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Floristic Inventories of Confined Disposal Facilities in the Great Lakes Area of Concern

PURPOSE: This technical note describes vegetation characteristics and implications for management of confined disposal facilities (CDFs) in the Great Lakes Area of Concern (GLAC). This is the first technical note for the Dredging Operations and Environmental Research (DOER) Program research task "Effects of Plant Species on the Transfer of Contaminants to CDF Animals." This DOER research task will evaluate the effect that various plant species/ communities have on the fate of contaminants in CDFs. As part of the first step in this effort, floristic inventories were conducted and compiled to determine the composition of CDF vegetation in the GLAC. The data in this technical note are provided as examples of the typical vegetation community development one would expect on a CDF in the Great Lakes and in similar freshwater dredging regions. Funding for this work was provided by the U.S. Army Engineer District, Detroit, and the Dredged Material Management Focus Area of the DOER Program.

BACKGROUND: Although vegetation is generally the least managed component in a CDF, it provides the greatest number of functions and challenges within a CDF. Vegetation can be beneficial because it helps to dewater dredged material, control dust, reduce volatilization losses, and improve effluent quality by filtering. Dense vegetation, however, may severely reduce the available storage capacity of the CDF, restrict the flow of dredged slurry within the CDF, and require removal in order to construct a cap or cover. It is also a direct conduit for transfer of contaminants from the dredged material to animals. There are many options for managing vegetation on CDFs. In a guidance document for assessment and remediation of contaminated sediments, the U.S. Environmental Protection Agency (USEPA) (1994) provides options for managing vegetation including 1) periodically cutting or burning the vegetation, 2) tilling, applying herbicides, 3) planting acceptable species, and 4) placing new sediments on top of existing vegetation. The implications of each management strategy must be considered on a case-by-case basis.

Contaminated dredged materials in many CDFs pose a possible risk to terrestrial foodchains and must be evaluated to prevent any long-term adverse effects. In many cases, simple management of vegetation can minimize risks. Identification and association of certain plant species or plant types with specific contaminants will allow vegetation management to be selective based on the contaminants in dredged material that contribute to the greatest route of exposure. The attraction of animal species to CDFs is determined, in part, by the vegetation characteristics of the CDF. In many cases, animal species of greatest concern, such as threatened or endangered (T&E) species, are attracted to and supported by specific native plant species or native plant community groups that may not be sustainable or present in significant numbers on CDFs. However, many animal species that are not dependent on specific plant species or plant communities are attracted to CDF vegetation for shelter and food. Higher animals thus may be attracted to the CDF in search

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of prey. This is the case with CDFs such as the Jones Island CDF in Milwaukee, Wisconsin. The 80-acre CDF is home or seasonal sanctuary to numerous animal species including earthworms, birds, rabbits, ducks, coyotes, and many others. In fact, it has been noted as a favorite bird watching site of the local populace. While the Jones Island CDF was not designated to provide habitat for wildlife, it does have innate value for such purposes. Since the GLAC CDFs were authorized under Public Law 92-611 to contain contaminated dredged material not suitable for open-water disposal due to potential biological impacts, the consequence of their use as terrestrial habitat for wildlife is a potential concern. Impacts to wildlife are generally evaluated using procedures described in the Upland Testing Manual (U.S. Army Corps of Engineers (USACE) 2003). These procedures evaluate the effects of direct exposure to dredged material by both plants and animals using standard index species for each. However, these procedures are general in assessment of potential impacts and do not account for variability that is inherent in a changing diversity of plant species or the risk that individual or classified groups of plant species may pose to animals exposed to these plants and their by-products. By establishing plant-specific bioaccumulation factors in relation to index species and determining fate and bioavailability of contaminants in various plant/soil rhizospheres, vegetation management strategies can be developed to minimize adverse effects to animal species inhabiting CDFs.

METHODS: Floristic inventories were conducted by Dr. Gerould Wilhelm on several CDFs in the GLAC from 1997 through 2003. These assessments were conducted using methods of identification and assessment as described by Wilhelm and Ladd (1988) and Swink and Wilhelm (1994). Plants were identified in 1-m^2 quadrats along variable transects depending on the size and shape of vegetative coverage at each CDF. Within each quadrat, a presence list of each species was made and assigned a Braun-Blanquet cover/abundance coefficient, with values ranging from 1 to 5. Generally, the coefficients were applied according to the following criteria:

- Species consisting of one to few stems in only one quadrat.
- Species occupying one to three quadrats and numbering several stems of clumps.
- Species occupying three to four quadrats and their density or cover being notable in each.
- Species occupying three to four quadrats and with a regular density throughout.
- Only those species which wholly dominate all four quadrats.

Relative importance values were calculated for each species in each transect unit by summing the relative frequency and relative cover/abundance values for each species and dividing by two. Floristic quality indices (Wilhelm and Ladd 1988, Swink and Wilhelm 1994) across a transect were documented by calculating the mean coefficient of conservatism (C) and floristic quality index (FQI) of each quadrat. The quadrat values were summed and averaged to describe the vegetative quality of each unit. The C values for all species recorded along the transect were calculated, along with the FQI, to determine the overall floristic quality of the sampled area.

It is helpful to think of the mean C values as a progressive scale of system integrity in which the scaler integers vary by orders of magnitude, such as with the Richter Scale. The C value is a coefficient that ranges from 0-10 assigned by Swink and Wilhelm (1994) to native species of plants of the Chicago region. Non-native species all receive default values of 0. The scaler values represent the confidence one feels as to the extent to which any particular species is likely to be found in a stable remnant plant community. Coefficients of 0-3 provide minimal confidence that the species was found in a plant community with full system integrity. Species with values from 4-6 are likely to grow in some sort of remnant context, but the degree of degradation remains a question. Species with C values of 7-10 provide strong levels of confidence that the area from which they were noted is of remnant quality.

When an inventory is conducted and the suite of species on a site is compiled, the mean C value of all species is quite informative. Areas with mean C values lower than 3.0 always reflect a high degree of disturbance and represent profound system instability. Areas with mean C values from 3-4 are usually fairly degraded, but must contain a fairly diverse component of conservative species, usually more than is achievable in routine wetland restorations. Areas with a mean C value higher than 4 suggest the presence of remnant biodiversity and are of such sufficient integrity that restoration attempts are unable to replicate. Most serial or successional areas, even those that are quite old, are not able to coalesce species matrices with enough conservative diversity to yield mean C values higher than 4. High-quality remnant systems have mean C values in the 5's and 6's and comprise less than 0.1 percent of the land area in Illinois.

Results of CDF inventories were compared to inventories of remnant-like lake prairies located within the GLAC. The Kawkawlin Prairie is located just a mile or so west from Saginaw Bay, Michigan, not far from the Saginaw River CDF. The Grand Beach Prairie is located in the Lake Plain of Lake Michigan, near New Buffalo, Michigan.

RESULTS: Observations and floristic inventory results for each CDF and reference location included in the study to date are summarized below. Table 1 summarizes the data for each site inventoried.

Milwaukee CDF. A 4-hr survey of the vascular vegetation of the Jones Island CDF (Figure 1) in Milwaukee resulted in the discovery of 85 species of vascular plants. The survey was not comprehensive. Rather, it was comprised of the inventories of 26 sediment core sample areas. A general description of the core areas consisted of a total inventory of all identifiable plant species within a 10-m radius of each sample point; each species therein was given an estimated percent cover value, which ranged as low as 1 for trace occurrences and as high as 100. Cover values generally were assigned in increments of 5.

In the older areas of the CDF, on sediment that may have exceeded 10 years of age, the dominant vegetation was *Phalaris arundinacea* (C = 0 Reed Canary Grass), *Salix interior* (C = 1 Sandbar Willow), and *Urtica procera* (C = 2 Tall Nettle), which represent a mean C value of 1.0. In areas that were scarcely one year old, the vegetation is sparse with only scattered growth of annuals, rosettes, and first-year perennials; the dominant species included, in order of their relative importance, *Polygonum lapathifolium* (C = 0 Heartsease), *Arctium minus* (C = 0 Common Burdock), *Chenopodium album* (C = 0 Lamb’s quarters), *Echinochloa crusgalli* (C = 0 Barnyard Grass), *Helianthus annuus* (C = 0 Annual Sunflower), *Impatiens capensis* (C = 3 Spotted Touch-Me-Not), *Polygonum pensylvanicum* (C = 0 Pinkweed), *P. persicaria* (C = 0 Lady’s Thumb), *Abutilon theophrasti* (C = 0 Velvetleaf), and *Acnida altissima* (C = 0 Water Hemp), which represent a mean C value of 0.3.

Figure 1. Vegetative cover on the Jones Island CDF in October 2002

All of the dominant species noted at Milwaukee were either non-native or represent native species with C values less than 4. Overall, the mean C value of the 89 species is 0.7, while that of the 41 native species was only 1.6. Such low values are not unusual for CDFs.

Some of the core sample sites exhibited an inhabitancy by halophytic species, such as *Aster brachyactis* (Rayless aster), *Atriplex patula* (Common Orach), *Chenopodium glaucum* (Oak-Leaved Goosefoot), *Diplachne acuminata* (Salt-Meadow Grass), *Hordeum jubatum* (Squirrel-Tail Grass), *Puccinellia distans* (Alkali Grass), and *Spergularia media* (Salt Spurrey). Such species were evident in and around sites 5, 6, 7, 8, 10, 12, and 14, which suggest that snow plowed from salted streets may have been stored on them or upslope from them. On a few of the sites (22, 27, and 29), *Lythrum salicaria* (Purple Loosestrife) was recorded, which also suggests that chlorides and other industrial salts are in the ambient hydrology. Additional species that routinely thrive in industrial waste ground include *Artemisia vulgaris* (Mugwort), *Heleochloa schoenoides* (False Timothy), *Helianthus annuus* (Annual Sunflower), *Phragmites australis* (Common Reed), and *Typha* X *glauca* (Hybrid Cattail). The older sites (1, 10, 13, 15, 17, 19-23, and 27-29) were largely characterized either by dense colonies of *Phalaris arundinacea* (Reed Canary Grass) with only scattered inclusions of other ruderal elements, while *Salix interior* (Sandbar Willow) dominated sites 18, 20, and 21.

Saginaw CDF. The Saginaw CDF is one of the numerous island CDFs in the GLAC and is located in Saginaw Bay near Bay City, Michigan. A floristic inventory of the Saginaw CDF produced an aggregate mean C of 0.9. The more recent lifts of dredged material were dominated by annual, biennial, or weak perennial weeds, many of them of Eurasian extraction (Figure 2). This assembly, however, quickly succeeds to one of three essential systems. In areas where there is regular overflow of sluice or sediment, but not so deep as to bury the rhizomes, the tendency is to shift to monoculture of *Phalaris arundinacea* (Reed Canary Grass, C = 0). In older areas where there is the regular influence perhaps of chlorides or other industrial salts, the tendency appears to be to default to *Phragmites australis* (Giant Reed, C = 1). In the older, higher elevations (Figure 3), the dominant species are clones of *Salix exigua* (Sandbar Willow, C = 1), with an undergrowth of *Urtica dioica* (Tall Nettle, C = 1). All of these dominant species are wind pollinated.

Figure 2. Recent lift of dredged material dominated by annual, biennial, and weak perennial weeds

Point Mouillee CDF. The Point Mouillee CDF is located in Lake Erie, south of Detroit, Michigan and was constructed as a barrier island to provide protection to shorelines in the Point Mouillee State Game Area. As such, it attracts a number of bird and mammal species and there is evidence it is used heavily by whitetail deer and rabbits. Both herbaceous and woody plant species showed evidence of heavy browsing with obvious preferences for certain species. Floristic inventories were conducted on Cell 5 in the Point Mouillee CDF in 2002 and 2003. An area of recent disposal (less than 1 year) was evaluated in 2002. This area had an aggregate mean C of 0.8. This area (Figure 4) was wholly dominated by annual weeds, such as *Echinochloa crusgalli* (Barnyard Grass, C = 0), and polygonum species in the section *Persicaria*

Figure 3. Older, higher elevation of dredged material dominated by sandbar willow and tall nettle

Figure 4. Recent disposal of dredged material was dominated by annual weeds

(all with C values of 0). In the wetter areas to the south, the muddy flats are inhabited by small annuals and halophytic species, suggesting that there may well be a fairly high chloride level. Within a few years, if left alone, this flat will probably be dominated by *Phragmites australis* (Giant Reed, C = 1), which lines the dike and all of the older ambient areas.

In 2003 an additional survey was conducted on Cell 5 along transects reflecting distinct zones associated with gradient and age of dredged material (Figure 5). Transects were selected beginning with the most recent disposal (Transect 1) and moving towards areas of oldest disposal and highest elevation. Transect 1 (Figure 6) was dominated by *Cyperus esculentus* with local inspersions of *Typha glauca*. Some sprigs of *Salix exigua* and *Phragmites australis* were scattered and were heavily grazed by deer. Typha was also grazed where it occurred. Transect 2 began at a very distinct wall of *P. australis* (Figure 7) inspersed throughout with tall sprouts of *Salix exigua* (Figure 7 inset), with the lower branches shade pruned by the 3-m-high sward of *P. australis*. Scattered growth of forbs *Urtica dioica* and *Polygonum scandens* with *Hackelia virginiana* occurred, most particularly along and in the vicinity of well-used deer trails. Transect 3 (Figure 8) was dominated by the tree willows, *Salix amygdaloides* and *Salix nigra*, along with their hybrid, *Salix* X *glatfelteri*; *Phragmites australis* is scattered throughout, as are mostly senescent trunks of the shrub, *Salix exigua*; the ground below is dominated by *Pilea pumila*, *Urtica dioica*, and *Polygonum scandens*. Transect 4 (Figure 9) was characterized by trees of *Populus deltoids* that have boles mostly 20 to 30 cm in diameter. Underneath, the area is dominated by shaded swards of *Phragmites australis*, along with scattered colonies of *Phalaris arundinacea*. The principal forb is *Urtica dioica*, with scattered colonies of *Pilea pumila*. Transect 5 (Figure 10) could only be described as a solid, nearly impenetrable stand of *Phragmites australis*.

Other CDF's in the lower Great Lakes Region. The CDF's at Dike 9 in Cleveland, Ohio; Times Beach in Buffalo, New York; and Alsip, near Chicago, Illinois; all registered low mean C values. The CDF at Alsip was less than 10 years old when inventoried. The Cleveland CDF has areas of various age and wetness, but the plants that comprise it are strongly similar to those of other CDF's. The situation at Times Beach is somewhat different. Since the 1970's it has been going through a form of old field succession, but with several different assemblages. It was only partially filled, with a topographic gradient comprised of high ground and coarse particles and progressively finer particles down gradient. At its lowest elevations, there are several emergent zones and even deeper water.

Comparison with Remnant Areas. Floristic data from the CDFs were compared to floristic data for two remnant lake-plain prairies. Note that the native mean C is relatively high (3.3, Table 1) for the Kawkawlin Prairie. Even though it is quite degraded, having suffered from chronic fire suppression and grazing, its floristic parameters are significantly higher than those associated with confined disposal facilities. The Grand Beach Prairie is one of the better Lake Plain remnants in Michigan. Another survey in July of 1991 discovered an additional 75 species, which averaged as conservative as those recorded in 1989. Compared to these areas, CDFs produce on average a low mean C (1.9, Table 1) reflecting the ruderal aspect of the association. As shown for Times Beach, both the mean C and resulting FQI declined as the CDF aged and the floristic community moved more towards a monoculture of less conservative species. This type of floristic transgression would be typical for many CDFs.

Figure 5. View from the dike of Cell 5 showing transgression of vegetation through transects

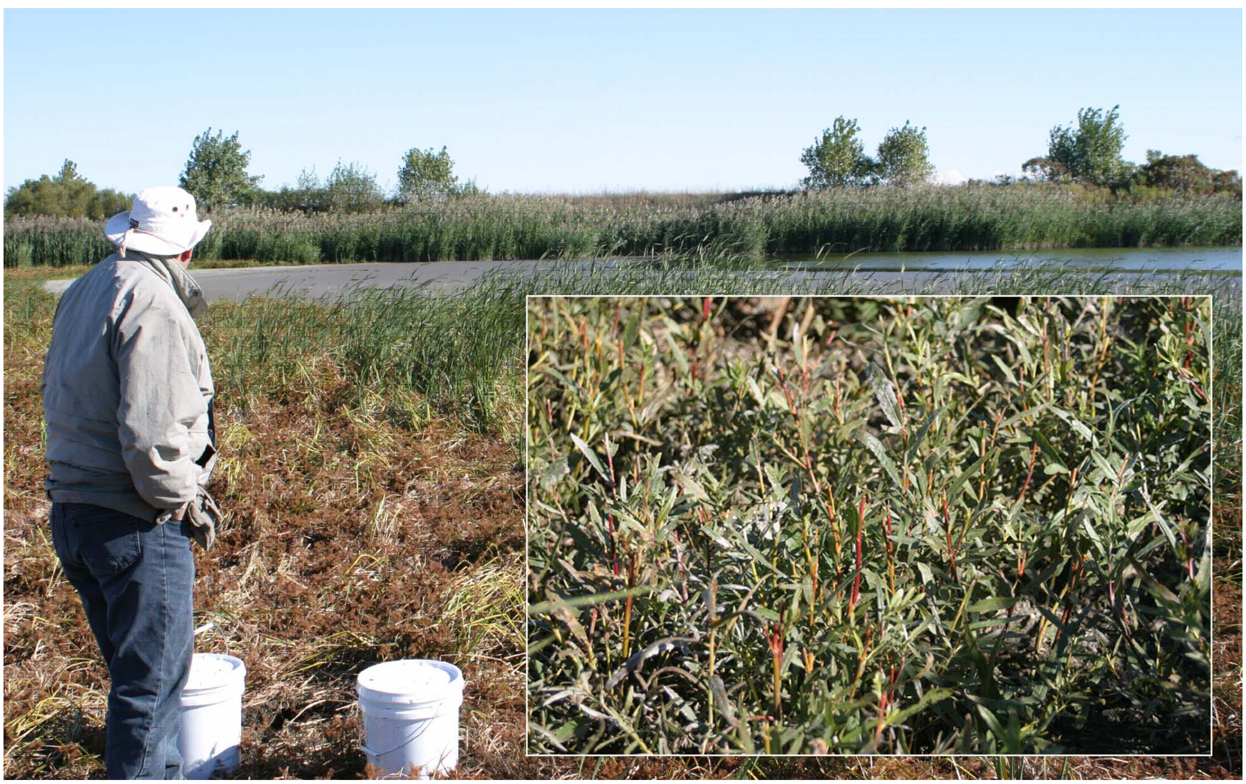

Figure 6. Transect 1 showing sprigs of *Salix exigua* grazed by deer (inset)

Figure 7. Beginning of Transect 2 dominated by *Phragmites australis* with *Salix exigua*

Figure 8. Transect 3 dominated by tree willows (*S. species*) and assorted forbs

Figure 9. Transect 4 was dominated by *Populus deltoides* with shaded grasses and forbs

Figure 10. Transect 5 contained a nearly impassable sward of *Phragmites australis*

Table 1
Floristic Quality Parameters for CDF Inventories

Site	Floristic Quality Parameters[1]					
	NT	NT w/a	MC	MC w/a	FQI	FQI w/a
Milwaukee CDF	41	89	1.6	0.7	10	7
Saginaw CDF	32	73	2.1	0.9	12	8
Pt Mouillee 2002	8	13	1.3	0.8	4	3
Pt Mouillee 2003	27	37	2.4	1.7	12.3	10.5
Cleveland CDF	30	80	1.4	0.5	8	5
Alsip CDF	42	72	1.6	0.9	10	8
Times Beach 1985	32	44	2.5	1.8	14	12
Times Beach 1996	19	36	2.0	1.1	9	6
Averages ± STD of CDFs	29 ± 11.2	55.5 ± 26.6	1.9 ± 0.5	1.1 ± 0.5	9.9 ± 3.1	7.4 ± 2.9
Kawkawlin Prairie	42	52	3.3	2.7	22	19
Grand Beach Prairie	72	74	5.7	5.5	48	47

[1] NT = native taxa, MC = Mean C, FQI = floristic quality index, w/a = with adventives.

DISCUSSION: The matrix of species that develops on CDF's and other industrial or fallow agricultural soils lacks the biodiversity of conservative native species that would enable the system to coalesce into a stable, self-renewing plant community. The species tend to be either non-native weeds or native matrix species that do not require a diverse suite of native insects and their attendant food chain organisms for pollination, propagation, and dispersal. Many of the ruderal species are wind-pollinated or are annual, biennial, or weak perennial elements that are easily pollinated by a few of the less conservative ubiquitous insects, and species that are not highly dependent on complex arrays of mycorrhizal development and rhizosphere organization.

Seral soils, such as those of CDFs, are inherently bereft of system diversity and are frequently isolated from refugia of remnant diversity. The biological effect of soil contamination with metals or organics on vegetation is difficult to quantify under any circumstances. It is all the more difficult, however, to isolate the effects of soil contamination from the universally observable macro-ecological phenomenon that all damaged ecosystems are unstable and show an inability to succeed to a healthy, biodiverse stability. Such systems tend ultimately to result in sterile monocultures of such coarse weeds as *Phalaris arundinacea* (Reed Canary Grass), *Phragmites australis* (Common Reed), *Lythrum salicaria* (Purple Loosestrife), or *Typha* (Cattail) species. Under most circumstances, these weakened systems will boom and bust in stochastic successional patterns that involve only non-native or weedy native species.

As long as the protocol with respect to vegetation on confined disposal facilities is to allow them to default to the few industrial and agricultural weeds that can inhabit them as diaspores from ambient industrial ground, CDFs will continue to remain problematic components of the landscape. A general understanding of the fate and effects of both autochthonous and allochthonous contaminants will be as elusive as their ability to achieve the stability that most healthy living systems exhibit.

The default, contemporary hypothesis with respect to vegetation development on CDFs appears to be that somehow an array of short-lived weeds growing in a nearly random assortment of low-diversity assemblages will interact in some way with contaminants and local wildlife to result in some other array of contamination in an abbreviated food chain.

A better approach to CDF restoration and land management is to use the diversity of species that are native to the area. The resulting floristic assembly would track the system on a more stable trajectory that approximates a locally natural succession, within which observations on the role of contaminants would be more robust. Currently, any contaminants that are biologically available at any given point in time tend to concentrate in progressively fewer species in extremely simple rhizospheres, which can magnify their impact in stochastic arrays, depending on the boom or bust cycle that is in effect at the moment.

One untested hypothesis would state that the greater the biological diversity in the rhizosphere and in above-ground phytomass, the more innocuous would be the negative impacts of metals and nutrients—which are of natural origin in any event. The relationship between the diversity of floristic species growing on dredged material and the transfer of metals to animals is of particular interest and is needed to predict the potential risks to colonizing animals over time. A related hypothesis might state that the more complex and stable the enzyme systems in the rhizosphere, the greater is the likelihood that organic contaminants will be metabolized or transformed into less toxic or innocuous components. The reduction of PAH and PCB compounds in the surface layer of dredged material as it ages can be attributed to both physical (volatilization) and biological (degradation) factors. The effect of various floristic communities on the persistence of organic contaminants and their bioavailability to animals is not clearly understood. Natural attenuation of organic contaminants by plants may play a key role in reducing the long-term risks to colonizing animals on CDFs.

CONCLUSIONS: Floristic inventory assessment of several CDFs since 1985 concludes that left unattended, CDF vegetation tends to exist and transcend as an unstable matrix of non-native and low-quality native species. Under most circumstances, these weakened systems will boom and bust in stochastic successional patterns that involve only non-native or weedy native species. The dominant species present are generally wind pollinated and do not require complex arrays of mycorrhizal development and rhizosphere organization. However, the presence of even low-quality vegetation provides habitat to support species of animals that are not interdependent on specific plant species. The effect these species of plants have on the fate of contaminants in the soil profile and in the transfer of contaminants through the plant/animal foodchain is a subject for further study. One hypothesis is that a more biologically diverse and robust rhizosphere and above-ground phytomass would reduce the negative impacts of metals. Organic contaminants may also be metabolized or transformed into less toxic or innocuous components in the presence of the more complex and stable enzyme systems in the rhizosphere provided in a more sustainable plant system.

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