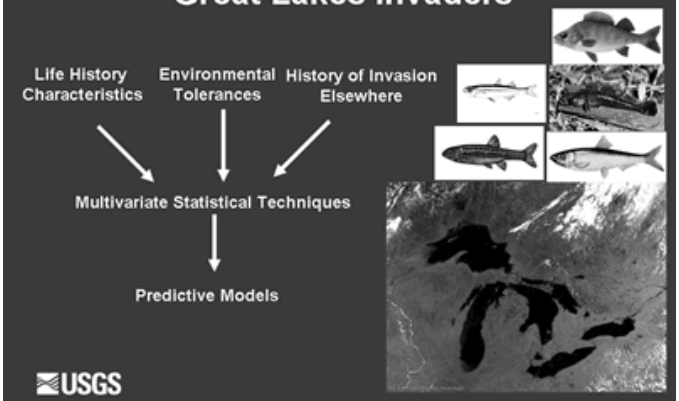
Risk Assessment: Predicting Great Lakes Invaders



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Current Invasive Species Research at UMESC

- ✓ AIS in the Upper Mississippi River
- ✓ Biological Synopses & Risk Assessments of Bigheaded Carps
- ✓ Toxicity of Rotenone & Antimycin to Silver & Bighead Carps
- ✓ Asian Carp: Competition with Native Fishes
- ✓ Risk Assessment of Zebra Mussels in the Upper Mississippi River: Implications for Unionid Mussels

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Aquatic Invasive Species in the UMRS

- ✓ History of Fish Introductions (failed & successful)
- ✓ Pathway analysis through time
- ✓ LTRMP data analysis

Non-native fish in the Upper Mississippi River System. A Long Term Resource Monitoring Program Report.

Prepared by:
Kevin S. Irons[1], Steve DeLain[2], Eric Gittinger[3], Brian Ickes[4], Cynthia Kolar[4], David Ostendorf[5], and Eric Ratcliff[6].

Product of the Long Term Resource Monitoring Program

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Bigheaded Carps, Genus *Hypophthalmichthys* (Pisces: Cyprinidae): Status of Biological Synopses and Risk Assessments

Cindy Kolar (UMESC)
Walt Courtenay, Jr., Jim Williams, and Christine Housel (FISC)

U.S. Department of the Interior
U.S. Geological Survey

Upper Midwest Environmental Sciences Center

Biology and Natural History

	Bighead	Silver	Largescale silver
Temperature	<2-38C	<2-40C	
Mature	3-4 yrs	3-4 yrs	1-2 yrs
Spawning	April-June	May-July	May-August
Fecundity	0.3 - 1 mil.	0.1-4.3 mil.	
Diet	zooplankon	phytoplankton	plankton (noc.)
Growth	18-23kg	18-23kg	faster than silver

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Bigheaded Carp Risk Assessment

Probability of Establishment	Organism within pathway	Entry potential	Colonization potential	Spread potential
Consequence of Establishment	Economic	Environmental	Perceived	
Organism Risk Potential	Probability of Establishment	Consequences of Establishment		

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Toxicity of Rotenone & Antimycin to Silver & Bighead Carps

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Asian Carp: Competition with Native Fishes

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Risk Assessment of Zebra Mussels in the Upper Mississippi River: Implications for Unionid Mussels

U.S. Department of the Interior
U.S. Geological Survey

Justification

- ✷Many resource management agencies are relocating adult unionids as a conservation tool to help reverse declines in unionid populations
- ✷Peer-reviewed literature suggests that relocation is a high risk conservation approach
- ✷Resource managers need alternate approaches
  - ✷introduce glochidia-infested fish
  - ✷large-scale assessment of factors contributing to their decline
  - ✷identify unionid beds at greatest risk from ZM

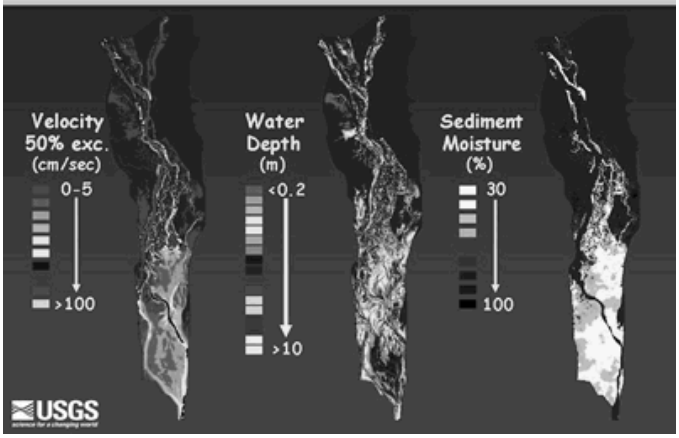
Approach

- ✷Objective
  - *To identify areas within a reach of the UMR that are at low, moderate, and high risk for zebra mussels*
- ✷Approach
  - ✷Determine relevant environmental requirements of ZM's, based on literature
  - ✷Determine ranges for each variable that promote/discourage ZM's
  - ✷Use LTRMP data to determine where combinations of these variables exist

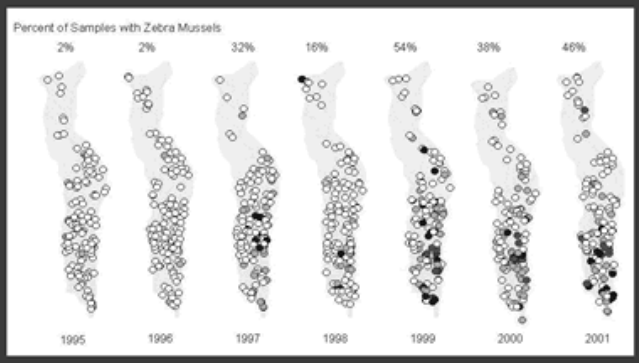
ZM Environmental Requirements

Variable	Low risk	Moderate risk	High risk
Temp (°C)	9-15 28-30	15-18 25-28	18-25
Velocity (cm/s)	7-9 125-150	9-10 100-125	10-100
Depth (m)	< 1	1-2	2-4
Distance to channel (m)	>5000	1000-5000	0-1000

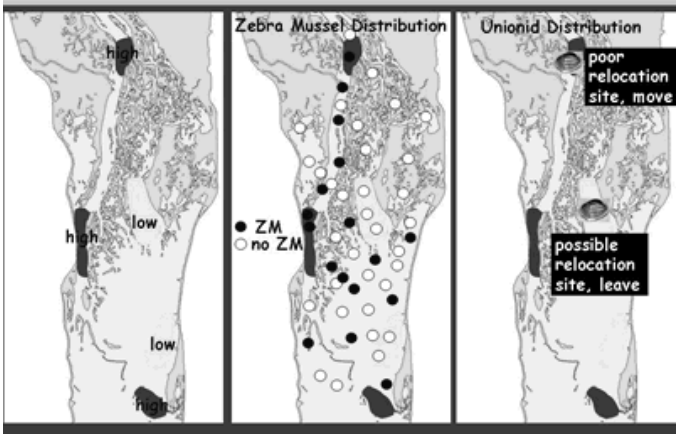
Physical Features



Zebra Mussel Data



Risk Assessment Model



What's Next?

Strategic Directions!

Invasive Species Initiative at UMESC
Interdisciplinary Strategic Plan Writing Team

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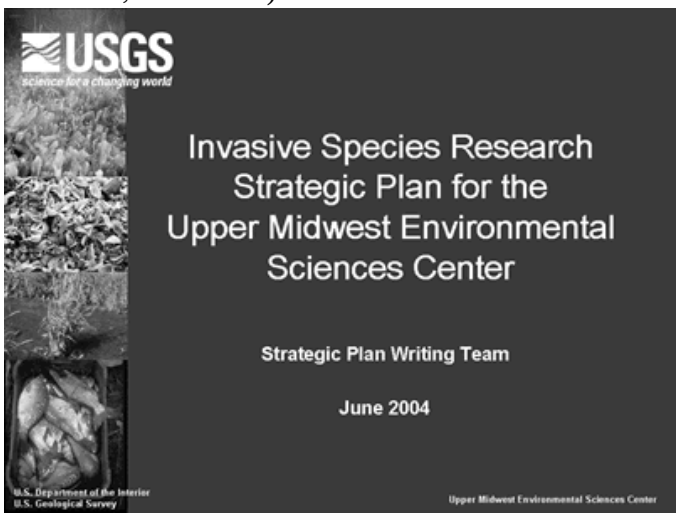
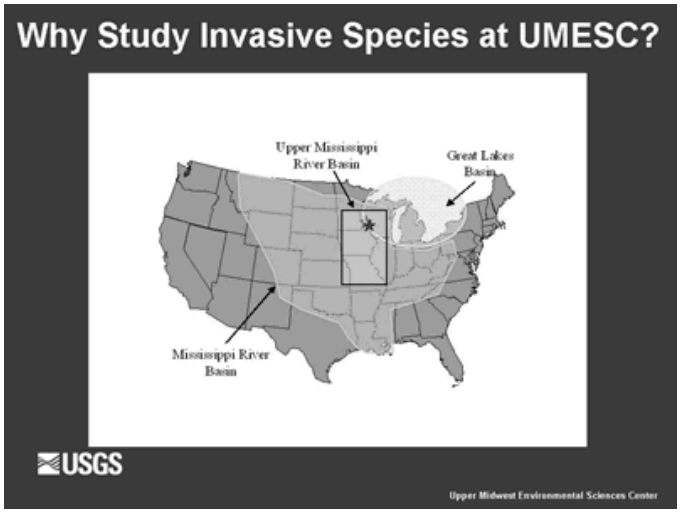
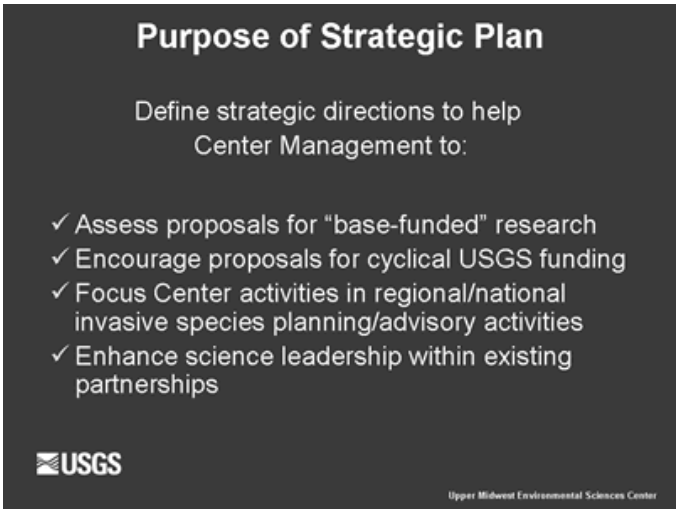
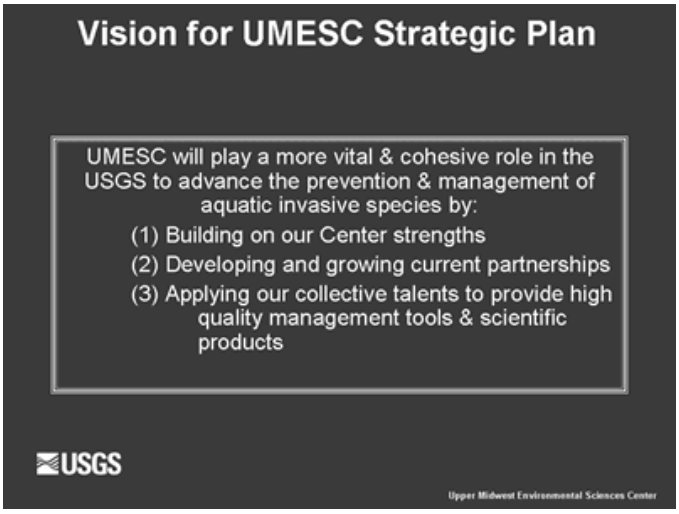
Invasive Species Research Strategic Plan for the Upper Midwest Environmental Sciences Center

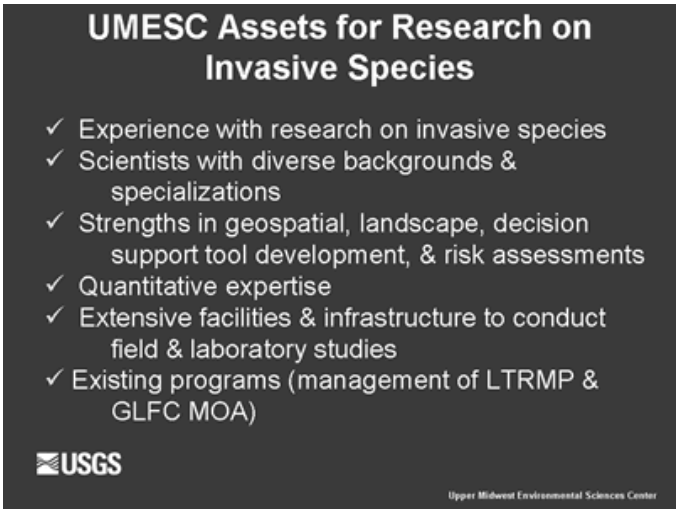
Cindy Kolar, Michael Boogaard, Steven Gutreuter, Eileen Kirsch, Kirk Lohman (and Verdel Dawson and Brian Ickes, *in absentia*)











Premises and Starting Points

- ✓ Take full advantage of Center facilities & human resources
- ✓ Leverage existing programs & partnerships
- ✓ Meet partner & client needs
- ✓ Act locally, but applicable at regional & national level
- ✓ Create regional & national recognition for Center for research on invasive species
- ✓ Look beyond current strengths at the Center to the future needs of partners and clients

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Proposed Areas of Research Focus

Primary Areas of Emphasis

- ✓ Ecological Forecasting & Risk Assessment
- ✓ Ecology of Invasive Species

Secondary Areas of Emphasis

- ✓ Science Support for Rapid Response
- ✓ Monitoring of Invasive Species
- ✓ Science of Management of Invasive Species & Ecological Restoration of Native Habitats & Taxa

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Ecological Forecasting & Risk Assessment of Invasive Species

The Issue

Research focus becoming more proactive
Important to predict success, distribution, effects, & outcome of management actions
Important at all stages of the invasion process
Relevant to all taxa
Growing field in invasion biology

The Goal

Develop high quality, practical, science-based tools for managers & other decision makers to prevent & manage invasive species

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Ecological Forecasting & Risk Assessment of Invasive Species

Objective 1

Use ecological forecasting & risk assessment information for preventing INTRODUCTION of invasive species

Examples

- ➢ Examine most critical pathways for entry, transport, & spread of IS
- ➢ Conduct risk assessments for individual species species screening tools

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Ecological Forecasting & Risk Assessment of Invasive Species

Objective 2

Use ecological forecasting & risk assessment information to understand SPREAD, ECOLOGICAL EFFECTS, & MANAGEMENT of IS

A. Factors associated with the species
B. Factors associated with the ecosystem

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Ecological Forecasting & Risk Assessment of Invasive Species

Examples of Factors Associated with the Species

- ✓ Determine potential of invader to spread to new areas
- ✓ Look at life history to understand potential effect
- ✓ Determine if RR should occur after ED
- ✓ Develop management tools for individual species

Examples of Factors Associated with the Ecosystem

- ✓ Determine properties that affect vulnerability
- ✓ Develop geospatial tools to determine regions or habitats most vulnerable
- ✓ Model spread of species through ecosystem

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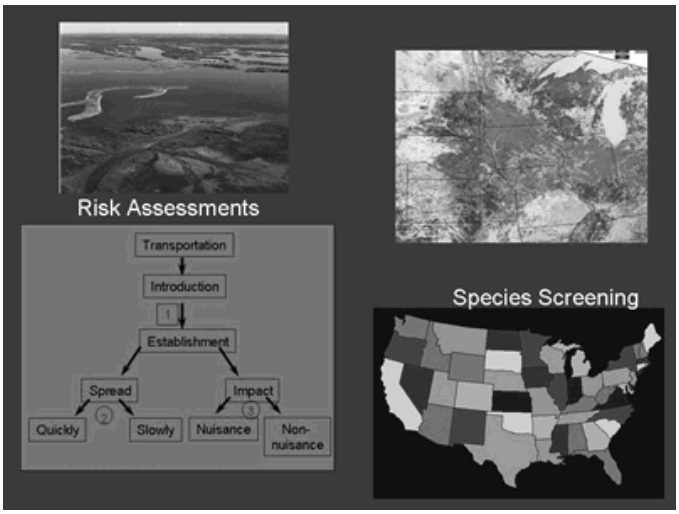

Ecology of Invasive Species

The Issue

Documenting & understanding ecological relationships of invasives is essential to develop effective control and management strategies and allocate resources.

What we learn may be applicable to future situations.

Ecology of invasives in large river & lake ecosystems not well understood.

The Goal

Identify the effects of harmful invasive species on native ecosystems and their components

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Ecology of Invasive Species

Objective 1

Study physiology, ecology, & population dynamics of invasive species to develop control and mitigation methods (Autecology)

Examples

- Identify stages or areas susceptible to control
- Determine specific life stage habitat requirements
- Determine native taxa most likely to be affected

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Ecology of Invasive Species

Objective 2

Determine the individual and cumulative effects of invasive species on ecosystem processes (Synecology)

Examples

- Investigate effects of IS on energy pathways & food webs
- Investigate effects of IS on physical environment
- Assess direct and indirect effects of IS on critical habitats & species

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Ecology of Invasive Species

Objective 3

Study ecosystem level processes and conditions that may control IS or minimize spread (Effects of Management)

Examples

- Study efficacy of management techniques in controlling IS & reducing spread
- Assess whether dams alter rates or extent of effects of IS on native species

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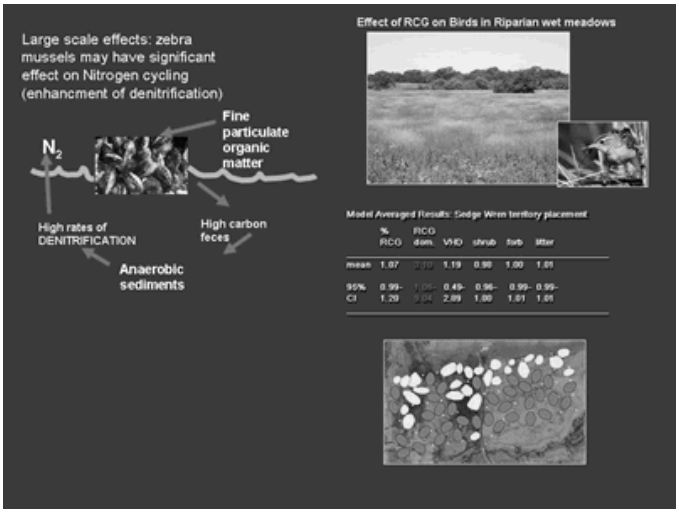

Science Support for Rapid Response

The Issue

- Growing evidence shows importance of early control of IS in preventing nuisance levels
- Early detection and rapid response is focus of regional & national efforts
- Unique expertise at UMESC in chemical & integrated control
- Meets partners needs

The Goal

Use current expertise at UMESC to provide science support for partners to control newly established or currently established aquatic IS with expanding range

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Science Support for Rapid Response

Objective

Maintain & demonstrate capability to develop rapid response plans for the control of aquatic IS

Examples

- Produce synthetic paper on current state of knowledge
- Integrate geospatial & chemical control expertise to demonstrate capability in rapid response plan development
- Provide scientific expertise for interagency rapid response teams

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Monitoring of Invasive Species

The Issue

- Accurate monitoring needed to understand spread, population biology, control & management strategies
- Monitoring is a focus of the National Management Plan for IS
- Standard survey methods are not always appropriate
- Management of LTRMP lends unique expertise in monitoring to UMESC

The Goal

Develop a better understanding of the spread of aquatic IS and refine methods for monitoring expanding populations for implementation by partner

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Monitoring of Invasive Species

Objective 1

Develop & improve methods to reliably monitor IS

Examples

- Develop sound monitoring techniques providing multi-scale data optimizing human resources
- Develop methods to assess populations of bighead & silver carps & round goby

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Monitoring of Invasive Species

Objective 2

Use existing monitoring expertise at UMESC to develop effective strategies for tracking status & trends of invading populations

Examples

- Synthesize existing LTRMP data sources for information on IS within UMRS; identify hot spots
- Integrate historical records, remote sensing data, field sampling in GIS to document spatial & temporal spread patterns at landscape & regional scales

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Science of Management of IS & Ecological Restoration

The Issue

By the time an IS is reported, it is usually well-established & may be affecting the ecosystem

Managers must conduct ecological restoration & management of highly disturbed system

Options for restoration & management limited

Technical expertise often needed to evaluate alternatives & to develop management plan

The Goal

Work with partners to study & evaluate alternatives for restoration & management of native species & ecosystem functions

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Science of Management of IS & Ecological Restoration

Objective 1

Collaborate on research to understand ecological processes most in need of restoration in MRS to mitigate effects of aquatic IS

Examples

- Identify sites & processes most in need of restoration
- Develop adaptive management frameworks for restoring native species in face of invaders

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Science of Management of IS & Ecological Restoration

Objective 2

Develop scientifically valid procedures to help guide managers to effectively manage aquatic IS

Examples

- Develop protocols for RR when invasions first reported
- Develop protocols for preventing range expansion
- Develop protocols for restoration of habitats or protection of T & E species

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Science of Management of IS & Ecological Restoration

Objective 3

Collaborate with interdisciplinary teams to develop new approaches to control populations of aquatic IS

Examples

- Develop new formulations of general or selective chemical toxicants
- Develop new biological control methods
- Develop integrated pest management strategies

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Science of Management of IS & Ecological Restoration

Objective 4

Provide technical assistance to clients & partner agencies

Examples

- Provide technical assistance on available control techniques
- Provide technical assistance to agencies responsible for restoration of native species and habitats

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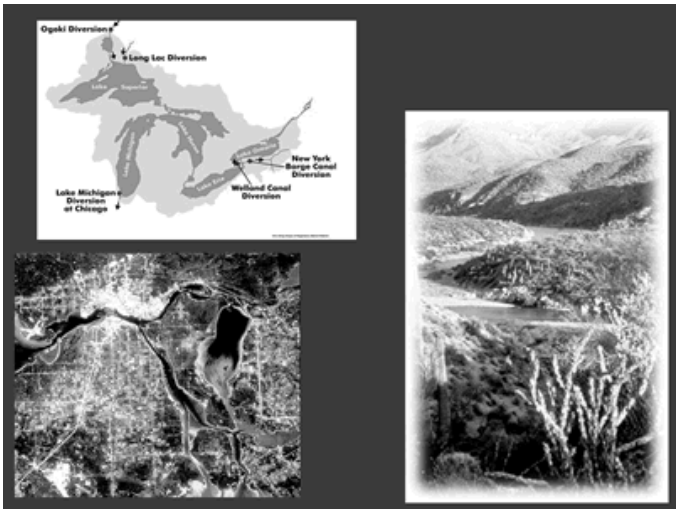

Recommendations

- ✓ Focus more on prevention
- ✓ More interdisciplinary focus
- ✓ Work with relevant USGS Programs and focus areas
- ✓ Use contacts within UMESC (e.g., Lubinski – TNC, Heglund – USFWS, Lohman – NPS, Kolar – MRBP)
- ✓ Visit field offices of cooperators (e.g., USFWS, USEPA)
- ✓ Asian carps have emergent control needs, perhaps should be considered primary area of research
- ✓ Integrate with the USGS National Institute for Invasive Species Science: more information
- ✓ This plan should be reviewed periodically

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Program Needs

- ✓ Additional training for ecological forecasting and risk assessment may be necessary
- ✓ Hiring an ecosystem modeler may help with risk assessments and effects research areas (could be met through collaboration)
- ✓ Possible laboratory experiments limited by facilities at UMESC—limited space for invasive species, more limiting for terrestrial species (could be met through collaboration)

RECENT USGS AWARD!

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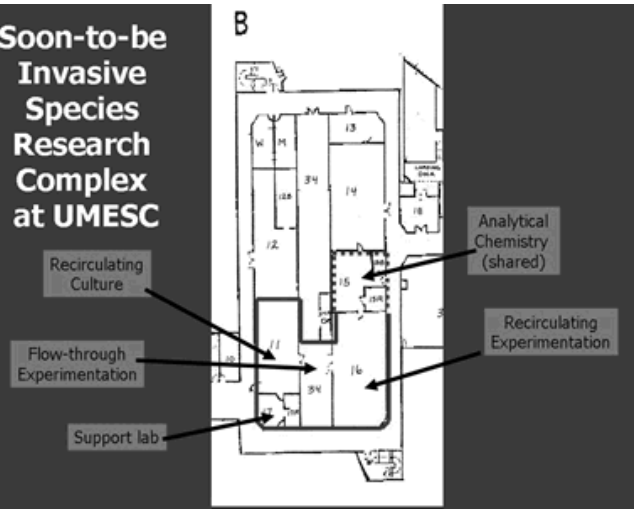
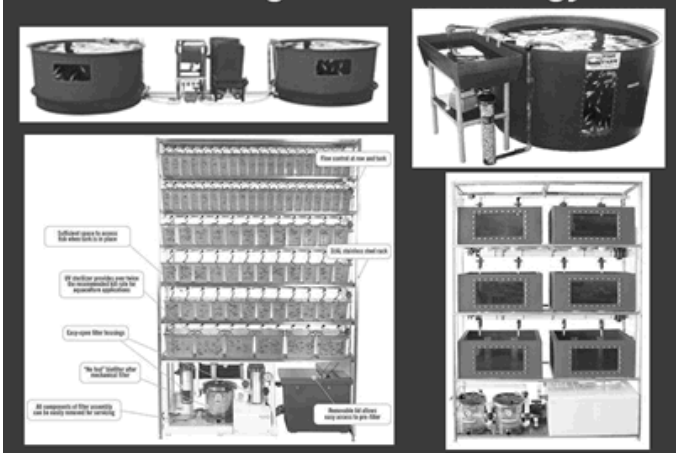
Soon-to-be Invasive Species Research Complex at UMESC



Recirculating Water Technology



Factors Pointing to Successful Program at UMESC

- ✓ Proximity to two highly invaded aquatic ecosystems
- ✓ Center's extensive history on invasive species research
- ✓ Management of the LTRMP & involvement with GLFC
- ✓ Strong quantitative focus
- ✓ Strengths in geospatial, landscape, decision support tools, & risk assessments
- ✓ Increasing awareness & concern of invasive species by partner entities
- ✓ Developing a more cohesive strategic research plan

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APPENDIX C. Partner Priorities for Invasive Species Submitted Before the Workshop

Partner Priorities for Invasive Species Submitted Before the Workshop

Participants were asked to submit the top three invasive species concerns and information needs as seen by their agency, office, or personally. Usually, the responses provided do not reflect agency-level priorities, but rather the invasive species problems that participants deal with day-to-day, initiatives begun at their offices, or current concerns at a level lower than agency policy. Some responses have been edited. Not all entities providing priorities attended the workshop. Their views were therefore not necessarily represented during the discussions.

Federal Partners

U.S. Geological Survey Great Lakes Science Center
Jaci Savino

1. Finding alternative controls for sea lamprey (i.e. other than lampricides).
2. Finding controls for invasive species such as round gobies that have become ubiquitous throughout the Great Lakes.
3. Developing restoration techniques for native species populations hurt by invasive species (unionids, sculpin, sturgeon, lake herring, *Diporeia*).

Jerrie Nichols

1. Preventing establishment. To my mind this is more than just predicting the next invader, or developing better early warning systems, or more widespread monitoring. I want to know why we have more trouble with aquatic nuisance species than the Baltic or other European areas do with the same set of pest species.
2. Control. We definitely need new tools here to eradicate and control. First the structure. We need a layered approach geared to each new exotic species and including rapid response teams.
3. Then new eradication tools- pheromone traps, stocking of native species, etc.

St. Paul District U.S. Army Corps of Engineers – Dan Wilcox

1. Zebra Mussel Management Feasibility Study – The USACE is proposing a 3-year $2.1 million feasibility study for management of zebra mussels on UMR. An ecological risk assessment approach would be used to evaluate alternative management measures. A management plan for this aquatic nuisance species would be developed based upon risk assessment and risk-based decision-making, including results of the following analyses:
   a. Estimate the risk of spread of zebra mussels to uninfested water bodies or tributaries such as the St. Croix River, and quantifying the risk of establishing viable reproductive populations in these systems.
   b. Characterize the importance of veliger sources such as Lake Pepin or Lake Michigan to establishing and maintaining downstream adult populations of zebra mussels.
   c. Characterize the distribution of zebra mussels with suspended solids, water temperature, current velocity and other habitat metrics.
   d. Evaluate the comparative susceptibility of different habitats, substrates, and man-made facilities to infestation by zebra mussels.

e. Assess the efficacy of all potential means of controlling zebra mussels – from commonly used technologies to relatively novel or extreme measures, including habitat alterations.
f. Assess the potential introduction, spread, and ecological and economic consequences of quagga mussel (*Dreissena bugensis*).
g. Assess the potential introduction, spread, and ecological and economic consequences of golden mussels (*Limnoperna fortunei*).

2. Assess the effects of fish passage improvements at Upper Mississippi River navigation dams on potential invasion rates of Asian carps.
3. Long-term monitoring and zebra mussel population dynamics modeling in the Upper Mississippi

U.S. Fish and Wildlife Service - Mike Hoff

1. Preventing ballast water introductions of aquatic invasive species into the Great Lakes
2. Preventing the exchange of aquatic invasive species between the Great Lakes and Mississippi River Basins via the Chicago Sanitary and Ship Canal
3. Preventing the invasion of the Great Lakes by bighead and silver carps via all pathways (i.e., bait, live food, aquaculture, etc.).

USEPA Research Priorities on Invasive Species – Elizabeth Murphy

The recently convened second national workshop on invasive species (February 2004) highlighted how the Agency is progressing on research, management and policies related to non-indigenous species (NIS). Potential action items for each of these topics were proposed and discussions have begun in support of drafting a strategy document that identifies a consolidated Agency position on how to meet the NIS problem. The strategy document will encompass and integrate research, management and policy subjects to identify an Agency position on NIS. Since the strategy document will have such a broad scope, the purpose of this synopsis is to highlight the critical research areas that will contribute to the success of the Agency's mission.
The following research areas have all been identified as critical, but are not ranked by priority.
Aquatic NIS Early Detection and Monitoring: The Agency already conducts aquatic biological inventories for compliance monitoring, and data from these inventories are already being mined to assess the abundance and distribution of NIS in freshwater and estuarine ecosystems. Further action has been proposed that would involve extending or designing inventories that better address issues related to NIS, such as rates of invasion, rates of spread and other post-introduction population dynamics. For example, the national EMAP program follows a probabilistic model for site selection, therefore few sites are resampled on a regular basis. Because resampling over a regular time frame is necessary to evaluate a range of NIS related questions, it is prudent that standard compliance monitoring be extended to ensure that such questions be addressed. Besides extending standard compliance inventories, it has also been proposed that complementary survey methods be implemented, such as genetic identification of native and non-native organisms and the development of a bioinformatic reference database.
Risk and Vulnerability Assessments of Aquatic Invasions: Notably, the Agency has made leading contributions towards the development and implementation of risk assessments of aquatic environments. The Agency is also on the forefront of developing and implementing risk assessments guidelines for the accidental or intended introduction of aquatic NIS (ie. accidental

release of organisms from commercial aquaculture facilities, non-native oyster introductions into Chesapeake Bay). Additional work now underway involves predictive modeling of spread following establishment, and gauging the possible impact of invasions on socioeconomic resources. Actions were proposed to extend this work to better evaluate the potential distributions and consequences of NIS in both freshwater and estuarine environments. It is noteworthy that additional work shall promote integration of multidisciplinary data from a variety of sources, such as genetic analyses, community assessments, and economic reviews.

Effects of Biological Invasions on Aquatic Ecosystems: The Agency's mission requires that action or regulation of a pollutant (either physicochemical or biological) be taken only after the range of effects (or consequences) of exposure has been thoroughly characterized. It is broadly recognized that NIS impact endemic communities either through direct genetic and ecological interactions, or through indirect environmental changes subsequent to invasion. While a growing body of evidence demonstrates direct effects of NIS on native biota, it is less clear how NIS change physical environments, and in so doing, impact environmental conditions such as water quality and availability. Actions have been proposed to evaluate how NIS of concern (i.e., smooth cordgrass, purple loosestrife, saltcedar, zebra mussels) may impact not only native biota through direct interactions (i.e., hybridization, competition) but also through indirect measures such as sediment accretion, substrate alterations, and water use patterns. In addition, research should also be pursued on how terrestrial invasions may ultimately influence water quality as well as ecosystem structure and function. Research on the proximate effects of terrestrial invasions on aquatic ecosystems (i.e., increased hemlock mortality from woolly adelgid infestations may impact stream insolation) is still in its infancy, and the ultimate effects (i.e., changes in nutrient cycling at the watershed level) are even less studied.

While the preceding three research areas have emerged as critical actions for the Agency to pursue, additional areas of research are either already being pursued, or are under development. These include the following:

- Habitat remediation and the development of best management practices to either prevent introductions, limit NIS spread or remove NIS from a given environment
- Economic assessment of NIS impacts
- Experimental analyses of post-introduction population dynamics (i.e., assessment of propagule pressure and probabilities of establishment and spread)

State Partners

Wisconsin Department of Natural Resources - Ron Martin

1. Regulating the point of sale and distribution of potentially invasive species-both plants and animals. As fast as we educate, there are always new species arriving in mail order catalogs, aquariums shops and on the Internet. The challenge is to limit and restrict these activities and educate the public about potential threats. Regulations to prevent new introductions through these various pathways are important but educating the public on the potential problems invasives cause is also key.

2. Leveraging resources--with limited funding available, it is obvious that state resource management agencies cannot solve the invasive species problems alone. How we can focus our collective energy and dedicate resources from Federal, state and local sources, as well as citizen

efforts, to achieve a common goal will be a huge challenge. State resource management agencies will need to examine ways to partner with local communities to control invasive species and work together with regional and national entities to curtail new introductions. The combined resources that can be brought together to address invasive species issues will help forge new constituency groups and assist in solving the problems we face.

3. Evaluating the effectiveness of our efforts--A lot of our program activities are directed at information and education/outreach efforts, inventory monitoring, and prevention and control. How effective are these program elements in slowing the spread of invasive species? The challenge is to be able to assess how effective our educational and monitoring efforts are and whether new and cutting edge research technologies that we might implement are effective. The key will also be to establish yardsticks to judge the effectiveness of prevention techniques, control strategies and eradication efforts.

Iowa Department of Natural Resources - Kim Bogenschutz

The top three concerns of the Iowa Department of Natural Resources Aquatic Nuisance Species Program are

1. Preventing the spread of Eurasian watermilfoil within the state
2. Preventing the introduction of zebra mussels into interior waters (only documented in Mississippi and Missouri Rivers so far)
3. Preventing the spread (bighead and silver carps) and introduction (black carp) of Asian carps in the state.

I am sure our Forestry and Wildlife Bureaus have their own priorities, but I don't know if you are addressing terrestrial species.

Illinois Department of Natural Resources - Steve Schults

Top three species of concern are as follows:

1. Bighead carp
2. Silver carp
3. Zebra mussels
4. Eurasian watermilfoil is increasing on our list. We're putting quite a few dollars towards controlling it in some demonstration lakes. But nothing compares to the figures spent on those nasty Asian carps!!

Non-Governmental Partners

Wisconsin Sea Grant - Phil Moy

1. Asian carp - bighead, silver, black, and the new proposed "black greaser".
2. I'd also like to see efforts towards zebra mussel prevention from the Mississippi
3. Can we stop the spread of Asian carps in the river?
4. Are there any biological limitations of Asian carps that will hinder their spread (dissolved oxygen, food, thermal tolerances etc.)?
5. Are barriers (electric or acoustic) a realistic option?

6. Are there other species we might expect to see soon - ruffe, goby, and the like and can anything be done?

Mississippi Interstate Cooperative Resource Association - Jerry Rasmussen

1. Asian carp control
2. Spread of zebra mussels
3. Lack of species screening and clean species listing procedures

The Nature Conservancy - Ken Lubinski

For all invasive species, a fundamental question is "Where are they now and where will they be tomorrow (Status and Trends)?"
Concerns and related science questions:

1. Asian (silver and black) carp - What will be their eventual status once they stabilize in the system? Will they be assimilated into the aquatic community like previous invasive fishes or will they out-compete other species and damage the mussel and plankton communities? How should the answers to these questions influence how we think about enabling fish passage at Upper Mississippi River locks and dams? Is a risk analysis related to increasing fish passage doable?
2. Zebra mussels - What is it about the Pools 1-3/Lake Pepin situation that is limiting their upstream colonization and can we use that information to manage the problem elsewhere?
3. What's next? How can we get on top of this problem by anticipating and preventing future invasions? Can we use predictive models to inform policy at the national level? Why don't/won't policy makers listen?
4. Conceptual - Does the full Upper Mississippi River provide a design by which we can ask the question "Is a healthy ecosystem really less susceptible to invasive species than a degraded system?" If keeping the river ecosystem healthy is a big part of avoiding invasive species, then how can we use that information in justifying more protection and restoration efforts?

APPENDIX D. Breakout Session Work

Group Composition

Group 1-Cindy Kolar, Peter Sorensen, Terry Hubert, Jay Rendall, Scott Yess
Group 2–Phil Moy, Jerry Rasmussen, David Kennedy, Mark Schultz, Mike Hoff
Group 3–Eileen Kirsch, Byron Karns, Mike Boogaard, Nick Rowse, Beth Murphy
Group 4–Gary Brewer, Jeff Rach, Teresa Newton, Jerrie Nichols, Valerie Barko
Group 5–Sharon Gross, Kirk Lohman, John Curnutt, Doug Wilcox, Ken Lubinski

Partner Priorities for Invasive Species Research

Group 1

1. New invaders
    - Assessment of potential risk
    - Risk assessment–Identify potential problems, species, or habits
    - Anticipate potential invaders and control mechanisms for them
2. Assessing impacts
    - Assessment of actual risk
    - Assess impacts to help prioritize and support need for control
3. Tools and methods to respond rapidly
    - Rapid response–Facilitate working quickly
    - Need for tools to respond rapidly
4. Integrated Pest Management (IPM) to remediate most troublesome species
    - Need more tools in the tool box for control
    - Need for tools and techniques to remediate (Integrated Pest Management)
    - Genetics for control
    - Recognition that control of invasive is long term

Group 2

1. Prevention of invasions
    - Methods, technology science support. Information transfer to public and politicians
    - Risk assessment to identify "clean" and high risk species
2. Control and management of numbers and spread
    - IPM (physical, chemical, biological)
    - Science and technology supporting rapid response
3. Restoration and/or monitoring (2:1 split)

Group 3

1. Actions-priorities
    - Suggest using Center for Disease Control model
    - Prevention–pathways of invasion, risk assessment
    - Early detection and monitoring
    - Rapid response–science based
    - Education–along with everything–especially rapid response
    - Species- priorities

- Asian carps, zebra Mussels, *Hydrilla*, earthworms, round goby
- Ecology of species leading back up to the above points

Group 4

1. Stop spread using new control methods (develop new control methods)
2. Find funding sources for rapid response-develop Department of the Interior expertise database
3. Decision Support Systems to prioritize impacts (economical and ecological) of invasive species.
   - Often limited by need basic life-history information
   - Merge habitat and species characteristics

Group 5

1. Prevention
   - Ecological and economical risk assessment
   - Need science to populate risk assessments and support for regulatory decisions
2. Control and management
   - Science (from risk assessments and other sources to support management decisions)
   - Tool development (biological and integrated control for Asian carps, zebra mussels, etc.)
   - Impact analysis in support of restoration

Facilitator Comments

1. Suggests using our public affairs person
2. Make sure to get our science out there

UMESC Invasive Species Research Strategic Plan Assessment

Group 1

Risk Assessment and Ecological Forecasting

General comment on organization of the plan: suggest making structure of document fit with other efforts (NISC National Management Plan, State Management Plans)

Strengths: Lots of need for risk assessments, not a lot of current expertise in country
Local expertise and potential partners with University of Minnesota (a proposal for an Integrative Graduate Education and Research Trainee program has been submitted to the National Science Foundation for risk assessment of invasive species)
Have access to a lot of data with the Long Term Resource Monitoring Program– may be able to verify models
Have partnerships already
Location of the Upper Midwest Environmental Sciences Center (UMESC) (being near invaded ecosystems)

Weakness: Difference between ecological forecasting and risk assessment is unclear in plan
Goal as presented in plan should be written more specifically to this emphasis area
Strengthen language on how risk assessments would affect management (e.g., what currencies would UMESC deal in? Economic, ecological, what taxa could we work on?)

Blind Spots: Models developed should be verifiable. So need to work to coordinate model development and experimentation and/or monitoring.
Make clearer what the strengths of UMESC are relative to other facilities and research entities (e.g., WES, University specialists).
Better define our niche for partners.
Provide our agency responsibilities.

Concerns about Other Areas of the Plan:
Prioritization of management alternatives (maybe fits better somewhere else)
Protocols for monitoring–best gear appropriate sampling
Strategic planning with other USGS facilities

Resulting Group Discussion:
Risk assessments can be useful, but they're not much used for management
Can insert science as best as can into management decisions
Capturing uncertainty in model components is a strength of risk assessments

Group 2

Ecology of Invasive Species

Strengths: Geographic Information Systems capabilities, clients, diverse specialties, statistics, facilities, location and co-location, partnerships, public support, field stations, desire (originally had experience here, but crossed out)

Weakness: Cost, public support = action, marketing, time for results, lack of funding, lack of distant field studies—past studies have been too closely tied to UMESC, geographic scope and scale, not much staff to do the field work, few ecological studies completed by UMESC, registration for chemicals requires a long time

Blind Spots: Funding and availability of personnel, USGS bureaucracy, uninformed elected officials (but not Wisconsin or Minnesota), overhead rate is high for USGS and may be a barrier, collaborative discomfort within USGS, timeliness of response—products are too slow

Unanswered Questions: Future budget, future Center Director, fall elections/ politics, status of the National Aquatic Invasive Species Act, newest invasive species/"species d'jour", long-term consequence of invasive species, future restoration goal—how might long-term restoration goals be affected by invasive species?

Group 3

Science Support for Rapid Response

Strengths: Chemical control expertise, geospatial expertise, facilities, expertise in getting regulatory permits, science-based management, agency partner network and relationships

Weakness: Rapid—How rapid is rapid? Limited number of registered chemicals (fish), alternative methods of control beside chemicals? Who does the actual management? Small toolbox–number of registered chemicals, costs, review process time lags within USGS, marketing benefits of chemical control is needed

Blind Spots: Social forces may not support use of chemicals, permits, need to rely on others to determine a problem (designed to be reactive)

Questions: What comes first: expertise or the problem?
Can we incorporate education/marketing?
Can rapid response plans be formulated before the problem (e.g., chemical spill plans, oil spill plans)?

Clarification: Expertise in chemical control for invasive fish and other aquatic invasive species

Idea: Rapid response account readily available and can carry over—concern over needing to spend budgeted amounts in a particular year and then money not being available when needed

Group 4

Monitoring of Invasive Species

Strengths: Complements ongoing program since uses LTRMP data
Strength if tied to key hypotheses

Weakness: Weakness if not tied to key hypothesis
Expensive, long term, takes money from other priorities
May not pick up the point of entry

Blind Spots: Funding
Expertise (microbial)
Takes too long to get data out
Need "real time" data (like Water Resources Discipline)—some technologies may be available
Mechanism for cooperation among states—share cost of monitoring. Potentially through the Mississippi Interstate Cooperative Resource Association

Group 5

Restoration/Prevention

Strengths: Biological and chemical control tools (Objective 3)
Providing technical assistance (Objective 4)

Weakness: Developing scientific protocols should be under rapid response (Objective 2)

Blind Spots: Development of quantitative ecological risk assessment is needed
Objective 1—Need to clarify role of invasive species in restoration efforts
Be more explicit: how would invasive species be incorporated into restoration experiments?
Change approach to adaptive management

Organizational: Suggest retitling this section or splitting it up to capture ideas within
Why use primary and secondary research emphases?
Suggest that Objective 2 might fit into 'Science support for rapid response' section

APPENDIX E. Group Discussion and Specific Comments about the Draft UMESC Invasive Species Strategic Plan

Group Discussion and Specific Comments about the Draft UMESC Invasive Species Research Strategic Plan

Ken Lubinski: Why does the strategic plan use primary and secondary research emphases? TNC priorities vary with need. There is no need to identify primary and secondary research interests—it's too constraining.

Dan Wilcox: Keep in mind that this is a strategic plan which means that it should not focus on current strengths, but needs to look to the future. A more strategic focus is needed—it is too constraining to focus on current strengths.

Gary Brewer: Need to prioritize research needs. Funding in next several years is bleak. Even with a hot topic like invasive species, it is difficult to be optimistic. Status quo is doing well. The UMESC would be best served by really trying to focus on existing resources and personnel. What focused area—where can UMESC make the best contribution?

John Curnutt: Why focus on monitoring? Successful monitoring is unattainable—don't waste your time.

Kirk Lohman: The goal of the monitoring section of the strategic plan is not to actually monitor invasive species, but to develop methods and protocols for others to more effectively sample for these species.

Valerie Barko: Some of these data are available from the LTRMP data.

Dan Wilcox: Yes, but the LTRMP does not monitor for zebra mussels.

Mark Schultz: Monitoring needs to include invasive species from public's perspective.

Kirk Lohman: The types of methods that could be developed might involve remote sensing.

Phil Moy: Clarification is needed in the monitoring section. I also thought that UMESC planned on monitoring for invasive species.

Sharon Gross: Reword objectives. Make sure that they are bounded by the language in the goal statements. The goals are clearly articulated, but the objectives are not.

Phil Moy: Science support for rapid response/invasive species management and control is achievable. I have drawn upon expertise at UMESC.

Peter Sorensen: Make clear the type of partners you are looking for within each section of the plan.

John Curnutt: Suggested that a system, such as is used for studying migratory birds, be used for aquatic invasive species—i.e., money is spread around and is not tied to one geographic area.

Jerry Rasmussen: Aquatic invasive species are different. Hard to get shared money for a local issue. Birds migrate and spend time in different geographical areas. General support is available for studying them because the same birds are found in different geographical areas. Aquatic invasive species are not the same critters in different places.

Ken Lubinski: Important to link ecology to economic risk assessments.

Dan Wilcox: Important for policy makers to do this. Investment—what are alternatives—relative cost to relative benefit. Decision support link.

Ken Lubinski: Decision makers: policy may use different tools.

Sharon Gross: Scientific data can lead to good ecological forecasting. This kind of research can be high profile and highly political. The UMESC should have its own 'poster species.' All out effort, what can UMESC make a difference on? Use this as a marketing tool. The goal within USGS is to realign ourselves to where we should be and what our partners want.

Dan Wilcox: Realistic work plans with cost estimates should be in the plan.

Jerry Rasmussen: Poster species should be the Asian carps. Each subbasin in the Mississippi River Basin Panel on Aquatic Nuisance Species identified Asian carp as top priority. This is also true of the Great Lakes Basin Panel on ANS.

John Curnutt: Blocking pathways is very important for Forest Service.

Sharon Gross: Asian carp is in budget for FY 05 in USGS. The USGS is one of the few Federal agencies that made that change. Titles of the subsections of the strategic plan are misleading.

Gary Brewer: The plan should be marketed to different audiences. E.g., a fact sheet for the technically challenged.

Peter Sorensen: Maybe not best to put all your eggs in the basket of Asian carp.

Dan Wilcox: Funding could come from other places like the Army Corps of Engineers (USACE), will need to do work on species like zebra mussels because they are mandated to do so. Also fish passage, and threatened and endangered species. The USACE has plans in place to provide funding for management-oriented research.

Phil Moy: How will partner comments be included in the plan?

Cindy Kolar: Partner comments will be included in the proceedings of this workshop. They will be used to finalize the strategic plan for the UMESC.

Fred Kusch: Does the group believe that the research outlined in the strategic plan is attainable and achievable?

Ken Lubinski: I don't want to go on record saying that this strategic plan is attainable and achievable. Research ideas outlined are broad and cover too many topics to be attainable.

Cindy Kolar: Our charge in developing this strategic plan was to identify areas of research that UMESC is capable of pursuing, not to develop specific study plans. The development of study plans based on aspects of the strategic plan is the next step at UMESC.

Teresa Newton: Strategic plans don't have to be bounded by achievability. The place for that is in study plans.

APPENDIX F. Facilitator Report

Invasive Species Research Strategic Planning Workshop for the Upper Midwest Environmental Sciences Center Executive Summary

Introductory Remarks:
The goal of the seminar was to provide the UMESC with new insights, productive appraisal and useful suggestions to improve the strategic plan. There is no doubt that the professional and focused approach of the group was critical factor in the success of the day. The good humor, hard questions, challenges and insights of the participants brought forth invaluable information that will help hone the final strategic plan document. The climate of the proceedings was generally very positive which created a safe environment which encouraged open, direct and professional dialogue.

Findings:

1. The role and function of Cindy K.'s office is not clearly understood by the participants. As a result there appeared to be a feeling that the work outlined in the strategic plan would create an overload and therefore would not be able to meet the demands of the objectives of the plan and the priorities of the participant organizations.
2. The Strategic Plan was clarified. Miscommunication and misunderstandings were clarified. Valuable information was provided to assist in the restructuring of the final draft of the plan.
3. The ability of the UMESC's capacity to provide risk assessment and eco-forecasting was questioned and needs to be addressed.
4. There appears to be a higher degree of misinformation than might be desirable regarding the UMESC's capabilities to "cast a broader net of service and technical assistance" to those in need.
5. The over-riding concerns of the group seemed to be focused on prevention, control and management of Invasive Species. In this consultant's opinion the major emphasis and concern focused on control and management and was out of balance with prevention. Is this a problem for either the long or short term?
6. Participants are not well informed regarding funding for research projects as was witnessed in the discussions through out the day.
7. The continuing budget shortfalls for all players at the table can cause "siloing" of effort. How you address the fact that you are "in this together" vs. independent entities will be critical to your success. This is one tough issue.
8. The overriding invasive species concern has to do with the various species of Asian Carp–no surprise.

1717 Sunset Drive La Crosse, WI 54601
phone 608.787.5771 fax 608.787.0037 e-mail fred@jfkassociates.com
website www.jfkassociates.com

Recommendations:

1. In order for any strategic initiative to succeed, it is imperative that communication be an ongoing agenda and action item. This session was a great start. You must make it an ongoing priority. While it makes for more work in the long run it will pay off. Perhaps consideration could given to a twice a month, monthly or quarterly "E newsletter" that would chart the development of your work in progress.
2. Education and professional awareness almost go hand in hand with number one. However, making those who you identify with the "need to know" more aware of the benefits of your work through "white paper reports," periodic regional educational update meetings, or perhaps even internet chat rooms or chat-boards might bring more support. When everyone involved better understands what in UMESC's work, "is in it for them," the possibility of more enthusiastic support and involvement should evolve. Better understanding, education, and awareness, motivates and encourages a climate where information and data is more easily attained, shared and transferred.
3. All the above being said, a balance must be struck between cohesiveness and productivity. It seems to me that this balance is critical to any successful strategic plan. I am not sure of the method. But my experience tells me that the most effective implementation of strategic plans occur when the ownership of the strategic plan, the implementation, benefits, deficits and ultimate successes are shared.
4. Finally a commitment to provide scheduled periodic strategic plan updates over the next 6 to 12 months will keep people in the loop and should insure ongoing awareness ownership, and maintain commitment to you and the plan.
5. I mentioned the concept of marketing several times during the day's proceedings. Frankly, marketing is in many ways at the heart of this executive summary. The more I experience the process of effective strategic planning outcomes the more I am impressed the role formal but impressively informal marketing plays in the success. I urge you to consider the importance of putting your best foot forward and not be shy of "strutting your stuff," and maintaining visibility with the key players, those who will be integral to your success.

Final remarks:

In my view the day was a success. The goal was achieved. This occurred because of your preparation and openness, the aforementioned professionalism of the participants and the critical nature and importance of the work put forth in the plan. If you continue to invite all players to "come into the tent of your plan" and proactively seek their involvement and thereby gain and maintain their commitment I have no doubt you will be successful.

1717 Sunset Drive La Crosse, WI 54601
phone 608.787.5771 fax 608.787.0037 e-mail fred@jfkassociates.com
website www.jfkassociates.com

Strategic Planning Workshop Notes

Group 1

Cindy
Peter
Terry
Jay
Scott

Partner Priorities

Assessment of potential risk
Assess impacts to help prioritize and support need for control
Need for tools to respond rapidly
Need for tools and techniques to remediate (IPM)
Assessment of actual risk
Risk Assessment – Identify potential problems, species or habits
Rapid Response – Facilitate working quickly
Tools in the Tool Box – CONTROL
Anticipate potential invaders and control mechanisms for them
IPM- Remediation
Genetics for control
Control of invasive is long term

Strategic Plan Assessment

Organization Issue: Make fit with other efforts (National Management Plan, State Management Plan)

Strength: Lots of need for risk assessments, not a lot of current expertise in country
Local expertise and potential partners with University of Minnesota
Have access to a lot of data with LTRMP – may be able to verify models
Have partnerships already
Location of UMESC

Weakness: Objective 1 – Ecol. forecasting unclear
Objective 2 – Reorganize risk assessment
Goal - More specific to this emphasis area
Strengthen how risk assessments would affect management (e.g. what

1717 Sunset Drive La Crosse, WI 54601
phone 608.787.5771 fax 608.787.0037 e-mail fred@jfkassociates.com
website www.jfkassociates.com

Currencies would UMESC deal in? Economic and Ecological)
Blind Spots: Models developed should be verifiable.
Coordinate model development and experimentation and/or monitoring.
Make clear where strengths are relative to others (e.g. WES, University specialists)
Define our niche for partners
Expertise – Agency Responsibilities
Other: Prioritization of management alternatives (maybe fits better somewhere else)
Other: Protocols for monitoring – best gear appropriate sampling
Other: Strategic planning with other USGS facilities

Discussion: Risk Assessments useful – developed, but not much used for management
Can insert science as best as can into management decisions
Capture uncertainty in model components

Group 2

Partner Priorities

4. Prevention of invasions
   Methods, technology science support. Information transfer to public and politics.
   "Clean" and high risk support.
   Risk Assessment Management
5. Control/ Management of numbers and spread
   IPM (physical, chemical, biological)
   Science and technology supporting R.R.
6. Restoration and/or monitoring
   (2:1 split)

Strategic Plan Assessment

Organization Issue: Ecology of Information Systems

Strength: GIS
Clients
Diverse specialties
Stats
Facilities
Location/ Co-Location
Partnerships

1717 Sunset Drive La Crosse, WI 54601
phone 608.787.5771 fax 608.787.0037 e-mail fred@jfkassociates.com
website www.jfkassociates.com

Public support
Field stations
Desire

Weakness: Cost
Public Support = Action
Marketing
Time for results
Lack of funding
Lack of distant field studies
Geographic scope and scale
Permanent staff for field work
Few studies completed
Ecological
Registration

Blind Spots: Funding/FTE's
USGS Bureaucracy
Uninformed elected officials (not WI or MN)
Overhead
Collaborative Discomfort
Timeliness of Response

Unanswered Questions: Future Budget
Future Director
Fall Elections/ Politics
Status of NAISA
Newest IS/ "Sp Dujour"
Long-term Consequence of IS
Future Restoration Goal

Group 3

Byron
Mike
Nick
Beth
Eiken

Partner Priorities

2. Actions-Priorities (CDC Model)

1717 Sunset Drive La Crosse, WI 54601
phone 608.787.5771 fax 608.787.0037 e-mail fred@jfkassociates.com
website www.jfkassociates.com

Prevention – Pathways of Invasion, Risk Assessment
Early Detection and Monitoring
Rapid Response – Science Based
Education – albang with everything – especially rapid response

3. Species- Priorities
   Asian Carp, Zebra Mussels, Hydrilla, Earthworms, Round GOBY:
   (All Ecology leading back up to the above points)

1717 Sunset Drive La Crosse, WI 54601
phone 608.787.5771 fax 608.787.0037 e-mail fred@jfkassociates.com
website www.jfkassociates.com

Strategic Plan Assessment

Organizational Issue: Science Support

Strength: Chemical control expertise
Geospatial expertise
Facilities
Expertise in getting permits
Science-based management
Agency partner network/ relationships

Weakness: Rapid????
Limited Targets (fish)
Alternative methods
Who does the actual management?
Small toolbox – number of registered chemicals
Money
Review process time lags
Marketing benefits of chemical control

Blind Spots: Social forces
Permits
Rely on others to determine a problem

Discussion: What's first – expertise or problem?
Incorporate education/marketing?
Can rapid response plans be formulated?

Clarification: Expertise = Chemical control for inv. Fish and other Aqis

Idea: RR account readily available and can carry over

Group 4

G.Brewer
J.Rach
J.Nichols
V.Barko
T.Newton

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website www.jfkassociates.com

Partner Priorities

4. Stop spread using new control methods
5. Find funding sources for rapid response
   Develop DOI expertise database
6. DSS to prioritize impacts
   (economical and ecological) of IS
   Limitation: need basic life history information

Strategic Plan Assessment

Organizational Issue: Monitoring

Strength: Complements/Uses LTRMP data
If tied to key Ho

Weakness: Not tied to key Ho (as written)
Expensive, long term, takes money from other priorities
May not pick up the point of entry

Blind Spots: Funds
Expertise (microbial)
Takes too long to get data out
Need "real time" data (like WRD)

Group 5

Curnuff
Gross
Wilcox
Lubinski
Lobmuh

Partner Priorities

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website www.jfkassociates.com

Prevention
Ecological/Economical risk assessment
Tool development (control/management)
Biological and integrated control (Asian carps, zebra mussels, etc…)
Science – pophlate R.A.'s
Important analysis in support Of restoration
Rapid Response
TNC = cons = protection and restoration/ influence policy

Strategic Plan Assessment

Organizational Issue: Restoration/Prevention

Strength: Bio/Chemical Control tools
Providing technical assistance

Weakness: Developing scientific protocols should be under rapid response

Blind Spot: Development of quantitative ecological risk assessment
Clarify role of invasive species in restoration efforts
Explicitly state need for restoration experts
Adaptive management

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website www.jfkassociates.com

APPENDIX G. Attendees

Attendees

USGS Invasive Species Workshop

June 23, 2004

Valerie Barko
Missouri Dept. of Conservation
3815 E. Jackson Blvd.
Open Rivers and Wetlands Field Station
Jackson, MO 63755
Day phone: 573-243-2659 x26
Fax number: 573-243-2897
E-mail: valerie.barko@mdc.mo.gov

Michael Boogaard
U.S. Geological Survey
Upper Midwest Environmental Sciences
2630 Fanta Reed Road
La Crosse, WI 54603
Day phone: 608-781-6238
E-mail: mboogaard@usgs.gov

Gary Brewer
U.S. Geological Survey
Leetown Science Center
11649 Leetown Road
Kearneyville, WV 25430
Day phone: 304-724-4507
Fax number:
E-mail: gary_brewer@usgs.gov

John Curnutt
U. S. Forest Service
626 East Wisconsin Ave
7th Floor
Milwaukee, WI 53202
Day phone: 414-297-4149
Fax number: 414-944-3963
E-mail: jcurnutt@fs.fed.us

Sharon Gross
U.S. Geological Survey
12201 Sunrise Valley Drive MS 301
Bethesda, VA 20192
Day phone: 703-648-4076
Fax number: 703-648-4238
E-mail: sgross@usgs.gov

Steve Gutreuter
U.S. Geological Survey
Upper Midwest Environmental Sciences
2360 Fanta Reed Road
La Crosse, WI 54603
Day phone: 608-781-6222
Fax number: 608-783-6066
E-mail: sgutreuter@usgs.gov

Mike Hoff
U.S. Fish and Wildlife Service
Federal Building, 1 Federal Drive
Fort Snelling, MN 55111-4056
Day phone: 612-713-5114
E-mail: Michael_hoff@fws.gov

Byron Karns
National Park Service
P.O. Box 708
St. Croix Falls, WI 54024
Day phone: 715-483-3284 x616
Fax number: 715-483-3288
E-mail: byron_karns@nps.gov

David Kennedy
U.S. Geological Survey
Upper Midwest Environmental Sciences
2630 Fanta Reed Road
La Crosse, WI 54603
Day phone: 608-781-202
Fax number: 608-783-6066
E-mail: dkennedy@usgs.gov

Eileen Kirsch
U.S. Geological Survey
Upper Midwest Environmental Sciences
2630 Fanta Reed Road
La Crosse, WI 54603
Day phone: 608-781-6226
E-mail: ekirsch@usgs.gov

Cindy Kolar
U.S. Geological Survey
Upper Midwest Environmental Sciences
2630 Fanta Reed Road
La Crosse, MI 54603
Day phone: 608-781-6223
Fax number: 608-783-6066
E-mail: ckolar@usgs.gov

Kirk Lohman
U.S. Geological Survey
Upper Midwest Environmental Sciences
2630 Fanta Reed Road
La Crosse, WI 54603
Day phone: 608-781-6341
Fax number: 608-783-6066
E-mail: klohman@usgs.gov

Ken Lubinski
USGS/The Nature Conservancy
11542 Hillside Road
Brownsville, MN 55919
Day phone: 608-781-6297
Fax number: 507-482-7035
E-mail: klubinski@usgs.gov

Phil Moy
Wisconsin Sea Grant
705 Viebahn Street
Manitowoc, WI 54220
Day phone: 920-683-4697
Fax number: 920-683-4776
E-mail: pmoy@uwc.edu

Elizabeth Murphy
U.S. Environmental Protection Agency
77 West Jackson Boulevard
Chicago, IL 60604
Day phone: 312-353-4227
Fax number: 312-353-2018
E-mail: murphy.elizabeth@epa.gov

Teresa Newton
U.S. Geological Survey
Upper Midwest Environmental Sciences
2630 Fanta Reed Road
La Crosse, MI 54603
Day phone: 608-781-6217
Fax number: 608-783-6066
E-mail: tnewton@usgs.gov

Jerrie Nichols
U.S. Geological Survey
Great Lakes Science Center
1451 Green Road
Ann Arbor, MI 48105
Day phone: 734-214-7218
Fax number: 734-994-8780
E-mail: S_Jerrine_Nichols@usgs.gov

Jeff Rach
U.S. Geological Survey
Upper Midwest Environmental Sciences
2630 Fanta Reed Road
La Crosse, WI 54603
Day phone: 608-783-6451
Fax number:
E-mail: jrach@usgs.gov

Jerry Rasmussen
Mississippi Interstate Cooperative Resource
1531 25th Street
Bettendorf, IA 52722
Day phone: 309-793-5811
Fax number: 309-793-5812

Jay Rendall
Minnesota Department of Natural Resources
500 Lafayette Road
St. Paul, MN 55155-4020
Day phone: 651-297-1464
Fax number:
E-mail: jay.rendall@dnr.state.mn.us

Nick Rowse
U.S. Fish and Wildlife Service
Twin Cities Field Office
4101 American Boulevard E.
Bloomington, MN 55425-1665
Day phone: 612-725-3548 x 210
Fax number: 612-725-3609
E-mail: nick_rowse@fws.gov

Mark Schultz
W8155 CTH ZB
Onalaska, WI 54650
Day phone: 608 781 1662
Fax number:
E-mail: Schultzma@charter.net

Peter Sorensen
University of Minnesota
1980 Folwell Avenue
Hodson Hall
St Paul, MN 55108
Day phone: 612-624-4997
Fax number: 612-625-5299
E-mail: soren003@umn.edu

Pam Thiel
U.S. Fish & Wildlife Service
555 Lester Avenue
Onalaska, WI 54650
Day phone: 608-783-8434
Fax number:
E-mail: Pam_Thiel@fws.gov

Dan Wilcox
U.S. Army Corps of Engineers
190 Fifth Street East
St. Paul, MN 55101-1638
Day phone: 651-290-5276
Fax number:
E-mail: daniel.b.wilcox@mvp02.usace.army