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Potential for Introduction of Invasive Species into Louisiana from Illinois River Dredged Material

Judy F. Shearer

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Judy F. Shearer

Environmental Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

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Abstract: Through human and natural activities, land loss in the Louisiana Coastal Area has exceeded 1.2 million acres since the 1930s. Restoration of the region will require new technologies and significant inputs on many fronts. One innovative proposal to aid in restoration efforts has been to transport dredged sediments from the Illinois River to Louisiana for land building and marsh restoration. Of concern in such a project is the potential for transporting invasive species from one state to another via the sediment or the transport vehicles. This report examines the likelihood of invasive species introduction and movement through such a project.

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Preface

The work reported herein was conducted as part of the Louisiana Coastal Area Science and Technology Program (LCA S&T). The LCA is sponsored by the U.S. Army Corps of Engineers (HQUSACE) and the Louisiana Department of Natural Resources. Dr. Barbara A. Kleiss, Environmental Laboratory (EL), U.S. Army Engineer Research and Development Center (ERDC), was the interim director of the LCA S&T during this investigation.

The principal investigator for the study and the author of this report was Dr. Judy F. Shearer, Aquatic Ecology and Invasive Species Branch (AEISB), Ecosystem Evaluation and Engineering Division (EEED), EL. Technical reviews were provided by Pamela Bailey and Dr. Barry S. Payne, both of EEED.

The information in this report concerning biota in Illinois River sediments was determined through surveys conducted by Illinois Natural History Survey personnel unless otherwise noted. On site plant surveys were conducted by Allen Plocher, Wetland Groups Coordinator; Brian Wilm, staff biologist; and Michael Murphy, Critical Trends Assessment Program. Murphy also conducted the seed bank studies of Illinois River sediments. Kip Stevenson and Todd Koel provided information on macroinvertebrates in Peoria Lake. Kevin Cummings provided comments on the Chinese mystery snail. Robert Schanzle and Mike Cochran of the Illinois Department of Natural Resources provided the information on mussels in the Illinois River at or near the dredge sites.

This investigation was performed under the general supervision of Dr. Timothy E. Lewis, Chief, AEISB; Dr. David J. Tazik, Chief, EEED; and Dr. Elizabeth C. Fleming, Director, EL.

COL Richard B. Jenkins was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.

Acronyms

DNA	Deoxyribonucleic Acid
DNR	Department of Natural Resources
EWM	Eurasian Watermilfoil
EWRR	Early Warning Rapid Response
LCA	Louisiana Coastal Plan
RFLP	Restriction Fragment Length Polymorphism
SMP	State Management Plan for Aquatic Invasive Species in Louisiana
USX	U.S. Steel South Works
USDA	United States Department of Agriculture

1 Introduction and Background

Introduction

The coastal wetlands of Louisiana account for 90 percent of the total coastal marsh occurring in the United States (U.S. Army Engineer District 2004). Through human and natural activities, land loss in this region has exceeded 1.2 million acres since the 1930s and, unless stemmed, loss is estimated to continue at a rate approaching 6,600 acres per year (U.S. Army Engineer District 2004). The natural deltaic processes of sediment and nutrient deposition that created and sustained Louisiana's wetlands for thousands of years have been inexorably altered by human activity and economic development. The resulting changes in hydrology, combined with the loss of land-building inputs (fresh water, sediment, and nutrients), have meant that land loss exceeds creation to such an extent that the coastal ecosystem is no longer a sustainable resource. Restoration in partial compensation of these losses will require innovative technologies and significant inputs on many fronts. One innovative proposal to aid in restoration efforts has been to transport dredged sediments from the Illinois River to Louisiana for land building and marsh restoration.

In recent years Illinois has embarked on extremely innovative and successful pilot projects to return displaced soil deposited in the Illinois River over the past 100 years back to the land (Marlin and Darmody 2005). Deposition has degraded the backwater lakes and side channels of the Illinois River resulting in a capacity loss exceeding 70% according to a 1985 survey (Demissie et al. 1992). Very few areas outside the main channel and maintained marinas exceed 0.61 m in water depth (Marlin 2004). In some parts of Peoria Lake, sediment deposits vary in depth from a few feet to over 20 feet (Marlin 2002). Examination of the deposited sediments by the U.S. Army Corps of Engineers found them to be primarily derived from Illinois topsoil and lacking the usual contaminants from urban and industrial areas. Core studies conducted in 1998–2000 indicated that mean composition values of the sediments were 6.6% sand, 40% silt, and 54% clay (Cahill 2001); however, subsequent studies found a few areas contained a high percentage of sand (Marlin 2002). Knowing the site parameters became an important component in selection of proper dredging equipment for removal as well as the best potential uses for the sediment (Marlin 2002). The acquisition of a vibra core that takes

3-m core samples greatly aided researchers in assessing composition, depth, and chemical content of the sediments at individual sites.

Proposed uses for the Illinois River sediments have included island and elevated habitat construction, farmland improvements, landscaping soil, construction fill, flowable fill, landfill cover, and manufactured construction products such as bricks (Darmody and Marlin 2002). Preliminary studies examined sediment suitability for the various proposed uses. A greenhouse study demonstrated that Peoria Lake sediment and central Illinois topsoil did not differ in fertility or productivity, and differences in growth and yield of barley and five garden vegetables were minor (Darmody et al. 2004). Natural colonization of the sediments was examined by depositing them at two different sites in May 2000 (Marlin 2002). At the first site, an agricultural field, the sediment dewatered rapidly and was suitable for disking within 1 month whereas at the second site, a gravel pit, dewatering was considerably slower. Six months later researchers from the Illinois Natural History Survey found the agricultural field site supported 47 plant species that were predominately weeds of old field and agricultural land. The gravel pit site supported 53 plant species that were common in early successional, disturbed emergent wetlands along the Illinois River. They surmised the majority of plants grew from seed in the sediment (Marlin 2002).

Characteristics were noted about the sediment structure at the preliminary test sites. Initially the sediments had poor structure and a fluid consistency. As drying ensued they tended to become crusty and developed cracks (Marlin 2002). Over time, weathering and tillage greatly improved the soil structure as did the initial addition of materials such as perlite, compost, or biosolids (Darmody et al. 2004).

Because the Illinois River watershed includes some industrial inputs, sediments of Peoria Lake were studied to determine their chemical properties and metal content. Of concern was metal uptake if the sediments were used for growing agronomic crops for human or animal consumption. Soil fertility data documented that the sediments were very similar to the naturally fertile and productive soils of Illinois farmland from which they were derived. To determine suitability of the sediments for plant production, five plant species were grown in Peoria Lake sediment in pots in a greenhouse study (Darmody et al. 2004). After growing for 4 to 5 weeks, samples were partitioned to determine dry mass yield and metal uptake.

All the plants grew on the dredged sediments as well as or better than on Illinois topsoil. The researchers found metal level uptake in the plants was well below levels present in plants grown in soils derived from industrial areas. A second more in depth study determined that the Peoria Lake sediment provided a suitable and safe medium for the production of garden vegetables (Ebbs et al. 2006). The sediments used in the study were recovered from one location in the Peoria Lake system and, unless further research disputes the findings, the presumption was made that dredged material from the lake or other segments of the Illinois River would have similar physicochemical characteristics and pollutant concentrations that fall within regulatory guidelines (Ebbs et al. 2006).

Background

The "Mud to Parks Project" was initiated when the City of Chicago envisioned using Illinois River sediment to develop a lakefront park bordering Lake Michigan on Chicago's south side (Marlin and Darmody 2005). The 573-acre site (designated USX) had belonged to U.S. Steel South Works, and much of it was covered with steel-mill slag devoid of any topsoil. In April 2004 Chicago received a $1.4 million grant to redevelop a 100-acre park on the site. Sediments were obtained from the Fon du Lac Park District's Spindler Marina access channel at East Peoria, IL (Marlin and Darmody 2005). Acquiring sediment from this area accomplished two purposes: (1) sediment removal restored water depths to levels where they could again be used by recreational boaters, and (2) reclaimed sediments could be used to overlay 100 acres of slag for park redevelopment. Sediments from this site were known to be free of contaminants and could be excavated to an 11-foot depth needed to load hopper barges (Marlin and Darmody 2005). A clamshell bucket was used to excavate the sediment and load it onto the barges (1,500 tons/barge) for transport to the park site. Excess water was removed and a large crane with a tightly closing bucket lifted the mud from the barges onto mining trucks, from which it was deposited into large piles at the USX site. The sediment was manipulated at the site in two very different ways. At one location sediment was "disturbed" as bulldozers mixed and layered the sediment as it was unloaded. Following layering, the site was seeded with rye grass (*Lolium* sp.) and alfalfa (*Medicago sativa*). At the second location, the sediment was deposited in piles, left to dry, and never worked to even out the terrain. The sediment at this location was termed "pure sediment" because it was largely undisturbed after deposition.

A botanist from the Illinois Natural History Survey examined the two locations on 30 July, 13 August, and 2 September 2004 to identify plant species growing on the sites prior to final leveling of the sediments to a depth between 2 and 4 feet over the park site (John Marlin, personal communication; Marlin and Darmody 2005). Excluding the planted rye grass and alfalfa, a total of 78 species of vascular plants were identified at the two locations (Appendix A). The disturbed site supported 49 species, while the pure sediments supported 28 species. Only seven species co-occurred in both pure and disturbed sediment sites. The difference in the numbers of species recorded at the two locations was in large part due to the disturbance regime. At the disturbed location, the mixing and layering of sediments positioned seeds already present on the site to new levels where light and moisture regimes induced germination. To try to determine more accurately which seeds were previously present at the site, an inventory was made of plants growing in close proximity to the disturbed site (termed "Edge" areas in Appendix A). It should be noted that plant introductions could also have come from seeds on transport vessels (e.g., barges, trucks, and bulldozers) or from wind or animal deposition. In fact, five species arrived by means other than sediment: corn (*Zea mays*) via barges, silver maple (*Acer saccharinum*), cottonwood (*Populus deltoides*), and willow (*Salix* sp.) via wind, and oak (*Quercus* sp.) via an animal.

Of the 28 species observed on the pure sediment, 4 mentioned above (silver maple, cottonwood, willow, and oak) were surmised to have arrived by means other than sediments, 5 [velvetleaf (*Abutilon theophrasti*), amaranth (*Amaranthus blitum*), oak-leaved goosefoot (*Chenopodium glaucum*), hairy crabgrass (*Digitaria sanguinalis*), lady's thumb (*Polygonum persicaria*)] were nonindigenous exotic terrestrial species, and the remaining 19 represented native taxa, 17 of which were obligate or wetland species (Table 1). The presence of the exotic terrestrial species in the sediments raises some questions as to the range of environmental conditions under which they can survive inundation. At present, seed tolerances for inundation of many of the species that were found remain unknown. All 17 of the obligate or wetland species found in the Illinois sediments also occur in Louisiana. Although none are included in a list of Louisiana noxious plant species, seven [waterhemp (*Amaranthus rudis*), red-rooted nutsedge (*Cyperus erythrorhizos*), yellow nutsedge (*Cyperus esculentus*), false daisy (*Eclipta prostrata*), small white morning glory (*Ipomoea lacunosa*), nodding smartweed (*Polygonum lapathifolium*),

Table 1. Facultative and obligate wetland species in pure sediment[1]

Scientific name	Common name	Wetland indicator[2]
Ammannia robusta	Scarlet toothcup	OBL
Cyperus erythrorhizos	Red-rooted nutsedge	OBL
Cyperus esculentus	Yellow nutsedge	FACW
Echinochloa walteri	Salt-marsh cockspur grass	OBL
Eclipta prostrata	Yerba De Tajo	FACW
Eragrostis hypnoides	Creeping love grass	OBL
Hibiscus laevis	Halberd-leaved rose mallow	OBL
Ipomoea lacunosa	Small white morning glory	FACW
Lindernia dubia	False pimpernel	OBL
Mimulus ringens	Monkey flower	OBL
Penthorum sedoides	Ditch stonecrop	OBL
Polygonum cf. *hydropiper*	Water pepper	OBL
Polygonum lapathifolium	Nodding smartweed	FACW+
Ranunculus sceleratus	Cursed crowfoot	OBL
Rorippa sessiliflora	Sessile-flowered cress	OBL
Sagittaria latifolia	Common arrowhead	OBL

[1]Data supplied by John Marlin, Illinois Waste Management and Research Center, Champaign, IL.

[2]Indicators obtained from Regional List: OBL = obligate wetland plant (occurs almost always [estimated probability 99%] under natural conditions in wetlands); FACW = facultative wetland plant (usually occurs in wetlands [estimated probability 67–99%], but occasionally found in non-wetlands) (U.S. Fish and Wildlife Service 1988).

and common arrowhead (*Sagittaria latifolia*)] are recognized as weeds by the Southern Weed Science Society (Bryson 2004). Seeds of yellow nutsedge and small white morning glory are regulated under the Louisiana Seed Law (State of Louisiana 2005a) and have restriction limits in shipments of agricultural, vegetable, flower, tree, or shrub seed.

To supplement seed bank information that was gathered in situ from the USX site, additional sediment was obtained from the Illinois River at Lower Peoria Lake and a backwater area about 20 miles upstream. These studies were not part of the USX project but were undertaken to provide additional documentation in anticipation of the mud-to-marshes project in Louisiana. The sediments were taken directly to a research greenhouse ensuring minimal exposure to contamination from outside sources. The sediments were placed in trays for a greenhouse study and observed over time for seed germination. The trays were kept moist to the point that upland weeds would have difficulty growing. Under these conditions only nine species grew from the sediments (Table 2). All but water purslane (*Ludwigia palustris*) had been reported from the pure sediments deposited at the Lake Michigan site. These nine plant species occur in Louisiana and would not constitute new introductions to the state. Although some are considered weedy [red-rooted nutsedge, yellow nutsedge, black nightshade (*Solanum nigrum*)] by the Southern Weed Science Society (Bryson 2004), none is listed as a noxious plant by the State of Louisiana. As mentioned above, yellow nutsedge is regulated under the weed seed laws in Louisiana. The wet condition treatments used in the study would seem to indicate that sites that were kept continuously moist following sediment deposition could see a large reduction in seed viability (e.g., 9 versus 28).

Table 2. Plants found in sediments collected from the Illinois River in a greenhouse tray study.[1]

Scientific name	Common name	Wetland indicator[2]
Ammania robusta	Scarlet toothcup	OBL
Cyperus erythrorhizos	Red-rooted nutsedge	OBL
Cyperus esculentus	Yellow nutsedge	FACW
Eragrostis hypnoides	Creeping love grass	OBL
Lindernia dubia	False pimpernel	OBL
Ludwigia palustris	Water purslane	OBL
Mimulus ringens	Monkey flower	OBL
Penthorum sedoides	Ditch stonecrop	OBL
Solanum nigrum	Black nightshade	OBL

[1]Data supplied by John Marlin, Illinois Waste Management and Research Center, Champaign, IL.

[2]Indicators obtained from Regional List: OBL = obligate wetland plant (occurs almost always [estimated probability 99%] under natural conditions in wetlands); FACW = facultative wetland plant (usually occurs in wetlands [estimated probability 67%-99%], but occasionally found in non-wetlands) (U.S. Fish and Wildlife Service 1988).

A second greenhouse study used 3-m cores that were taken with a vibra core from Lower Peoria Lake and placed in shallow trays. The cores were separated into 13 sections representing different depths and soil compositions. For this study a total of 107 flats of sediment were observed over time for seedling germination (J. Marlin, personal communication). Only 9 of the 13 core locations had seed germination. The total number of plants recovered from the sediments in the 107 flats only totaled 62, and included

60 sedges (*Cyperus* spp.), 1 bullrush (*Scirpus validus*), and 1 member of the grass family (Poaceae) that did not flower and could not be identified. It should be noted that the name *S. validus*, not the currently accepted species name *Schoenoplectus tabernaemontani* (K.C. Gmel.) Palla (Flora of North America 2002), was used by the Illinois Natural History Survey researchers. The *Cyperus* spp. were not identified to species level and most likely included *C. erythrorhizos* and *C. esculentus*, which were reported in species lists for the USX site.

In spring 2004 a bill to implement an aquatic invasive species plan was passed by the Louisiana House and Senate and signed into law by Governor Kathleen Blanco (State of Louisiana 2005b). The State Management Plan for Aquatic Invasive Species in Louisiana (SMP 2005) lists 64 invasive species (excluding insects) that have been reported, introduced, and/or established in Louisiana (Appendix B). Fifty-three of the 64 invasive species are found primarily in aquatic or wetland habitats, and the remaining 11 species are considered terrestrial. Of the 11 terrestrial species on the list (Appendix B), 6 do not occur in Illinois, 1 (the feral hog) would not be considered an issue, and the remaining 4 did not appear on plant lists from the seed bank studies of Illinois River sediments. Thirty-seven of the 53 aquatic or wetland species do not presently occur in Illinois and therefore, reintroduction would not be an issue in a mud-to-marshes project. The remaining 16 species already present in Louisiana that also occur in Illinois include: water flea (*Daphnia lumholtzi*), common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), tilapia (*Oreochromus* spp., *Sarotherodon* spp., or *Tilapia* spp.), tench (*Tinca tinca*), Asian clam, zebra mussel, yellow iris (*Iris pseudacorus*), dotted duckweed (*Landoltia punctata*), purple loosestrife (*Lythrum salicaria*), Eurasian watermilfoil (*Myriophyllum spicatum*), brittle naiad (*Najas minor*), watercress (*Nasturtium officinale*), yellow floating heart (*Nymphoides peltata*), and curly pondweed (*Potamogeton crispus*). It should be noted that there are no known wild populations of tilapia established in Louisiana although several species are permitted as aquaculture fish species. Although purple loosestrife is listed in Appendix A as having been reported in Louisiana, the U.S. Department of Agriculture's Plants National Database website does not show it as presently occurring in the state. SMP 2005 also identifies four invasive species threats to Louisiana (Appendix B). Of the four species only Cylindro (*Cylindrospermopsis raciborskii*) has been reported as occurring in Illinois.

Sediments that will be transported to Louisiana for a mud-to-marshes project will most likely come from Spindler and East Port portions of Peoria Lake. Sediments in the area can be excavated to 6–8 foot depths (J. Marlin, personal communication). Illinois Department of Natural Resources (DNR) personnel examined the site and typically found mussels only in the top layers of sediment. They surmised that, if mussels were to be picked up in the excavation, only those located near the top of the barge would have any chance of survival during transport. Survival would also be reduced because free water is pumped from the barges at the dredge site.

In previous surveys conducted at the Spindler site, the only mussels found included threeridge (*Amblema plicata*), mapleleaf (*Quadrula quadrula*), and giant floater (*Pyganodon grandis*) (J. Marlin, personal communication). Although not found in the Spindler survey, one additional species, the fragile papershell (*Leptodia fragilis*) was noted often to be associated with silty sediments typical of the Spindler site. In more recent (2003) surveys conducted at a different location in Peoria Lake, researchers from the Illinois DNR found eight mussel species including threeridge, mapleleaf, giant floater, fragile papershell, white heelsplitter (*Lasmigona complanata*), threehorn (*Obliquaria reflexa*), rock pocketbook (*Arcidens confragosus*), and deertoe (*Truncilla truncata*). The substrate at this site was more complex and included more sand and gravel than the silty sediments of the Spindler site. During some additional work in the area, a diver found one additional species, the mucket (*Actinonaias ligamentina*). All of the aforementioned mussels are native species that also occur in Louisiana (Payne et al. 2002; Payne et al. 2003; Louisiana Natural Heritage Program 2006). If the native mussels were to survive the long transport from Illinois to Louisiana, conditions could not be brackish. They would not be expected to survive under those conditions.

Although not collected in the aforementioned surveys, the zebra mussel (*Dreissena polymorpha*) and the Asian clam (*Corbicula fluminea*) do occur in the Illinois River System and the possibility does exist that either one could occur in dredged sediment. They are both identified as species of concern in SMP 2005. Both these species have already established in Louisiana and would not constitute new introductions to the state in a mud-to-marshes project. The possibility also exists that one additional exotic invasive species could appear in sediments in the Illinois River. The Chinese mystery snail (*Cipangopaludina chinensis*) is not known to currently exist in the Illinois River System around Peoria, but it is spreading in the Midwest (J. Marlin, personal communication). Of concern is that it could be expected to invade Peoria Lake in the near future as habitat preference is in quiet water with a mud or silty substrate (Clench and Fuller 1965). The species should not be a threat to sites in Louisiana that are brackish as it reportedly prefers freshwater (Kipp and Benson 2008).

Macroinvertebrate communities were characterized in the Peoria Lake section of the Illinois River prior to dredging activities in the late 1990s (J. Marlin, personal communication). A total of 99 samples collected with a 508-cm^2 Ponar grab sampler yielded 702 organisms. Of these, midges, fingernail clams, and mayflies accounted for 97% of all the organisms. The samples did not contain any zebra mussels; however, one Asian clam was found. In light of this report and those mentioned above, it appears the Asian Clam is present in the region but in very low numbers. None of the species documented in the macroinvertebrate community of Peoria Lake would be a new introduction to Louisiana.

As part of SMP 2005, the Louisiana Task Force specifically identified 36 species of concern for the state (Appendix C). For the purposes of this list, the term aquatic was expanded to include species that in general were terrestrial in nature but could arrive through aquatic pathways [e.g., cogongrass (*Imperata cylindrica*) and Formosan termite (*Coptotermes formosanus*)]. The species were categorized as being extensively established, locally established, or potential arrivals. Purple loosestrife in this section was identified as being a potential arrival. Of the 36 species of concern, only 10 (Eurasian watermilfoil, Cylindro, grass carp, zebra mussel, silver carp, tilapia, purple loosestrife, common carp, bighead carp, and water flea) occur in Illinois. With the possible exceptions of Cylindro, tilapia, and purple loosestrife, the remaining seven are already established in Louisiana. The possibility exists that some life cycle stage could be transported in sediments or attached to transport vehicles; however, any one of these aquatic species could also arrive in Mississippi River water during high water flows.

2 Potential Species of Concern in a Mud-to-Marshes Project

Appendix C lists aquatic nuisance species of concern that could potentially threaten Louisiana aquatic ecosystems either by new introductions or by the spread of existing species. With the exception of Cylindro and purple loosestrife, species that are listed as potential arrivals [brown mussel (*Perna perna*), green mussel (*Perna viridis*), channeled apple snail (*Pomacea canaliculata*), pacific oyster (*Crassostrea gigas*), Asian oyster (*Crassostrea ariakensis*), Chinese mitten crab (*Eriochirus sinensis*), and green crab (*Carcinus maenas*)] do not occur in Illinois. Nearly all are brackish water species and therefore are not of concern in the transport of sediment from one state to another. Purple loosestrife potentially could be transferred in sediments from Illinois; however, it would not be expected to survive brackish conditions in Louisiana's coastal marshes as it prefers freshwater systems. It apparently can survive high temperatures associated with southern climates because well-established populations exist in northern Mississippi and along the Tennessee River in Alabama.

Cylindro and aggressive biotypes of Eurasian watermilfoil and phragmites (*Phragmites australis*) may present cause for concern in a mud-to-marshes project. Although the two plant species have been reported as occurring in Louisiana, the aggressive biotypes have either not been reported or populations are limited in distribution (see sections below). Both Eurasian watermilfoil and phragmites are widely distributed in the Midwest and potentially could invade Louisiana via sediment transfer. The likelihood of invasion appears low, however, because neither species was reported as being present in the sediment seed bank in any of the aforementioned Illinois studies. The two biotypes possess certain definable characteristics that set them apart as invaders. These characteristics include one or more of the following features: abundant seed production, rapid population establishment, seed dormancy, long-term survival of buried seeds, adaptations for spread, production of vegetative reproductive structures, and the capacity to occupy sites disturbed by human activities. All of these features increase the likelihood of plant survival and persistence under a wide range of environmental conditions.

Eurasian watermilfoil

Eurasian watermilfoil is known to occur in a variety of habits, becoming established in both impoundments and natural waters, sometimes brackish water or in clear, cool, spring-fed rivers. Problems associated with this species include displacement of native vegetation, disruption of navigation and recreation by the formation of impenetrable mats, and decreased water flow. The history of the spread of Eurasian watermilfoil in the United States is made unclear by the existence of herbarium specimens that were mislabeled and by the confusion with the native species, northern watermilfoil (*M. sibiricum* Kom.). Its history is further confounded by reports of hybridization between the nonindigenous Eurasian watermilfoil and the native northern watermilfoil (Moody and Les 2002). The molecular data suggest that invasiveness into new regions may be related to hybridization. The hybrid and introduced Eurasian watermilfoil are difficult to distinguish morphologically and verification requires DNA analysis.

Eurasian watermilfoil exhibits high plasticity and is able to tolerate and thrive in a variety of environmental conditions. It grows best on fine-textured inorganic sediments with an intermediate density of 0.8 to 1.0 g ml^{-1} (Barko and Smart 1986). It grows relatively poorly on highly organic sediments that have low sediment density and on course substrates that have a high sediment density (Smith and Barko 1990). It grows in still to flowing waters, can tolerate salinity of up to 15 parts per thousand, grows rooted in water from 1 to 10 m although there are reports of growth in deeper water (regularly reaching the surface while growing in water 3 to 5 m deep) and can survive under ice (Holm et al. 1997). Although growth is best in alkaline waters, Eurasian watermilfoil can tolerate pH levels ranging from 5.4 to 11. Relative to other submersed plants, Eurasian watermilfoil requires high light, has a high photosynthetic rate, and can grow over a broad temperature range.

During the growing season, Eurasian watermilfoil plants undergo autofragmentation, usually after flowering. The abscising fragments often develop adventitious roots at the nodes before separation from the parent plants so they can readily take root when deposited in a new area. Fragments are also produced by wind and wave action and by boating activities, with each fragment having the potential to develop into a new plant. While water currents readily transport fragments, it is thought that recreational boat traffic is one of the most important means of dispersal.

Phragmites (also called Common Reed)

In the late 20th century, phragmites increasingly became a problematic weed throughout the continental United States in both fresh and brackish wetlands. Prior to the early 1900s, the species was described as being uncommon in these areas (Saltonstall 2002, 2003a, 2003b, 2003c). Today plants form extensive monocultures in marshes, shores, tidal areas, and along streams, lakes, and estuaries. Several hypotheses have been suggested to account for the weed's spread including site disturbance, pollution, changes in hydrologic regimes, and increased soil salinity (Marks et al. 1994). Alternatively Saltonstall (2002, 2003a, 2003b, 2003c) hypothesized that a non-native strain of phragmites could be responsible for increased aggressiveness and spread of the species. She compared modern populations with historical ones from herbarium collections and found differences in the DNA that aligned modern populations more closely to Eurasian phragmites (haplotype M) than to native North American strains. Particularly disturbing was that native strains were no longer present in many of the sites documented by herbarium samples but had been replaced with the highly competitive and aggressive Eurasian strain. Considering that morphologically the two strains appear similar in appearance, the presence of the introduced phragmites was in all likelihood overlooked while it was steadily replacing native populations.

The rapid spread of phragmites and the virtual absence of native herbivores in expanding populations have also contributed to the hypothesis that a more aggressive genotype has been introduced (Tewksbury et al. 2002). Literature and limited surveys documented only 26 herbivore species on phragmites in North America (Tewksbury et al. 2002). These included 16 recent introductions, 5 of unknown status, and only 5 native species. Of interest is that only two of the native species (a skipper and a gall midge) are monophagous on phragmites; the other three have recently expanded their feeding range to include phragmites, indicating the availability of a new host, most likely the haplotype M.

Saltonstall (2003a) determined through DNA sequencing there are 11 non-invasive native North American haplotypes (haplotypes A-H, S, Z, AA) that are unique to North America and are considered to be native. The invasive haplotype M is common across Europe and continental Asia and has become well established and widespread in North America. Today the genetic structure of most North American populations resembles that of Europe (Saltonstall 2002, 2003a). The aggressive haplotype M has almost entirely replaced native phragmites types in New England, has expanded both south and west (Blossey et al. 2004), and has been detected in Louisiana (Saltonstall 2003a, 2003c). The origin of an additional haplotype along the Gulf of Mexico (haplotype I) is unresolved, but it is genetically distinct from the 11 native haplotypes and shares none of the mutations that link them (Saltonstall 2003a). Morphologically it is very similar to haplotype M (Saltontall 2002; Swearingen 2006). To be definitively confident which specific haplotype occurs in any region requires genetic analysis. Alternative to using DNA sequencing techniques, Restriction Fragment Length Polymorphism (RFLP) analysis can be used to readily distinguish native, non-native, and Gulf Coast haplotypes (Saltonstall 2003c).

Cylindro

Cylindro is widely dispersed within the continental United States and may already be present in Louisiana because it is relatively common in Texas (Professor Jim Grover, University of Texas, Arlington, personal communication). It is included here as a species of concern because it is listed in SMP 2005 as a potential arrival. Cylindro is from an interesting group of organisms termed cyanobacteria or blue-green algae. It has been reported from a wide range of environmental conditions including hot springs, Antarctic lakes, and extremely salty pools. It is a very small microscopic blue-green alga and may go undetected in a water sample due to its size and its morphological similarity to other blue-green algal species (St. Amand 2002). The formation of terminal heterocysts (nitrogen-fixing cells) greatly aid in identification. It may also go undetected in a water body because it does not form a surface scum but resides lower in the water column, often imparting at most a brown tint to the water (Jones and Sauter 2005). Cylindro also does not produce the volatile organic compounds tied to taste and odor problems associated with algal blooms (Chiswell et al. 1997). During algal blooms it can produce several toxins including: cylindrospermopsin, a toxin that primarily affects the liver but can affect the heart, kidneys, and other organs; saxitoxin, a neurotoxin that can cause poisoning to fish and fish eaters (including man); anatoxin-a, a neuromuscular agent that can result in paralysis, respiratory distress, and convulsions (SMP 2005), and paralytic shellfish poisons (Jones and Sauter 2005). Originally thought to be a subtropical species, Cylindros' range has recently been revised because it has been found in several Midwestern states (Jones and Sauter 2005). Spread is through human activities or natural events and, like other aquatic species, it could be transported to new areas by boaters, anglers, floods, or any other activity that transports water across distances.

3 Recommendations

The following activities are recommended and should be carefully considered as part of an initial mud-to-marshes project:

- Pre-project species survey
- Seed bank study
- Early Warning Rapid Response (EWRR) plans for species of concern
- Site monitoring.

Pre-project species survey

Before implementation of a mud-to-marshes project in Louisiana, a species survey is recommended to detect and map any biota that are present on the project site. In particular, if populations of any species of concern to the State of Louisiana (Appendix C) are detected during the surveys, an attempt should be made to eradicate them before project implementation to prevent further spread. For species that are present but cannot be eradicated, a containment plan should be implemented for each infestation. Doing so will dismiss any suggestions that infestations were a result of sediment transport from Illinois. Secondly, a monitoring regime should be developed so that new species arrivals can be documented and a determination can be made as to their potential pathways of introduction. If none can be traced to sediment transport, similar mud-to-marshes projects could be initiated that could benefit both Louisiana and Illinois. If desirable species appear, it also lends weight to the value of such projects in land reclamation. Unfortunately, disturbance opens up new niches for species invasions, and propagules could be deposited by biotic or abiotic sources such as wind, water, or animals. Knowing what might come into a newly reclaimed area following disturbance would provide project implementers invaluable data on how projects might be altered to significantly reduce the arrival of unwanted species. It also could be used in planning revegetation efforts that could allow establishment of desirable species and exclude unwanted invasives.

Seed bank study

An additional greenhouse seed bank study is also recommended. Sediments from the Illinois River and the Louisiana project site should be analyzed to determine seed bank composition. Such studies would support Illinois field evaluations in separating which species, if any, could have arrived from Illinois sediment relocation and which species were already present in Louisiana sediments. Unlike previous studies undertaken in Illinois where sediments were kept moist with fresh water, the protocol would be to also incubate the soils, not only with fresh water to verify Illinois seed bank study results but with water that would be typical of the Louisiana project site, particularly in relation to salinity. Current thought is that most species in the seed bank of Illinois sediments will not tolerate and survive brackish conditions; therefore, transfer via sediments is not a concern in the initial mud-to-marshes project. These studies would help document and verify which species can tolerate changes in salinity and which cannot survive. Those that cannot survive would therefore not be an issue for future projects where brackish conditions exist.

Restoration efforts in the LCA should take into consideration setting up contingency invasive species management plans simply because such efforts could provide corridors for invasive species expansion. Although no new introductions are anticipated from Illinois sediments, invasive species that are already present in Louisiana may be opportunistic of any disturbance associated with the deposition of fresh sediments and quickly colonize open niches.

In general the goals of an invasive species management program are prevention, control, and eradication. Prevention is the practice of keeping nuisance species from being introduced into an uninfested area. Successful implementation involves sanitation practices to prevent spread of propagules and adherence to laws and regulations enacted to meet this objective. Prevention is the most efficient and cost-effective approach to combating invasive species; however, early awareness of potential introductions is the key. Moreover, legislation is only effective if enforced. Control is defined as the suppression or “containment” of a particular species once it becomes established in an area. Control methods do not always prevent invasive species from reproducing; therefore, control measures must often be continued year after year. Eradication is the complete elimination of all invasive species from an area. Eradication usually can be achieved only in the case of new, small infestations. Although prevention and eradication can and should play important roles in most management programs, emphasis is usually placed on control and containment once invasive species are established. Although Louisiana’s established aquatic invasive species management plan (SMP 2005) addresses the importance of prevention, control, and eradication, the State Task Force has cited exacerbating circumstances that complicate invasive species problems in Louisiana. These circumstances include lack of communication or cooperation among state agencies, lack of education, knowledge and concern or ignorance of existing laws, lack of laws or enforcement of existing laws, lack of funding, and Louisiana's geography and climate that provide few barriers to the diffusion of species (SMP 2005).

Several steps are necessary to implement an invasive species management program. The initial step requires a survey for biota of concern at site(s) that will be receiving Illinois sediment. Data collected during the survey can provide the basic information for a beginning database on the biota of concern. Such information is not limited to but often includes species name, location of the population, population size, site description, type of habitat, presence of other plant or animal species, and presence of any threatened or endangered species. A survey also offers an opportunity to document any other biota of concern that had not been considered for listing because they were not known to exist in Illinois and/or Louisiana at the time of this report. Using a national standard such as the National Vegetation Classification System (Anderson et al. 1998; Grossman et al. 1998) would ensure accuracy, clarity, and consistency in reporting. By using a standard reporting system at the local level, the data gathered could then be used nationally to produce uniform statistics in vegetation resources from vegetation cover data and to link local level vegetation inventory and map efforts.

Early Warning Rapid Response plan

For each population of concern identified in either the initial survey or subsequent pre-invasion monitoring, an associated site-specific EWRR plan is required. Included in each response plan are control strategies, implementation procedures, post invasion monitoring techniques and frequencies, and criteria for treatment evaluation. While a number of control strategies exist for each species of concern, it is the individual invasion site that will dictate which options can be implemented. If several options are available they should be evaluated in terms of potential effectiveness, advantages, drawbacks, costs, and permits. Integrating control options is highly desirable and can often provide the best long-term management approach with the least environmental impacts. This approach examines all the alternatives with regard to such factors as:

- The extent of the infestation
- Scale, intensity, and timing of a treatment
- Effectiveness against the target
- Duration of control
- Human health concerns
- Endangered or threatened species impacts
- Other environmental impacts and the associated mitigation, if needed
- Program costs
- Permit requirements (Federal, state, local).

Eradication is the goal of any EWRR plan and is achievable if infestations are detected when they consist of relatively few individuals. However, some of the biota of concern (see Appendix C) have established populations in the region and containment may be the only option. Once a response plan has been put into effect, post-invasion monitoring continues until eradication has been achieved or remains an ongoing process if containment is the only option. If treatments are not limiting the spread, the response plan will need to be reevaluated and new control procedures implemented.

Site monitoring

Monitoring should remain the core of an EWRR plan. Only through continual monitoring can new infestations be detected and/or project success evaluated. Professional surveys should be conducted on a regular basis to document trends in restoration efforts. If progress is not forthcoming, some reevaluation of project design is probably in order.

Transport option

One additional option that might be considered for the project would be to transport dry rather than wet sediments. Following dredging, sediments could possibly be stockpiled near the river for dewatering and then transferred back to barges for transport to Louisiana. Of major consideration would be the cost and practicality of storing and reloading dry sediment onto barges compared to direct transport of wet sediment. Stockpiling to dry the material might offer an additional advantage in that drying would further reduce the chance of transporting nuisance aquatic species.

4 Conclusions

The “Mud to Parks Project” in Illinois demonstrated that it is feasible to harvest large amounts of sediment from the Illinois River, transport it by barge to a new location, unload it, and spread it to reclaim land area. Although transportation distances are considerably greater, the same procedures could be used to relocate sediments from Illinois to Louisiana for coastal restoration purposes.

Of concern in such a project is the potential of transporting invasive species from one state to another via the sediment or the transport vehicles (e.g., barges and trucks). Data presented herein indicate that new introductions of species of concern to Louisiana (Appendix C) are highly unlikely as a result of a mud-to-marshes project because they either do not occur in Illinois or they do not presently occur in areas where sediments will most likely be dredged. On the other hand, reintroduction of invasive species of concern already present in Louisiana is a possibility (although not anticipated because they were absent from species lists of previous Illinois sediment studies). Although reintroductions may not be viewed as problematic as new introductions, they may result in infestations at new sites. Introduction of invasive biotypes of Eurasian watermilfoil and phragmites is also not anticipated; however, the appearance of any new infestations of either of these two species should be taken seriously. Samples should be submitted for genetic analysis and, if they are determined to be the more aggressive biotypes, an EWRR plan should immediately be implemented to eradicate them from the project site.

Finally, disturbance associated with marsh reclamation has the potential to open new corridors for invasive species movement and establishment within the state. Therefore, test sites should be monitored on a regular basis to document any changes that occur over time. Such information should prove invaluable for both detecting any unwanted species invasions and to document the positive outcomes of a mud-to-marshes project.

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Appendix A: Vascular Plant Species Growing on Sediment Deposits at the U.S. Steel South Works Site

Already Present	Scientific Name	Common Name	Pure Sediment	Disturbed Sediment	Edge	Wetland Indicator Status
	*Abutilon theophrasti**	Velvetleaf	*	*		FACU-
▪	*Acer saccharinum*	Silver Male	*	*	*	FACW
	Amaranthus albus	Tumbleweed		*		FACU
	*Amaranthus blitum**	Amaranth	*	*		
	*Amaranthus hydridus**	Green Amaranth		*	*	UPL
	*Amaranthus powellii**	Smooth Amaranth			*	FACU
	*Amaranthus retroflexus**	Rough Amaranth		*	*	FACU+
	Amaranthus rudis	Waterhemp	*	*		FACW
▪	*Ambrosia artemisifolia*	Common ragweed		*	*	FACU
	Ammannia robusta	Scarlet Toothcup	*			OBL
	*Anthemis cotula**	Stinking Chamomile		*		FACU
▪	*Artemisia vulgaris**	Mugwort		*	*	UPL
▪	*Aster pilosus*	Hairy Aster		*	*	FACU-
▪	*Centaurea maculosa**	Spotted Knapweed			*	UPL
▪	*Chaenorrhinum minus**	Dwarf Snapdragon			*	UPL
	Chamaesyce maculata	Nodding Spurge		*		FACU-
▪	*Chamaesyce supina*	Spotted Creeping Spurge		*		UPL
▪	*Chenopodium album*	Lamb's Quarters		*	*	FAC-
▪	*Chenopodium botrys**	Jerusalem Oak		*	*	FAC-
	Chenopodium glaucum	Oak-leaved Goosefoot	*			FACW
	*Cirsium vulgare**	Bull Thistle		*		FACU-
	Cycloloma atriplicifolium	Winged Pigweed			*	FACU
	Cyperus erythrorhizos	Red-rooted Nut Sedge	*			OBL
	Cyperus esculentus	Nut Sedge	*			FACW
▪	*Daucus carota**	Queen's Ann's Lace		*	*	FACU-
	*Digitaria sanguinalis**	Hairy Crabgrass	*			FACU

Already Present	Scientific Name	Common Name	Pure Sediment	Disturbed Sediment	Edge	Wetland Indicator Status
▪	*Diplotaxis tenuifolia**	Sand Rocket		*	*	UPL
	*Echinochloa crusgalli**	Barnyard Grass		*		FACW
	Echinochloa walteri	Salt-Marsh Cockspur Grass	*			OBL
▪	*Echium vulgare**	Viper's Bugloss			*	UPL
	Eclipta prostrata	False daisy	*			FACW
	Eragrostis hypnoides	Creeping Love Grass	*			OBL
▪	*Eragrostis minor**	Low Love Grass			*	UPL
▪	*Eragrostis pectinacea*	Small Love Grass			*	FAC
▪	*Erigeron canadensis*	Horseweed		*	*	FAC-
▪	*Eupatorium serotinum*	Late Boneset		*		FAC+
▪	*Helianthus annuus**	Garden Sunflower		*		FAC-
	Hibuscus laevis	Halberd-lvd. Rose Mallow	*			OBL
	*Hibuscus trionum**	Flower-of-an-hour		*	*	UPL
	Ipomoea lacunosa	Small White Morning Glory	*			FACW
▪	*Kochia scoparia*	Burning Bush		*	*	FACU-
▪	*Lactuca serriola**	Prickly Lettuce		*		FAC
	Lapsana communis	Nipplewort		*		UPL
	Lindernia dubia	False Pimpernel	*			OBL
▪	*Melilotus alba**	White Sweet Clover		*	*	FACU
	Mimulus ringens	Monkey Flower	*			OBL
▪	*Oenothera biennis*	Evening Primrose		*	*	FACU
▪	*Panicum capillare*	Witch Grass		*	*	FAC
	Penthorum sedoides	Ditch Stonecrop	*			OBL
	*Plantago major**	Common Plantain		*		FAC+
	Poinsettia dentata	Toothed Spurge		*	*	UPL
	Polanisia dodecandra	Clammy Weed			*	UPL
	Polygonum cf. hydropiper	Water Pepper	*			OBL
	*Polygonum convolvulus**	Black Bindweed		*		FAC-
	Polygonum lapathifolium	Nodding Smartweed	*	*		FACW+
	*Polygonum persicaria**	Lady's Thumb	*	*		FACW
▪	*Populus deltoides*	Cottonwood	*	*		FAC+
▪	*Portulaca oleracea**	Common Purslane		*	*	FAC-

Already Present	Scientific Name	Common Name	Pure Sediment	Disturbed Sediment	Edge	Wetland Indicator Status
	Quercus sp.	Oak	*			/
	Ranunculus sceleratus	Cursed Crowfoot	*			OBL
	Rorippa sessiliflora	Sessile-Flowered Cress	*			OBL
	Sagittaria latifolia	Common Arrowhead	*	*		OBL
▪	*Salix* sp.	Willow	*			/
▪	*Salsola iberica**	Russian Thistle			*	FACU
	*Senecio vulgaris**	Common Groundsel		*	*	UPL
▪	*Setaria faberi**	Giant Foxtail		*	*	FACU+
▪	*Setaria viridis**	Green Foxtail		*	*	UPL
▪	*Silene csereii**	Glaucous Campion		*	*	UPL
	Solanum nigrum	Black Nightshade	*	*	*	FACU-
	*Sonchus arvensis**	Common Sow Thistle		*	*	FAC-
	*Sonchus asper**	Spiny Sow Thistle			*	FAC
	*Trifolium pratense**	Red Clover		*		FACU+
	*Verbascum thapsus**	Common Mullein		*		UPL
▪	*Verbena bracteata*	Creeping Vervain			*	FACU
	Verbena simplex	Narrow-leaved Vervain		*		UPL
	Verbena urticifolia	White Vervain		*		FAC+
	Xanthium strumarium	Cocklebur	*	*		FAC
	Zea mays	Corn		*		UPL

●Scientific names followed by an "*" indicate species introduced into the Midwestern United States.

●A "▪" in the "Already Present" column indicates species previously established at the U.S. Steel Site.

●Plants are placed within five wetland indicator categories, which include: Obligate Wetland (OBL), Facultative Wetland (FACW), Facultative (FAC), Facultative Upland (FACU), and Upland (UPL).

Within any of these five categories, a "+" indicates that a particular taxon has a greater tendency to occur in wetlands, while a "-" indicates a lesser tendency. Following this, indicator status categories, in descending order of probability of occurrence in wetland habitat to upland habitat, would be: [(OBL) Obligate Wetland] > [(FACW+) Facultative Wetland+] > [(FACW) Facultative Wetland] > [(FACW-) Facultative Wetland-] > [(FAC+) Facultative+] . [(FAC) Facultative] > [(FAC-) Facultative-] > [(FACU+) Facultative Upland+] > [(FACU) Facultative Upland] > [(FACU-) Facultative Upland-] > [(UPL) Upland]. Estimated probabilities of occurrence in wetlands associated with each category are: OBL > 99%, FACW = 67-99%, FAC = 50%, FACU = 1-33%, and UPL < 1%.

●Table compiled by Illinois Natural History Survey personnel and provided courtesy of John Marlin, Illinois Waste Management Research Center, Champaign, IL.

Appendix B: Invasive Species in Louisiana Invasive Species Reported, Introduced, and/or Established in Louisiana

Group	Scientific Name	Common Name
Amphibians	*Eleutherodactylus coqui*	Coqui
Amphibians	*Eleutherodactylus planirostris*	Greenhouse frog
Coelenterates	*Phyllohiza punctata*	Australian spotted jellyfish
Crustaceans	*Daphnia lumholtzi*	Water flea
Fish	*Astronotus ocellatus*	Oscar
Fish	*Cichlasoma cyanoguttatum*	Rio Grande cichlid
Fish	*Colossoma or Piaractus* sp.	Unidentified pacu
Fish	*Ctenopharyngodon idella*	Grass carp
Fish	*Cyprinus carpio*	Common carp
Fish	*Hypophthalmichthys molitrix*	Silver carp
Fish	*Hypophthalmichthys nobilis*	Bighead carp
Fish	*Hypostomus* sp.	Suckermouth catfish
Fish	*Macropodus opercularis*	Paradisefish
Fish	*Mylopharyngodon piceus*	Black carp
Fish	*Oreochromus, Sarotherodon, or Tilapia*	Tilapia
Fish	*Tinca tinca*	Tench
Mammals	*Myocastor coypus*	Nutria
Mammals	*Sus scrofa*	Feral hog
Mollusks	*Corbicula fluminea*	Asian clam
Mollusks	*Dreissena polymorpha*	Zebra mussel
Plants	*Alternanthera philoxeroides*	Alligatorweed
Plants	*Bacopa egensis*	Brazilian water-hyssop
Plants	*Blyxa aubertii*	Blyxa
Plants	*Ceratopteris thalictroides*	Water sprite
Plants	*Colocasia esculenta*	Wild taro or Coco yam
Plants	*Dopatrium junceum*	Dopatrium
Plants	*Egeria densa*	Brazilian waterweed

Group	Scientific Name	Common Name
Plants	*Eichhornia crassipes*	Water hyacinth
Plants	*Hydrilla verticillata*	Hydrilla or Waterthyme
Plants	*Imperata cylindrica*	Cogongrass
Plants	*Ipomoea cairica*	Mile-a-minute vine
Plants	*Iris pseudacorus*	Yellow iris
Plants	*Landoltia (Spirodela) punctata*	Dotted duckweed
Plants	*Lantana camera*	Lantana
Plants	*Ligustrum japonicum*	Japanese privet
Plants	*Ligustrum sinense*	Chinese privet
Plants	*Limnophila indica*	Indian marshweed
Plants	*Lonicera japonica*	Japanese honeysuckle
Plants	*Ludwigia hexapetala*	Uruguay seedbox
Plants	*Luziola peruviana*	Peruvian watergrass
Plants	*Lythrum salicaria*	Purple loosestrife
Plants	*Macfadyena unguis-cati*	Catclawvine
Plants	*Marsilea macropoda*	Big-foot water clover
Plants	*Murdannia keisak*	Marsh dewflower
Plants	*Myriophyllum aquaticum*	Parrot feather
Plants	*Myriophyllum spicatum*	Eurasian watermilfoil
Plants	*Najas minor*	Brittle naiad or Brittle waternymph
Plants	*Nasturtium officinale*	Watercress
Plants	*Nelumbo nucifera*	Sacred lotus
Plants	*Nymphaea lotus*	White Egyptian lotus
Plants	*Nymphoides peltata*	Yellow floating heart
Plants	*Ottelia alismoides*	Duck lettuce
Plants	*Panicum repens*	Torpedo grass
Plants	*Pistia stratiotes*	Water lettuce
Plants	*Polygonum cuspidatum*	Japanese knotweed
Plants	*Potamogeton crispus*	Curly pondweed
Plants	*Pueraria montana*	Kudzu
Plants	*Rotala indica*	Indian toothcup
Plants	*Sagittaria guayanensis*	Guyana arrow head
Plants	*Salvinia minima*	Common salvinia or Water spangles

Group	Scientific Name	Common Name
Plants	*Salvinia molesta*	Giant salvinia
Plants	*Triadica sebiferum*	Chinese tallow tree or Popcorn tree
Plants	*Sorghum halepense*	Johnsongrass
Plants	*Tamarix ramosissima*	Saltcedar
Crustaceans	*Eriocheir sinensis*	Chinese mitten crab*
Mollusks	*Perna perna*	Brown (Mexihalo) mussel*
Mollusks	*Perna viridis*	(Asian) green mussel*
Cyanobacterium	*Cylindrospermopsis raciborskii*	Toxic blue-green algae*
* Potential invasive species threats to Louisiana.		

Appendix C: Species of Concern Identified in the State Management Plan for Aquatic Invasive Species in Louisiana

Scientific Name	Common Name	Group	Status[1]
Eichhornia crassipes	Water hyacinth	Plant	EE
Triadica sebiferum	Chinese tallow tree	Plant	EE
Myriophyllum aquaticum	Parrot feather	Plant	EE
Hydrilla verticillata	Hydrilla	Plant	EE
Colocasia esculenta	Wild taro	Plant	EE
Egeria densa	Brazilian waterweed	Plant	EE
Myriophyllum spicatum	Eurasian watermilfoil	Plant	EE
Pistia stratiotes	Water lettuce	Plant	EE
Salvinia minima	Common salvinia	Plant	EE
Salvinia molesta	Giant salvinia	Plant	LE
Imperata cylindrica	Cogongrass	Plant	LE
Lythrum salicaria	Purple loosestrife	Plant	PA
Cylindrospermopsis raciborskii	Cylindro	Cyanobacterium	PA
Cichlasoma cyanoguttatum	Rio Grande cichlid	Finfish	E
Cyprinus carpio	Common carp	Finfish	E
Ctenopharyngodon idella	Grass carp	Finfish	E
Hypophthalmichthys molitrix	Silver carp	Finfish	E
Hypophthalmichthys nobilis	Bighead carp	Finfish	E
Mylopharyngodon piceus	Black carp	Finfish	E
Tilapia, Oreochromis, Sarotherodon	Tilapia	Finfish	PA
Corbicula fluminea	Asian clam	Mollusk	EE
Dreissena polymorpha	Zebra mussel	Mollusk	EE
Perna perna	Brown mussel	Mollusk	PA
Perna viridis	Green mussel	Mollusk	PA
Pomacea canaliculata	Channeled apple snail	Mollusk	PA
Crassostrea gigas	Pacific oyster	Mollusk	PA
Crassostrea ariakensis	Asian oyster	Mollusk	PA

Scientific Name	Common Name	Group	Status[1]
Myocastor coypus	Nutria	Mammal	EE
Solenopsis invicta	Red imported fire ant	Insect	EE
Coptotermes formosanus	Formosan termite	Insect	EE
Aedes albopictus	Asian tiger mosquito	Insect	EE
Apis mellifera scutellata	Africanized honeybee	Insect	PA
Phyllorhiza punctata	Australian spotted jellyfish	Jellyfish	LE
Daphnia lumholtzi	Water flea	Crustacean	LE
Eriochirus sinensis	Chinese mitten crab	Crustacean	PA
Carcinus maenas	Green crab	Crustacean	PA

[1] Status: EE = Extensively Established; LE = Locally Established; PA = Potential Arrival;
E = combined categories of EE and LE due to mobility of fish species.

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14. ABSTRACT

Through human and natural activities, land loss in the Louisiana Coastal Area has exceeded 1.2 million acres since the 1930s. Restoration of the region will require new technologies and significant inputs on many fronts. One innovative proposal to aid in restoration efforts has been to transport dredged sediments from the Illinois River to Louisiana for land building and marsh restoration. Of concern in such a project is the potential for transporting invasive species from one state to another via the sediment or the transport vehicles. This report examines the likelihood of invasive species introduction and movement through such a project.

15. SUBJECT TERMS

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Monitoring	Sediment

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