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This is a work in progress. Your input is welcomed and appreciated. Please see the section on Next Steps (page 4) if you have additional information or action items to contribute.

A Framework for Ecosystem Restoration of The Ohio River and its Watershed

Ohio River Foundation

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Introduction

Purpose and Need

This paper is intended to identify and compile different issues necessary to consider ecosystem restoration of the Ohio River. This effort was encouraged and assisted by federal and state agencies, environmental organizations, and watershed scientists. The timing and need driving production of the document was the authorization of an United States Corps of Engineers' Ohio River Ecosystem Restoration Program Integrated Decision Document. Many comments are taken from those filed on the Corps report. This document seeks to expand and improve the framework developed by the Corps of Engineers to create a comprehensive and effective restoration plan.

Background

In October of 2000, the Corps of Engineers received authorization, in the Water Resources Development Act, for their $308 million Ohio River Ecosystem Restoration Program. Unfortunately, it is not comprehensive, not scientifically supported, and not fiscally viable. Serious concerns exist amongst the federal and non-federal partners (see Table 1). Due to scientific and financial weaknesses, the program continues to receive no support from the various state agencies or the U.S. Fish & Wildlife Service. These parties and other non-federal partners are key participants if any restoration efforts are to be successful. These commenters to the Corps' program stated expectations that the end result of the current program will be few, if any, projects.

Furthermore, the Corps' current program focuses primarily on the replacement of approximately 5% of lost natural assets of the river. This focus is misplaced for two reasons. First, replacement of such a small percentage of lost habitat falls short of the comprehensive goal of the program. Second, the replacement strategy focuses solely upon assets lost without regard for current river conditions. Replacing assets that were lost due to inundation or submersion is like putting back a house that was washed away in a storm but there is now 20 feet of water where it once stood. It is a plan that may be losing sight of the river for the water. Any restoration program should consider the current physical and chemical situation of the river and propose changes and efforts that can restore the function and processes that have been altered. Only after that type of scrutiny can an analysis of specific goals and projects proceed.

Any discussion of restoration of the Ohio River must be put in the proper context. The river has changed. The depth has changed. The flow has changed. The mix of species has changed, many are extinct or endangered. Habitat diversity has changed, and much habitat has been lost or degraded. The Ohio River of today is not the same river that it was 150 years ago, and not the same river it was 60 years ago. There was a time when the river could be easily forded in many places. Now those places are more than 20 feet underwater, the increases in water depth caused by dams.

Therefore, unless one is advocating removal of all existing dams--a position this paper does not advocate--restoration of the river is not a reasonable goal. Still, without removing the dams there are measures that can be taken to improve the condition of the river for the benefit of people and wildlife.

A possible obstacle to conservation and restoration is how people identify with the river. Some people still choose to characterize the river as a working river. Increasingly, however, the river is being used for recreation, as a source of drinking water, and as an important asset in people's quality of life. It is worth millions of dollars a year to the tourism and recreation industries. It also provides millions of people with drinking water. It is also considered to contain one of the most diverse populations of freshwater mussels in the country, even though almost half of the original population is now extinct, endangered, or in need of protection. The popular mischaracterization of the river is becoming, slowly but surely, a description of its history, not a reflection of its present or future. Fortunately, the paradigm of how we think about this river and its future are changing with the times. The public and officials are now realizing the status quo must now change.

The first step to positive, sustainable change is to develop a program that is scientifically supportable. To further that goal this document describes some of the parameters and possible goals of such a program. This approach has found support from many of the potential program participants. This document was produced with input from experts from several of the non-federal partners, academia, and the federal government.

The intent of the document is not to be dispositive of all issues, but to be a talking paper for scientific experts to continue to discuss and refine substantive program features. The authors recognize that to truly be an ecosystem program the program would have to look beyond the main stem river to the entire 200,000 square mile watershed. Unfortunately, we are confined to what can and should be accomplished with $308 million rather than a multi-billion dollar watershed program. It will still be important to the future health of the Ohio River, and success of restoration efforts on the main stem, to look to improving and protecting environmental conditions throughout the watershed. Thus, for discussion purposes, watershed issues beyond the main stem that do impact the condition of the river will be mentioned. Those issues may not be addressable by the existing Corps' Ecosystem Restoration program funding; however, they may be discussed in the context of an overarching watershed ecosystem plan.

While funding hurdles will remain for a scientifically supportable approach to ecosystem restoration even after a consensus is reached (see inset), the hurdles are not insurmountable. The Corps' program can be amended to satisfy the concerns of the non-federal partners and scientific experts, and thus, become scientifically and fiscally supportable. If this does not occur, there will be few, if any, projects generated from the current program. Consequently, the public and the river will be poorer for it, and will have missed a golden opportunity to correct decades of degradation of this national resource.

Cost Share Concerns

The cost-share issue is a significant impediment to this program. Under its different authorities (sec. 1135, 206, and others) the Corps is constrained to 65/35 or 75/25 funding regimens. However, projects under those programs are undertaken and so funded without regard to whether they are restoring damage resulting from Corps activities. Typically, when a Corps activity is being constructed a mitigation project accompanies it to offset any environmental harm.

It is pretty clear that the environmental harm to the Ohio River is chiefly resulting from the Corps' placement of the 20 high lift dams and the maintenance of the navigational system. Unfortunately, when constructed the cumulative impact from those dams was not addressed, nor mitigation projects undertaken. Thus, what should have been yesterday's mitigation program is today's restoration program. This result is a 65/35 cost-share, instead of a 100% federally funded program.

Construction of those dams was 100% federally funded. While some benefit inured to the public, the local public should not now be saddled with the responsibility of fixing the problem.
The current cost-share is 65% federal/35% non-federal. For a river within a particular state that may be workable, but is not for a multi-state river, like the Ohio or Mississippi.

Next Steps

Ohio River Foundation is attempting to create a workable framework for real environmental enhancement on the Ohio River. This document is not intended to replace the Corps program, but to work with it and improve upon it. It is the beginning of a process which continues with discussion of the contents of this paper, the Corps document, and other concerns we must face to create a viable and healthy Ohio River Ecosystem.

Input on this document from government agencies, conservation groups, local residents, and others is the foundation for continued improvement of the unified conservation efforts for the Ohio River. If you have anything to add, including information for existing sections, additional action items, or new areas we should focus on, please send your comments. The comments will be included in subsequent revisions. The next revision is anticipated in January, 2003. Watershed meetings will also be held in spring, 2003, to engage in further discussion of topics, issues, projects, and other issues mentioned in this paper.

Send comments by December 31st to:

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Action Items

Introduction

To define a science-based program, we first look to what the river was and now is. In the course of less than one hundred years we have drastically changed the character and condition of the Ohio River. There was a time when a person could walk across places where it was only about one foot deep. But that is no longer the case. In many places it is more than twenty feet deep and has a minimum 9-foot channel maintained by the United States Army Corps of Engineers for commercial navigation purposes. To assist it in achieving its navigation goals the Corps also constructed 20 high-lift dams.

The results of navigation activities on the river, such as the dams and dredging, have come at a high cost to the river. Habitat destruction or degradation, species extinction, hydrology interruption, and migration interruption are just some of the effects. However, because the river is not physically the same river it once was, restoration to its former self is not practical. Also, to haphazardly replace assets that no longer exist is failure to see the forest for the trees.

A scientific effort at any comprehensive restoration of the river should look at the processes and function of the river that have been removed or altered. In analyzing and assessing these changes we can then look to habitat and species issues.

A comprehensive program must also have a long-term monitoring, assessment, and maintenance component. Ultimately, the program's success will be directly dependent upon monitoring and maintenance of any projects. It will be important to have oversight of program activity under the watchful eyes of one agency. Having the responsibility under one agency's purview will avoid the otherwise inevitable breakdown of the program due to one or more project partners' failure to monitor their respective project(s).

In conjunction with establishment of a long-term program, it is imperative that the regulatory program for the river be reviewed. Currently, activities permitted under the program are cumulatively impacting the river corridor. For example, sand and gravel mining continues unabated in the river. The supposed panacea offered is the affixation of conditions to an operating permit. Exploration of alternatives, as employed in other parts of the country, is not being conducted by the regulating or the regulated community. The results are, and will continue to be, ongoing insults to Ohio River habitat. For every step forward on ecosystem restoration there will be a step back.

Furthermore, effects of barge fleeting and other permitted activities are being judged by environmental studies that are, in many cases, more than two decades old. To continue to permit activities based upon old information, especially where new information exists, is inexcusable. These analyses need to be updated, and planning and regulatory functions should no longer rely upon these studies.

If this is to be a river reborn then it must not be managed as it has been in the past. It requires a new way of thinking. Greater economic growth opportunities of tomorrow for the Ohio River are not going to be navigation and industry related, but driven by increased recreation, residential and commercial development.

An Ecosystem Management Plan

The cumulative effects of many projects (large and small) have wrought profound changes upon the habitat, water quality, and species diversity in the Ohio River and its watershed. The dams and their operations, commercial and recreational traffic and their support facilities including harbors, marinas and fleeting areas, sand and gravel dredging, maintenance dredging, riparian development, and tributary alterations have changed the natural life cycle of the river and all life in its watershed.

The Corps' authorized program lacks an overall ecosystem management plan, which should include ongoing monitoring, goals and other activities beyond the completion of projects. Without such a plan the interaction of projects of different programs under different state and federal agencies cannot be designed or monitored, resulting in unintended consequences resulting from inappropriate projects or absence of maintenance.

The Corps' program is one of many programs that would be necessary to improve the Ohio River ecosystem. It is conceivable that the success of that program can be aided by efforts afforded by other existing programs. But an overarching program is needed to make sure different programs and projects work seamlessly together and unforeseen problems are minimized. The interaction of any projects must be planned and considered to avoid the possibility of unintended consequences from upstream projects.

Unlike other restoration projects being discussed or implemented around the country, the Ohio River program stretches across many different state and federal agency jurisdictions. As currently structured, based upon the different policy interpretation by the three Corps Districts in the watershed, and the interests of many other agencies, an alternative methodology or governing structure must be considered for any chance of program success.

To assist in the implementation of any ecosystem restoration program, and to also improve upon the environmental management of the entire Ohio River ecosystem, an ecosystem management plan, similar to that created for the Upper Mississippi River should be considered.

Regulatory Permit Program

Death by a thousand cuts is an apt analogy when describing how rivers can be affected by not one discrete project but by the cumulative effects of many. In order for any restoration project or program to be successful it will be necessary for development and operational activities in the future to be planned. Otherwise, the indiscriminant fleeting of barges, riparian development, and dredging will obfuscate any benefits flowing from a restoration effort. Changing the fee structure for the state 401 and federal 404 programs to better associate the project with the potential or actual environmental harm may be a good first step. However, the first and best check and balance will be for river communities to update local zoning and better plan their riverine development, restoration, and protection.

Barge Traffic and Barge Fleeting

Barge traffic impacts on aquatic biota is a subject that has been studied extensively by the Corps and others (Gloman 1984, Miller et al. 1997). Many impact types have been identified, however the extent of impacts has not been extensively analyzed. Several impact types are dependent upon season, flow stage, and local conditions, while others are constant. Impacts include but are not limited to the following:

- Propeller entrainment and disruption of surface-floating and mid-water eggs and larvae
- Propeller-induced adult mortality
- Mortality of fish dislodged from winter velocity shelters
- Disruption of shoreline nesting by barge wakes
- Siltation on mussels and other benthic biota including aquatic vegetation beds that are impacted by turbidity and re-suspension of near-shore sediments, which retards light penetration and prohibits germination of many submerged aquatic plants
- Spills of pollutants from barges and loading docks
- Direct physical impacts of barges and propeller thrust on benthic biota, especially mussels

There are numerous barge fleeting areas throughout the main stem of the Ohio River and major tributaries, mainly associated with coal powered electrical generating stations, mineral producers, and commercial ports. Since fleeting is generally in shallow shoreline areas, substantial impacts can occur to mussel beds, aquatic vegetation beds, and shoreline fish spawning habitat when these fleeting areas are developed and dredged. Physical impacts of tow traffic are intensified around these areas.

Aggregate Dredging

Much of the upper Ohio River is fed by glacial outlet streams, carrying glacial till material including sand and gravel, into the Ohio. Commercial extraction of this aggregate from the Ohio River has been occurring for the last hundred years. Current technology allows for a single dredge unit to remove up to 375 tons of dredged aggregate per hour. This production rate fills two barges per day.

There are two types of dredge in common use today. Clamshell dredges are similar to Eckman or Petersen substrate samplers familiar to aquatic biologists, two buckets that snap together to collect material. One or more clamshell dredges may be used on a dredging barge. Ladder dredges have a system of buckets on a boom that extends to the river bottom. These dredges can remove material up to 60 feet below the surface.

Dredging activities do direct damage to benthic habitat and communities from disruption and removal of habitat and materials. Many of the effects cited in the sections on habitat can be related to dredging activity. The dredges create deep, hypoxic areas in the bottom of the river, effectively dead zones where oxygen levels are too low to support most aquatic life. The activities re-suspend sediments, rapidly returning nutrients locked in relatively slow sediment trophic cycles to the water column where they can contribute to eutrophication. Other pollutants, including many persistent chemicals that are no longer used in the area, can be resuspended and cause environmental problems including water quality degradation, human health problems, or DELT anomalies in fish.

The dredging activities also require processing and distribution facilities. Aggregates are washed, crushed, sorted by size, stored, and distributed in facilities located on the banks or in the river itself. This takes a large amount of equipment, fuel, additional barges, fleeting sites, and energy. Impacts from the processing include riparian habitat loss, increased erosion, siltation, and downstream sediment transport, accidental but inevitable fuel and chemical spills, and negative effects associated with large barges and tug operations. As significant as they are, the impacts of actual aggregate removal can be overshadowed by the secondary effects of transporting, storing, and processing the material.

Pollution

Although beyond the scope of the current program, a discussion of pollution is necessary. Even if habitat is drastically improved, water quality cannot be neglected. Marginal water quality improvement may come from habitat work; however, real improvement must come from other sources.

Currently, fishing and swimming advisories run the course of the river. Whether caused by contamination from atmospheric deposition of mercury, or fecal coliform from combined sewer overflows, they are impacts that will have to be addressed. Additionally, runoff from roadways and agricultural properties is a watershed problem with impacts felt locally and regionally. The Ohio River contributes approximately 30% of the flow of the Mississippi River, and has been identified as a major source of nutrients. This nutrient contribution is, in part, a potential source of nutrient deposition at the mouth of the Mississippi where a dead zone has been steadily growing.

Riverine Habitat Diversity

A healthy diverse river ecosystem consists of intertwined habitat types and multiple trophic levels. These habitats include bottomland hardwood floodplains, wetlands and rich riparian habitats leading to rivers' edge. These habitats are essential for good water quality and a healthy riverine system of meanderings, debris, islands, sandbars, deep runs and riffles among other characteristics. Each of these habitat types supply some basic function for nutrient cycling, aquatic invertebrates, and aquatic and terrestrial wildlife.

The dynamic environment of the river serves multiple trophic layers. Debris and its accompanying detritus serve as substrate for bacterial colonies often fed upon by aquatic micro- and macroinvertebrates. The macroinvertebrates such as amphipods and aquatic insects use riffles and macrophytes as refuge. Riffles and macrophytes help oxygenate the river allowing further nutrient cycling. These macroinvertebrates in turn serve as food sources for juvenile fish often spawned within the macrophyte beds, riffles, or deep pools. All of these habitats serve as refuge for these same fish and their larger fish and wildlife predators. The island habitats, sandbars, and deep runs also serve as refuge for aquatic wildlife and predators, part of the complex, interwoven trophic levels.

In many places within the Ohio river these refuge areas and food sources have been disrupted, disturbed, or removed, thus destroying the chain of nutrients and trophic layers that should function in the river. Ohio streams provide habitat to 1,400 species of aquatic wildlife (Sanders 2001). Impoundments, channelization, loss of river islands, and damage to the riparian zones have resulted in increased erosion and siltation. The result of this has been the loss of diverse habitats and an increase in slow water exchanging embayments.

Habitat Quality in Tributary Mouths

Impoundment of the Ohio River has raised water levels to transform tributary mouths from stream environments to lake-like environments, often for distances of several miles into the stream's lower reaches. Embayments configuration has induced construction of recreational marinas, which can degrade habitat through intensive boat use and introduction of petroleum pollutants. A number of embayments have silted in due to soil runoff and lack of flow velocity resulting from impoundment. Additionally, silt is often deposited at the embayment mouths during periods of high flow on the main stem of the Ohio River, necessitating dredging activities.

Bottomland and Riparian Forests

Hardwood bottomland forest and riparian forest zones are important in improving water quality and biodiversity. In fact, the conditions present in bottomland forests and riparian zones often support more species and increased species diversity due to the nutrients exchanged and the saturation of the soil (Mitsch & Gosselink 1993). Riverside forest habitats serve as buffers absorbing nutrients and preventing excessive suspended solid loads from silting and clouding river water. Similarly, high flows supplying nutrients replenish these habitats helping to keep productivity high (Mitsch & Gosselink 1993). In general, hardwood bottomland forest and riparian forest zones prevent erosion and moderate water flow and temperature by helping to store water in high flow times (Sanders 2001).

With the removal of these forest habitats, there is an increase in erosion, siltation, and high velocity flows. This leads to an increase in suspended solids, siltation, mud and flow velocity further eroding river banks. This chain of events may result in a muddy high velocity channel with little light penetration for growth of aquatic macrophytes. Increasing nutrient loads from the increased erosion and lack of buffer zone can lead to increased algal growth. Also the aquatic environment is less suited to the reproduction of some fish or macroinvertebrates whose eggs and larvae would smother in the silted conditions.

In the Ohio River flood plain, a typical habitat structure was a matrix of bottomland forest interspersed with components of other wetland types such as sloughs and oxbows. Much of this habitat has been drained and cleared for agriculture, leaving the remainder highly fragmented; however, several high-quality natural areas remain.

Freshwater Mussels in the Ohio River

Freshwater mussels are proportionally the most endangered group of animals in the United States. Despite the water quality improvements in the Ohio River, freshwater mussel populations continue to decline. The primary causative factor in the decline and present endangered status of freshwater mussel species is loss of habitat. Habitat requirements for most species of freshwater mussels are poorly understood. Physical habitat includes at a minimum silt-free substrates and silt-free water, which is greatly affected by barge traffic as previously mentioned.

Life cycle requirements include a specific fish host at critical stages.

Fish Movements and Mussel Dispersal

Before the installation of numerous dams along the Ohio River, fish movement was likely controlled or curtailed only by food, environmental limitations, or tolerance factors associated with specific habitats within the river. Such tolerance factors may have included temperature, dissolved oxygen, or refuge limitations. These factors are influenced seasonally and fish life cycles including diurnal feeding cycles, reproduction, etc. change in response to these environmental factors. Likewise mussels reproduce and behave according to seasonal cycles. Mussel larvae or glochidia depend upon fish movements to colonize river habitat. The glochidia attach themselves to fish gills or fins. Some glochida are host specific relying on certain species of fish to develop this stage of the life cycle. Upon further development the glochidia eventually drop to the stream substrate causing no harm to the fish. Once attached to the substrate, they develop and may live for 70 years (Sanders 2001).

Increased numbers of dams in the Ohio River have prevented fish movement thus preventing both fish and mussels from colonizing and genetically exchanging material throughout the river. This has led to expanses of river with few species of fish or mussels and the need for legal protection of mussels throughout Ohio. Dams prevent migratory/highly mobile fish species from moving freely throughout the river to exploit the variety of habitats necessary for different parts of their life cycles. Lock chambers and high flows facilitate fish passage to some extent, but their operation is generally not designed to facilitate fish passage, and passage may not be available at critical times in the life cycles of migratory fishes. If host fishes are prevented from moving upstream or downstream during critical life stages of mussel reproduction and development, then this mechanism of development and dispersal is disrupted.

Invasive Species Control

Invasive plants and animals in the Ohio River have the potential to displace or prey upon native species, often reducing species richness and habitat quality. Some species (most notably the zebra mussel) can have significant economic impacts as well. Zebra mussels aggressively colonize available hard substrates. They are a serious threat to native mussel populations, and also can be extremely costly to control on industrial and municipal water intake structures.

Unfortunately, eliminating a species after it has become established usually is impossible. However, it may be possible to slow the spread of these unwanted species into our waterways. Ballast water exchange is one method of reducing additional introductions of foreign organisms. Ballast dumping regulations within North American waterways may help to prevent the spread of exotic species. Anglers and others can avoid accidentally spreading these species by dumping bait buckets only in areas where they were filled, and by not taking unusual animals home to add to an aquarium.

There are numerous species of aquatic and terrestrial plants and animals that threaten the Ohio River ecosystem. Refer to the Invasive Species Appendix for an overview of some species of concern to the Ohio River.

Proposed Actions

Introduction

Creating an inventory of areas and issues that need to be addressed is only the first step toward restoring critical ecological function to the river. The Ohio River ecosystem is vast, and the number of individuals, organizations, and government agencies working with the river is numerous. Coordinating effort along the river and among the groups working with it is critical to create meaningful change in the face of limited funding and other challenges. It is important that we determine what actions will best meet our goal of ecosystem restoration, and cooperate to ensure success.

The action items listed below have been taken from comments submitted to the Corps of Engineers Ohio River Ecosystem Restoration Program Integrated Decision Document, and other sources, including personal communications. These are only a few of the possible actions. With this document, the purpose is to present ideas and fuel discussion for improvements to the Corps proposal. In further revisions, the hope is that this list will be refined to form a supportable plan that will guide successful ecosystem restoration.

Regulatory Permit Program

Assist local governments with development of zoning and other land-use planning and regulating controls
Establish and follow an ecosystem-wide plan for economic development and environmental protection that considers interactions and cumulative effects of all projects
Create a fee structure for permitting that accurately reflects costs of potential or actual environmental harm, based on recent economic analysis.

Barge Traffic and Barge Fleeting

Reduce the number of empty barges by charging daily user fees for maintain/storing barges in the Ohio River[1]
Mandate shielded propellers to minimize fish entrainment[2]
Installation of mooring cells or steel and rock pylons built away from the shoreline using best available technology at critical locations so that barges can avoid temporary mooring over mussel beds or against identified shoreline areas[3]
Prohibit the use of abandoned or sunken barges as dock facilities even if grandfathered
Barge unloading facilities must be upgraded to best available technology in order to eliminate pollutant losses to the river and pollutant accumulation on the river bottom.

Aggregate Dredging

Continue research on pavement design, including alternative methods and materials for friction and wearing courses. Develop land-based sources for this material.
Restrict dredging to areas where the least negative impact will occur
Limit the amount of newly dredged area to the amount of area that has fully recovered from prior activity

Pollution

Enforce existing pollution laws under CWA 401, 404, anti-degradation, TMDL, and NPDES laws and regulations
Encourage adoption of Best Management Practices for pollution reduction within watershed
Encourage local authorities to go beyond BMPs and address sustainable development and planning issues.

Riverine Habitat Diversity

Stabilize eroding shorelines of river bank and islands using armoring, removal or placement of submerged dikes (where appropriate) and tree plantings but further evaluate the use of "rip-rap", "T" dikes, and "A" jacks as adequate structure to habitat diversity. It has been suggested that the use of natural materials and native plants be used as opposed to rip-rap and artificial material.[4]
Investigate the usage of high dams implicated in continuing erosion.[5]
Create spawning shoals - restore natural existing and/or recreate artificial spawning shoals and/or use artificial structures in locales not interfering with shipping navigation.[4]
Create vegetated shallows both in the main stem Ohio River and in selected embayments through vegetation planting and construction of shallow protective dikes (if necessary). These habitat types are used by several fish species for spawning and nursery as well as waterfowl and wading birds.[4]
Enhance backwater habitat quality and restore flow to silted side channels, to maintain shallow open water while providing quiet, backwater habitat.[4]
Evaluate tributaries influence on the main stem and facilitate these changes to expand the restoration project to include streams within the 100-year floodplain.[6]
Evaluate and further remove sources of point and non-point source pollution as well as trash.[7]
Use of Biological Indices or long-term monitoring to evaluate success of changes to habitat and environmental.[8,9,10]
Due to the disturbing nature of the suggested program, track and control opportunistic exotic plants and animals.[11]

Habitat Quality in Tributary Mouths

Reforestation of the lower reaches of tributaries to reduce siltation into the embayments and create valuable wildlife habitat[12]
Creation, restoration or enhancement of wetlands in the upper ends of tributary embayments to reduce siltation and create valuable fish and wildlife habitat[1]

Alteration of mainstem and tributary flows so that silt deposition at an embayment mouth is minimized or eliminated[1]

Bottomland and Riparian Forests

Create significant contiguous areas of bottomland forest and riparian forest as a means of increasing fish and wildlife habitat and reducing habitat fragmentation.[4]
Create large contiguous areas of palustrine emergent wetlands. Emergent wetlands are used by a large variety of water birds and other wetland wildlife.[4]
Use locally grown plants to supplement the ecosystem.[10]
Address better the intent of bottomland hardwood forest restoration.[6]
The 981 mile corridor may be underestimating the opportunity and need of the restoration program.[6]
Include the Wetland Reserve (already implemented within areas of the 100 year floodplain) and the Conservation Reserve Programs as part of the restoration project.[6]

Freshwater Mussels in the Ohio River

Installation of markers around shallow mussel beds to reduce direct impacts from barge traffic[3]
Provide the commercial navigation industry with charts showing the location of mussel beds and other sensitive resources, with information concerning why these resources should be avoided[1]
Closely monitor marked and unmarked beds and discontinue if illegal or over-collection occurs[2]
Continue to monitor zebra mussel colonization of native freshwater mussels[1]
Continue to investigate the feasibility of creating mussel habitat in the Ohio River and/or in the lower reaches of its tributaries in areas that presently or historically supported mussel populations[1]
Creating side channels with continuous flow and suitable substrate below existing darns, or creating artificial "islands" with back chutes[1]

Fish Movements and Mussel Dispersal

In partnership with the Service and other agencies, initiate a study that will identify Ohio River migratory fish species and associated mussels. Describe the average seasonal opportunities for upriver movement of migratory fish species on the Ohio River and the potential consequences, if any, of dams on fish and mussel fauna in the Ohio River. This study could be accomplished through: obtaining information on spatial and temporal migratory patterns and swimming abilities of these fish species; compiling information on migratory fishes in the Ohio River and the seasonal timing of fish movements within the Ohio River; evaluating migration behavior with respect to migration purpose; obtaining information of fish travel pathways and swimming performance; estimating hydraulic conditions at dams using data on dam designs; compiling information on dam operations and standard hydraulic engineering equations; describing average water velocities as a function of head; determining average water temperatures as they relate to migration timing/spawning period; compiling models of critical velocity for sexually mature fish; and predicting the average head at dams by week of the year based on historical water elevations.
If warranted, modify lock chamber management to facilitate fish passage at key times. This could be based on the results of the study described above. Or, a demonstration project could be initiated with appropriate monitoring of success.[4]
Modify and create side channels to protect and enhance fish and wildlife habitat.[10]
Modify existing dams and flow to improve habitat vital to fish passage, spawning, and nesting.[10]
Re-evaluate and alter flow, dam, lock management and operation.[13]
Operate dams to create natural flow.[10]
Explore other alternative methods of fish passage, if warranted.[13]

Invasive Species Control

"Invasive species control" is a misnomer. Either we prevent introductions (difficult, if not impossible) or we learn to live with them (merely difficult). Establish regulations on ballast-dumping, transport of exotics, etc. and enforce them. Research and understand impacts of species likely to establish here.
Create recreational boat washing stations, educate boaters on the importance of use.

References for Proposed Actions

[1] Miller, Michael C., University of Cincinnati, Pers. Comm. September, 2002.

[2] Repasky, Robert, Ohio River Foundation, September 26, 2002.

[3] Mignogno, D. M. Litwin, B. Douglas, K. Lammers, and J. Collins. Draft Fish and Wildlife Coordination Act Report. U.S. Fish and Wildlife Service, Cookeville, Tennessee. 2000.

[4] US Fish & Wildlife Service Report Appendix D of Integrated Decision Document & Environmental Assessment. October 2000.

[5] Fremont, Mike. River's Unlimited. September 1, 2000.

[6] Howell, Mason. US Dept. of Agriculture. September 1, 2000.

[7] Wiseman, Sue. Pennsylvania Cleanways. August 7, 2000.

[8] Schulte, Jerry. Ohio River Valley Water Sanitation Commision. September 1, 2000.

[9] Taylor, Willie. US Dept. of Interior. September 20, 2000.

[10] Miller, Kelly. American Rivers. September 1, 2000.

[11] Dent, Donald. Kentucky Nature Preserve Commission. September 11, 2000.

[12] Mignogno, D. M. Litwin, B. Douglas, K. Lammers, and J. Collins. Draft Fish and Wildlife Coordination Act Report. U.S. Fish and Wildlife Service, Cookeville, Tennessee. 2000.

[13] Cogen, Rich. Ohio River Foundation. September 2, 2000.

Appendices

Table 1. Agency Support of Corps of Engineers Program

		Study of an Ecosystem Program Spring 2000		Corps' Program (Authorized Fall 2000)		Objections to Corps' Program										
STATE/US	Agency	**Boiler Plate Support w/ Funding Caveat**	**No Comment Submitted**	**Does NOT Support**	**Supports**	**Deficient Plan**	Impractical Cost-Share	No Exotic or Invasive Species Consideration	Corps Unilateral Approval Authority	Lacks Comprehensive Ecosystem Design	Inefficient Lead Agency (High design and Construction Costs)	100 Year Flood Plain Use Not Detailed	O & M of Nav. System Not Considered(i.e., fish Passage, Flow Modification, etc.)	100 Year Flood Plain Tributaries Not Included	Supports Regionnally Preferraferred Alternative or USFWS Proposal	No Long Term Monitoring Program or Habitat Needs Assessment
IN	Department of Natural Resources ("DNR")	X		X		X	X			X					X	X
KY	Department of Fish and Wildlife Resources	X		X		X	X				X				X	
KY	Natural Resources and Environmental Protection Cabinet, Division of Forestry		X		X											
KY	State Nature Preserves Commission		X			X		X								
OH	DNR	X		X		X	X									
OH	Division of Wildlife		X	X		X	X								X	
WV	Division of Natural Resources	X		X		X	X				X				X	
IL	DNR		X	X		X	X	X	X	X						
PA	Beaver County Planning Commission		X	X		X	X									
US	U.S. Department of Agriculture		X			X						X		X		
US	U.S. Department of the Interior, Fish & Wildlife		X	X			X			X			X		X	X
KY	Div. of Env. Protection				X*											
	ORSANCO				X*											

* agency will not play major role in development or implementation of projects

Invasive Species Appendix

Zebra Mussels

According to the Ohio Sea Grant Foundation Fact Sheet 045, zebra mussels (*Dreissena polymorpha*) were first discovered in Lake St. Clair in 1988. Within one year, they had colonized the surfaces of nearly every firm object in western Lake Erie. By December 1993, zebra mussels have been found in all of the Great Lakes and in waterways in 18 states and two provinces. Major river systems that now have zebra mussels include the St. Lawrence Seaway and the Hudson, Illinois, Mississippi, Ohio, Arkansas, and Tennessee rivers. Zebra mussels also have been reported in several inland lakes, including Lake Wawasee in Indiana; Hargus Lake and White Star Quarry in Ohio; Kentucky Lake and Dale Hollow Reservoir in Kentucky; at least 10 lakes in Michigan; and Balsam, Rice, and Big Bald Lakes in Ontario.

Dreissena polymopha are native to an area in Russia near the Caspian Sea. Canals built during the late 1700s allowed the mussels to spread throughout eastern Europe. During the early 1800s, canals were built across the rest of Europe, which made bulk shipping much easier but also allowed rapid expansion of the zebra mussel's range. By the 1830s, the mussels had covered much of the continent and had invaded Britain.

The introduction of zebra mussels into the Great Lakes appears to have occurred in 1985 or 1986, when one or more transoceanic ships discharged ballast water into Lake St. Clair. The freshwater ballast, picked up in a European port, may have contained zebra mussel larvae and possibly juveniles; or, adult mussels may have been carried in a sheltered, moist environment, such as a sediment-encrusted anchor or chain. The faster speed of today's ships provides exotic species a better chance of surviving the trip across the Atlantic. Being a temperate, freshwater species, the zebra mussels found the plankton-rich Lakes St. Clair and Erie to their liking.

The rapid spread and abundance of both mussels can be partly attributed to their reproductive cycles. A fully mature female mussel may produce up to one million eggs per season. Egg release starts when the water temperature warms to about 54 degrees Fahrenheit (12 degrees Celsius) and continues until the water cools below 54 degrees Fahrenheit. In Lake Erie, spawning may begin as early as May and end as late as October, but it peaks during July and August at water temperatures above 68 degrees Fahrenheit (20 degrees Celsius).

Eggs are fertilized outside the mussel's body and within a few days develop into free-swimming larvae called veligers. Veligers swim by using their hair-like cilia for 3 to 4 weeks, drifting with the currents. If they don't settle onto firm objects in that time, they die; and the vast majority actually suffer this fate. It is estimated that only 1 to 3 percent survive to adulthood. Those that find a hard surface quickly attach and transform into the typical, double-shelled mussel shape; they are then considered to be juveniles.

Mussels become adults when they reach sexual maturity, usually within a year. They grow rapidly, nearly an inch in their first year, adding another 1/2 to 1 inch their second year. European studies report mussels may live 4 to 6 years. Three years seems to be the maximum life span in Lake Erie, but there is insufficient data to know what to expect in other North American bodies of water.

Zebra mussels generate a tuft of fibers known as a byssus, or byssal threads, from a gland in the foot. The byssus protrudes through the two halves of the shell. These threads attach to hard surfaces with an adhesive secretion that anchors the mussels in place. Small juveniles can actually break away from their attachments and generate new, buoyant threads that allow them to drift again in the currents and find a new surface. Zebra mussels can colonize any firm surface that is not toxic: rock, metal, wood, vinyl, glass, rubber, fiberglass, paper, plants, other mussels-the surface need only be firm. Beds of mussels in some areas of Lake Erie now contain more than 30,000-and sometimes up to 70,000-mussels per square meter.

Zebra mussel colonies show little regard for light intensity; hydrostatic pressure (depth); or even temperature, when it is within a normal environmental range. The life stage most sensitive to low temperature is the veliger stage, and juveniles are more sensitive than adults. All life stages are sensitive to low levels of dissolved oxygen, particularly as temperature increases. Colonies grow rapidly wherever oxygen and particulate food are available and water currents are not too swift (generally less than 6 feet per second). Thus, colonies are rare in wave-washed zones, except for sheltered nooks and crevices. In most European lakes, the greatest densities of adult mussels occur at depths ranging from 6 to 45 feet.

Zebra mussels can also colonize soft, muddy bottoms when hard objects deposited in or on the mud-such as pieces of native mussel shells-serve as a substrate (base) for settling veligers. As a few mussels begin to grow, they in turn serve as substrate for additional colonization, forming what is known as a druse. Quagga mussels can live directly on a muddy or sandy bottom and appear more tolerant of low temperatures and extreme depths than zebra mussels.

Zebra mussels disrupt the aquatic food chain. Literature reviews suggest that they eat mostly algae in the 15-40 micrometer size range. Each adult mussel, however, is capable of filtering 1 or more liters of water each day. They remove nearly all particulate matter, including phytoplankton and some small forms of zooplankton, including their own veligers. Instead of passing any undesired particulate matter back into the water, mussels bind it with mucous into loose pellets called pseudofeces that are ejected and accumulate among the shells in the colony.

By removing significant amounts of phytoplankton from the water, zebra mussels remove the food source for microscopic zooplankton, which in turn are food for larval and juvenile fishes and other plankton-feeding forage fish. These forage fish support sport and commercial fisheries. This competition for phytoplankton, the base of the food chain, could have a long-term negative impact on Great Lakes fisheries. Observations of the effects of zebra mussel filtration upon the food base for fish communities are still inconclusive.

Most rocky areas in Lake Erie are almost completely covered with mussels several inches deep. In laboratory observation, the accumulation of pseudofeces in these beds creates a foul environment. As waste particles decompose, oxygen is used up, and the pH becomes very acidic. Biologists were initially concerned that such poor environmental conditions could potentially hinder normal egg development of reef-spawning fish (walleye, white bass, and smallmouth bass). However, large hatches of walleye documented in Lake Erie in 1990, 1991, and 1993 suggest that flushing water currents are sufficient to prevent environmental deterioration.

Zebra mussels readily encrust native North American mussels (family Uniodidae). In Lakes St. Clair and Erie, heavy fouling by zebra mussels has severely reduced populations of native mussels. Some native mussel species are more tolerant to fouling than others, but even for these resistant species, zebra mussel encrustation leads to reduced energy reserves and vulnerability to other environmental stressors, such as extreme water temperatures, lack of food, or parasites and disease. As zebra mussels spread, biologists are concerned that populations of native mussels will decline, and perhaps some of the rarer species may be completely eliminated.

Zebra mussels apparently have contributed to the improvement of Lake Erie's water clarity, which began with the initiation of the phosphorus abatement programs of the 1970s. Shallow embayments are being recolonized by rooted, aquatic plants, since turbidity no longer shades them out. According to Dr. Ruth Holland Beeton, who conducted research near Stone Laboratory on Lake Erie in the 1970s, before phosphorus abatement programs, water clarity was approximately 3 feet, improved to 6 to 10 feet in the 1980s after a decade of reduced phosphorus inputs, and improved again to 10 to 17 feet in the early 1990s, after zebra mussels colonized the area.

The prodigious filtering of water by zebra mussels may increase human and wildlife exposure to organic pollutants (PCBs and PAHs). Early studies have shown that zebra mussels can rapidly accumulate organic pollutants within their tissues to levels more than 300,000 times greater than concentrations in the environment. They also deposit these pollutants in their pseudofeces. These persistent contaminants can be passed up the food chain so that any fish or waterfowl consuming zebra mussels will also accumulate these organic pollutants. Likewise, human consumption of these same fish and waterfowl could result in further risk of exposure. The implications for human health are unclear.

The zebra mussel's proclivity for hard surfaces located at moderate depths has made water intake structures, such as those used for power and municipal water treatment plants, susceptible to colonization. Since 1989, some plants located in areas of extensive zebra mussel colonization have reported significant reductions in pumping capabilities and occasional shutdowns.

Beaches are also affected by zebra mussels. The sharp-edged mussel shells along swimming beaches can be a hazard to unprotected feet. By autumn of 1989, extensive deposits of zebra mussel shells were on many Lake Erie beaches. The extent of these deposits varied with successive periods of high wave activity.

Lake-wide control of zebra mussels is not yet feasible. The European community, after two centuries of infestation, and the Great Lakes community, after years of infestation, haven't been able to develop a chemical toxicant for lake-wide control that isn't deadly to other aquatic life forms.

In some parts of Europe, large populations of diving ducks have actually changed their migration patterns in order to forage on beds of zebra mussels. The most extreme case occurred on Germany's Rhine River. Overwintering diving ducks and coots consumed up to 97 percent of the standing crop of mussels each year. High mussel reproduction rates, however, replenished the population each summer.

In North America, the species most likely to prey on relatively deep beds of zebra mussels are scaup, canvasbacks, and old squaws. But populations of these species are quite low; in fact, canvasbacks are so rare that they are protected. In the Great Lakes, diving ducks are migrating visitors, pausing only to feed during north-land southward migrations. However, Canadian researchers have documented increasing numbers of migrating ducks around Pt. Pelee in western Lake Erie, and these ducks were observed to be feeding heartily on zebra mussels. In southern Lake Michigan, zebra mussels encrusting an underwater power plant intake attracted flocks of lesser scaup. Unfortunately, some were pulled into the intake pipe and drowned. The stomachs of these dead scaup were full of zebra mussels. Mallard ducks also are frequently observed foraging on zebra mussels on shoreline rocks and shallow structures. In addition, freshwater drum, or sheepshead, are known to feed substantially on zebra mussels; and yellow perch have been observed feeding on juveniles, particularly when they are detached and drifting.

One novel approach to controlling zebra mussel populations is by disrupting the reproductive process. Zebra mussel eggs are fertilized externally; therefore, males and females must release their gametes (sperm and eggs) simultaneously. After release, zebra mussel sperm remain viable for only a short time-perhaps only a few minutes. Disrupting the synchronization of spawning by males and females may effectively reduce the numbers of fertilized eggs. Researchers are currently studying the environmental cues and physiological pathways that coordinate zebra mussel spawning activity.

Recently, Ohio River populations of zebra mussels have declined in some areas (M. C. Miller personal communication).

Purple Loosestrife

Purple loosestrife is a dense, herbaceous, non-native perennial that grows up to 7 feet tall. With an attractive purple to magenta flowers, purple loosestrife cultivars re popular ornamental. The flowers bloom in long spikes with 1-50 square stems per plant. One plant can produce over 100,000 seeds. The linear green leaves are opposite along the stem. This plant has a woody taproot and fibrous rhizomes that form thick mat. Purple loosestrife is similar to the native loosestrife Lythrum alatum ,however, L. alatum has alternate leaves on the upper stem, wider spaced flowers and is smaller in size. Looking closely t both flowers L.salicaria has 12 stamens and L. alatum has 4-6 stamens. Currently in Ohio, Lythrum salicaria is illegal to sell. However, commercially viable cultivars like L.virgatum can cross pollinate with wild populations of purple loosestrife and produce viable seed (Ohio Division of Natural Areas and Preserves INVASIVE PLANTS OF OHIO Fact Sheet 4).

Purple loosestrife occurs mostly in wetland environments, but when well established, it can survive drier conditions. Wetlands impacted by this plant include marshes, fens, wet meadows, stream and river banks, and lake shores.

Purple loosestrife was introduced to North America from Europe and Asia in the early 1800s as contaminant in ship ballast, as well as a medicinal herb and garden plant. It escaped and became a pioneer species of newly constructed waterways and canals. Purple loosestrife occurs throughout the United States with its heaviest concentrations in the northeast. Although Lythrum salicaria is currently no longer available to purchase, cultivars continue to be distributed. In Ohio, this plant can be found throughout the state, although it is more established in the northern half.

Purple loosestrife adapts readily to natural and disturbed wetlands. As it establishes and expands, it out-competes and replaces native grasses, sedges, and other flowering plants that provide a higher quality source of nutrition for wildlife. Purple loosestrife forms dense, homogeneous stands that restrict native wetland plant species and reduces habitat for waterfowl. Seed production is as prolific as the vegetative growth. Seeds are widely distributed by animals, machinery and people and in waterways.

Kudzu

Kudzu (*Pueraria montana*) is a climbing, semi-woody, perennial vine in the pea family. Deciduous leaves are alternate and compound, with three broad leaflets up to 4 inches across. Leaflets may be entire or deeply 2-3 lobed with hairy margins. Individual flowers, about 1/2 inch long, are purple, highly fragrant and borne in long hanging clusters. Flowering occurs in late summer and is soon followed by production of brown, hairy, flattened, seed pods, each of which contains three to ten hard seeds (Plant Conservation Alliance—online at www.nps.gov/plants/alien/fact/pulo1.htm).

Kudzu was introduced into the U.S. in 1876 at the Philadelphia Centennial Exposition, where it was promoted as a forage crop and an ornamental plant. From 1935 to the mid-1950s, farmers in the south were encouraged to plant kudzu to reduce soil erosion, and Franklin D. Roosevelt's Civilian Conservation Corps planted it widely for many years. Kudzu was recognized as a pest weed by the U.S. Department of Agriculture and, in 1953, was removed from its list of permissible cover plants

Kudzu kills or degrades other plants by smothering them under a solid blanket of leaves, by girdling woody stems and tree trunks, and by breaking branches or uprooting entire trees and shrubs through the sheer force of its weight. Once established, Kudzu plants grow rapidly, extending as much as 60 feet per season at a rate of about one foot per day. This vigorous vine may extend 32-100 feet in length, with stems 1/2 - 4 inches in diameter. Kudzu roots are fleshy, with massive tap roots 7 inches or more in diameter, 6 feet or more in length, and weighing as much as 400 pounds. As many as thirty vines may grow from a single root crown.

Kudzu is common throughout most of the southeastern U.S. and has been found as far north as Pennsylvania. Kudzu grows well under a wide range of conditions and in most soil types. Preferred habitats are forest edges, abandoned fields, roadsides, and disturbed areas, where sunlight is abundant. Kudzu grows best where winters are mild, summer temperatures are above 80 degrees Fahrenheit, and annual rainfall is 40 inches or more.

For successful long term control of kudzu, the extensive root system must be destroyed. Any remaining root crowns can lead to reinfestation of an area. Mechanical methods involve cutting vines just above ground level and destroying all cut material. Close mowing every month for two growing seasons or repeated cultivation may be effective. Cut kudzu can be fed to livestock, burned or enclosed in plastic bags and sent to a landfill. If conducted in the spring, cutting must be repeated as regrowth appears to exhaust the plant's stored carbohydrate reserves. Late season cutting should be followed up with immediate application of a systemic herbicide (e.g., glyphosate) to cut stems, to encourage transport of the herbicide into the root system. Repeated applications of several soil-active herbicides have been used effectively on large infestations in forestry situations. Efforts are being organized by the U.S. Forest Service to begin a search for biological control agents for kudzu.

Reed canary grass

Reed canary grass (*Phalaris arundinacea*) is a 2-9 foot tall, non-native grass with flat, rough-textured, tapering leaves from 3½-10 inches long. The stem is hairless and stands erect. One of the first grasses to sprout in the spring, reed canary grass produces a compact panicle 3-16 inches long that is erect or slightly spreading. The flowers are green to purple early in the season and change to beige over time. This grass forms a thick rhizome system that quickly dominates the soil. There is some debate as to the origin of the species. Sources document native and non-native genotypes of reed canary grass. The non-native strain is thought to be more invasive than the native strain (Ohio Division of Natural Areas and Preserves INVASIVE PLANTS OF OHIO Fact Sheet 6).

Reed canary grass occurs in wetlands such as marshes, wet prairies, wet meadows, fens and stream banks. This grass quickly dominates areas of wet, exposed soils and can also grow in areas of standing water by producing special roots off the submersed portion of the stem. Reed canary grass can also grow on dry soils in upland sites and under partial shade; however, it does best in full sun and moist soils.

The non-native strain of reed canary grass was introduced from Europe and Asia in the early 1800s. It was selected for its vigor as a forage crop and erosion control. In Ohio, reed canary

grass is widespread throughout the state.

Reed canary grass reproduces vegetatively as well as by seed. It aggressively dominates an area and displaces the native vegetation replacing it with a monoculture of grass. This species of grass produces little in the form of shelter and food for wildlife, although it has been used for bank stabilization in wetlands and waterways. Seeds are easily dispersed by means of waterways, animals and people.

Snakehead

The northern snakehead is native to eastern Asia and has been introduced to western Asia and eastern Europe during the 20th century (Courtenay et al., 2002, cited by Maryland Department of Natural Resources). It has been successful in establishing reproducing populations in a variety of freshwater environments at least in Japan and in western Asia, well outside of its native range. Only in the last few years have sporadic observations of this species occurred in the United States, including waters in Florida and Massachusetts. In addition, illegally imported live specimens of the northern snakehead have been confiscated by law enforcement officials in Florida and Texas. The likely source of northern snakeheads that have been found in U.S. waters is live food fish markets.

The northern snakehead has been found to live in stagnant shallow ponds, swamps and slow streams with mud or vegetated substrate, with temperatures ranging from 0 to >30oC. The diets of adults are mostly made up of small fish, although some may be as large as one-third of the predator's body length. In addition to fish, the northern snakehead has been known to eat frogs, crustaceans, and insect larvae. It reaches sexual maturity in 2 to 3 years and approximately 30-35 cm (12-14 inches) in length and maximum size exceeds 85 cm (33 inches). Females release 1,300 to 15,000 eggs per spawn, which can occur 1 to 5 times per year. The floating eggs take 28 hours to hatch at 31°C, 45 hours at 25°C and much longer at cooler temperatures. Larvae remain in a nest guarded by their parents until yolk absorption is complete at approximately 8 mm in length. At approximately 18 mm the young begin feeding on small crustaceans and fish larvae. The northern snakehead has been reported to be an obligate air-breather, which means that it can live in oxygen-depleted waters by gulping air at the water's surface and survive several days out of water if kept moist.

The recent appearance of a reproducing population of northern snakeheads in a spring-fed Maryland pond has federal and state wildlife officials as well as the public alarmed about the potential impacts to game species and the resiliency of the aquatic ecosystems. This situation reminds us all of the vulnerability of our wild habitats and the consequences of the actions of a single individual can have on an entire ecosystem.

Common reed grass

Common reed grass is a tall, invasive perennial wetland grass ranging in height from 3-15 feet. The plant produces horizontal rhizomes that grow on or beneath he ground and produce roots and vertical stalks (culms). The rhizomes allow the plant to form large colonies. The stiff, hollow stalks support leaf blades which are smooth, broad and flat (1 ½-2 inches wide). A large terminal inflorescence (panicle)is produced in late June and is purplish in flower and grayish in fruit. Large quantities of seed are produced, however, most or all of the seed may not be viable (Ohio Division of Natural Areas and Preserves INVASIVE PLANTS OF OHIO Fact Sheet 5).

Common reed grass is prevalent in open wetland habitats and favors alkaline and brackish waters. These areas include drier borders and elevated areas of brackish and freshwater marshes, along riverbanks and lake shores and almost anywhere there are slight depressions that hold moisture. The species is particularly frequent in disturbed or polluted soils along roadsides, ditches and dredged areas. It is also known to tolerate highly acidic conditions.

Some populations of common reed grass are more invasive than others and may be non-native. It is suspected that the non-native, aggressive strain of common reed grass was introduced to North America in the early 20th century. It can now be found throughout the United States. In Ohio, this strain is primarily found in the northern par of the state, however it has recently progressed south.

Common reed grass can be considered a natural component of some undisturbed wetlands. However, the invasive strain grows aggressively in areas that are disturbed or stressed by pollution, dredging or other alteration of the natural hydrologic regime. Invasive stands of common reed grass eliminate diverse wetland plant communities, providing little food or shelter for wildlife.

Ruffe

According to the Ohio Sea Grant Foundation Fact Sheet 064, The ruffe (*Gymnocephalus cernuus*), is a small but aggressive fish species native to Eurasia. It was introduced into Lake Superior in the mid-1980s in the ballast water of an ocean-going vessel.

Because the ruffe matures quickly, has a high reproductive capacity, and adapts to a wide variety of environments, it is considered a serious threat to commercial and sport fishing. It also has the potential to seriously disrupt the delicate predator/prey balance vital to sustaining a healthy fishery.

Explosive growth of the ruffe population means less food and space in the ecosystem for other fish with similar diets and feeding habits. Because of this, walleye, perch, and a number of small forage fish species are seriously threatened by continued expansion of the ruffe's range.

While it is too early to tell exactly how the ruffe will affect other fish in the St. Louis River, its numbers have increased dramatically while other species, especially emerald shiner, yellow perch, and trout perch, have declined. It would be easy to blame all of these changes on the ruffe, but some could be the result of natural fluctuations, fishing pressure, or fisheries management practices.

Ruffe were first collected in the Duluth/Superior harbor area of Lake Superior in 1986 during a routine analysis of the local fishery. Although officially identified in 1987, ruffe were probably introduced about 1985. In the short time since its introduction, the ruffe has become the most numerous fish in the St. Louis River. As of 1993, the ruffe has spread east along Lake Superior's coast to the Sand River in northern Wisconsin, and north to Thunder Bay, Ontario. Ruffe probably moved across the lake to Thunder Bay via interlake ballast exchange. So far, Lake Superior is the only place ruffe were found in the Western Hemisphere. The ruffe's ability to move from lake to lake in ships' ballast, however, will make it difficult to prevent the fish from expanding its range to the lower Great Lakes.

Fisheries managers first tried to control ruffe by increasing their number of predators, especially walleye and northern pike. They did this by limiting sport catches of these species, and stocking walleye and northern pike. Early results of the predator stocking program have been disappointing, but it is too early to judge the effectiveness of this approach since fish often take several years to switch to a new food source.

Researchers analyzed stomach samples of the predators and found very few ruffe in walleye and northern pike stomachs. Bullheads appear to be the only species that consistently eat ruffe. Research suggests that predators stocked to control ruffe may not eat them because they prefer soft-rayed shiners and small hard-rayed fish like darters and young perch. This could explain the increase in ruffe and reduction in these forage species.

The battle to keep the ruffe from spreading is being fought on several fronts. For instance, poison will be used to eradicate ruffe when the fish is found in small numbers at a new location. Poisoning was considered for areas where the ruffe is firmly entrenched, but was ruled out. As one researcher said, "The cost would have been staggering, and it probably would have failed. All it takes is one pair of ruffe to survive and the problem starts all over again."

Chemical controls that kill ruffe but leave other species unharmed are being sought. For instance, researchers are exploring the possibility that the ruffe is susceptible to low doses of the lampricide TFM, a chemical that in low doses kills lamprey but not other fish. Recent field tests have shown that treating streams with TFM for lamprey control kills a high percentage of the ruffe. TFM, however, is registered for use on lamprey only. Fisheries managers have also considered a program to net and destroy as many ruffe as possible in the St. Louis River, on the theory that the ruffe's range would not expand as rapidly if populations were controlled.

Fisheries managers will plan eradication and control measures for Lake Superior rivers and streams on a case-by-case basis. The overall goal, however, is to contain ruffe to the western part of Lake Superior.

To keep ruffe from spreading to the other Great Lakes, the Lake Carriers Association developed voluntary guidelines for handling ballast water in Great Lakes ships. Under these new guidelines, ships going to other Great Lakes are required to exchange ballast in deep (at least 240 feet) water west of a demarcation line between Ontonagon, Michigan and Grand Portage, Minnesota and at least five miles from the south shore of Lake Superior.

The ruffe can thrive in a wide range of temperatures and habitat. It has a faster first-year growth rate than most of its competitors. It starts reproducing at age two or three, but can reproduce after the first year in warmer waters. An average female can produce 13,000 to 200,000 eggs per season. Due in part to its hearty reproductive rate, ruffe populations can explode quickly.

In Europe, the ruffe is found in fresh and brackish (salinity less than 3-5 ppm) waters and in all types of lakes--from deep, cold, and clear to shallow, warm, and full of nutrients. In rivers, the ruffe prefers slower-moving water; in lakes, it prefers turbid areas and soft bottoms, usually without vegetation.

Unlike other perch species, the ruffe is more tolerant of murky, nutrient-rich (eutrophic), conditions (see graph below). Like walleye, the ruffe spends its days in deeper water and moves to the shallows to feed at night.

To avoid predators, the ruffe prefers darkness. Although it has poor eyesight, the ruffe's head has a well developed system of bone canals that contain sensory organs called "neuromasts." Such organs are common among perch species in early life stages, but they tend to atrophy as the fish reach adulthood. In adult ruffe, however, these sensory organs continue to detect water vibrations given off by both predators and prey.

In Europe, the ruffe is known to eat other fish's eggs, but its main diet consists of small water insects and larvae found primarily in the bottom (benthic) layer of the water column. In the St. Louis River, an important hatchery area for many Lake Superior fish, ruffe stomach samples reveal few fish eggs. But the ruffe is an opportunistic feeder and will eat almost anything. So far, the ruffe seems to have the same basic diet of insects and larvae it has in its native Eurasian environment. While fish eggs do not seem to be part of the ruffe's regular diet in the St. Louis River, that's no guarantee fish that eggs won't be part of the ruffe's diet in other North American habitats.

Whether ruffe feed on fish eggs may be less important than whether ruffe eat the food preferred by other fish. Because of its sheer numbers and the variety of food it eats, the ruffe will reduce food sources for many fish species. If the ruffe, in turn, is not eaten by native predators--or if young predator fish starve before they get big enough to eat ruffe, the result will be an explosion of ruffe and population bottlenecks in other species.

For example, recently hatched yellow perch must consume large amounts of plankton in a fairly short time in order to grow to the next stage. At stage two, yellow perch must eat larger food items--small crustaceans and insects--abundant near the bottom of the water column. Only after passing these two hurdles do yellow perch get big enough to eat other fish. If the ruffe interrupts either growth stage by reducing the food supply just as the yellow perch need it (an ecological bottleneck), the yellow perch population will crash.

Round Goby

According to the Ohio Sea Grant Foundation Fact Sheet 065, In the last decade, considerable public and scientific attention has been focused on the zebra mussel, an aquatic invader in the Great Lakes. The zebra mussel actually is a recent addition in a long history of invaders, ranging from rainbow smelt, alewife, and lamprey to the recently introduced ruffe and spiny water flea. Now another foreign species has begun to spread throughout the inland waterways. The round goby (*Neogobius melanostomus*) was discovered in the St. Clair River, the channel connecting Lake Huron and Lake St. Clair, in 1990. This species comes from the same area of the world as the zebra mussel (around the Black and Caspian Seas). Presumably, they arrived the same way as zebra mussels: in ballast water discharged by transoceanic vessels.

In 1993 it began to spread to other waterways, and the likelihood of its spreading to watersheds such as the Mississippi River drainage system has raised concerns over its potential effects on North American native species and ecosystems.

Exotic species, such as the round goby, have destroyed and disrupted aquatic communities across the nation. The entry of another foreign invader to the already abused Great Lakes environment is an unwelcome addition to the plethora of other problems, including habitat destruction, overfishing, pollution, and loss of native species.

Round gobies possess four characteristics that make them effective invaders.

Round gobies are aggressive, pugnacious fish. They feed voraciously and may eat the eggs and fry of native fish such as sculpins, darters, and logperch. They will aggressively defend spawning sites in rocky habitats, thereby restricting access of native species to prime spawning areas.

They have a well-developed sensory system that enhances their ability to detect water movement. This allows them to feed in complete darkness, and gives them a major competitive advantage over native fish in the same habitat.

They are robust and are able to survive under degraded water quality conditions. This ability and their propensity to swim into holes and other crevices probably allowed round gobies to enter and survive in the ballast water of ships.

Round gobies spawn over a long period during the summer months so they can take advantage of optimal temperature and food conditions. Females mature at 1 to 2 years and males mature at 3 to 4 years. Spawning can occur frequently from April through September. Each female produces from 300 to 5,000 large (4 x 2.2 mm [0.16 x 0.09 inch]) eggs; these eggs are deposited in nests on the tops or undersides of rocks, logs, or cans; they subsequently are guarded by the males.

Round gobies prefer a rocky or gravel habitat; they hide in crevices or actively burrow into gravel when startled. In the Black and Caspian Seas, gobies generally inhabit the nearshore area, although they will migrate to deeper water (up to 60 m [197 feet] depth) in winter. They also are found in rivers and in slightly brackish water. In Europe, the diet of round gobies consists primarily of bivalves (clams and mussels) and large invertebrates, but they also eat fish eggs, small fish, and insect larvae. In the United

States, studies have revealed that the diet of round gobies includes insect larvae and zebra mussels

Gobies may compete successfully with native benthic fish such as sculpins and darters. Substantial reductions in local populations of sculpins already have been reported from areas in which gobies have become established. Gobies may compete with sculpins for food or drive them from their preferred habitat and spawning area. In laboratory experiments, gobies will eat darters and other small fish. Of perhaps more concern is their predation on the eggs and fry of lake trout, which has been observed in laboratory experiments. The reproduction of the lake trout in the Great Lakes is extremely limited.

On the positive side, round gobies eat large quantities of zebra mussels, an invader that is causing an increasingly large number of problems because of its huge reproductive output. Zebra mussels are an important component of the gobies' diet in their native range; and, in laboratory studies in North America, a single round goby can eat up to 78 zebra mussels a day. However, it is unlikely that gobies alone will have a detectable impact on zebra mussels. The round goby is expected to be one of several species (including ducks, crayfish, diseases, and other fish species) that eventually will reduce the abundance of zebra mussels. Gobies are preyed upon by several sport fish species (e.g., smallmouth and rock bass, walleyes, yellow perch, and brown trout). Because the diet of round gobies consists predominately of zebra mussels, there may be a direct transfer of contaminants from gobies to sport fish.

Gobies affect anglers in several ways. These fish aggressively take bait from hooks. Anglers in the Detroit area have reported that, at times, they can catch only gobies when they are fishing for walleye