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Restoring complex vegetation in urban settings: The case of tidal freshwater marshes

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Abstract. Tidal freshwater marshes have diverse plant communities that vary spatially and temporally due to hydrology, animal activity, and other factors. Development of urban centers along rivers of the U.S. Atlantic coast has reduced the historic extent and quality of these and other coastal wetlands. Because the vegetation of these wetlands is more complex than that of salt and brackish marshes (where restoration of vegetation typical of natural systems has sometimes been successful), restoration of tidal freshwater marsh vegetation is likely to be more difficult, particularly in urban areas. Watershed urbanization alters hydrology, sediment load, propagule availability and composition, nutrient status, and other variables that together create an environment different from that of wetlands in less developed areas, possibly precluding restoration of typical marsh vegetation. Tidal freshwater wetlands were historically extensive along the Anacostia River in Washington, DC, but most of these were lost due to filling, dredging, or hydrologic alteration. Over the last decade, the U.S. Army Corps of Engineers has implemented projects designed to restore tidal freshwater wetlands along the Anacostia, which involved increasing elevation with dredged river sediment and planting native vegetation. To illustrate some of the mechanisms affecting vegetation development in restored tidal freshwater marshes in urban areas, I present a case study on one of these wetlands, Kingman Marsh, that also includes research at another restored wetland and two natural reference sites. Studies by my research groups indicate that the restored wetlands undergo essentially a planting-modified process of primary succession. Low densities of seeds are initially present in the substrate, and prolific seed dispersal into the restored sites results in high initial plant diversity comprised of plantings and ruderal (i.e. weedy) natives and exotics. Seed banks develop rapidly at the restored sites, probably due to colonization and early reproduction by ruderal species. Hydrology and disturbance by non-native animals (including resident Canada goose) are important variables controlling establishment of vegetation in these systems. Recent literature and the case study indicate that the environmental conditions of urban settings impose constraints in restored wetlands that result in plant communities more like those of urban natural wetlands than those of wetlands in less urbanized watersheds. This suggests that rather than design wetland restoration projects with the goal of creating "pristine" wetland vegetation, restorationists must identify, accept, and if possible capitalize on the ecological constraints of the urban environment in setting achievable and desirable restoration goals.

Keywords: tidal freshwater marshes, urban wetlands, vegetation, restoration, seed dispersal, seed banks

Introduction

The ecological and socioeconomic values of wetlands have been widely recognized (Mitsch and Gosselink, 2000a), and wetlands are arguably more important in urban settings than in rural or undeveloped landscapes (Niering, 1970; Schmid, 1994; Mitsch and Gosselink, 2000b; Savard *et al.*, 2000). Their greater importance in urban environments arises paradoxically from rising human population densities (greater use) and our activities that alter and destroy wetlands (fewer wetlands; Mitsch and Gosselink, 2000b). Development in many urban centers has destroyed the vast majority of historical wetlands through filling and dredging, and altered remaining wetlands through hydrologic modification, chemical contamination, habitat isolation, and other factors (Niering, 1970; Schmid, 1994; Brady and Flather, 1994; Holland *et al.*, 1995; Guntenspergen and Dunn, 1998; Reinelt *et al.*, 1998; Panno *et al.*, 1999; Zhu and Ehrenfeld, 1999). Given the increasing value placed on wetlands in urban settings, restoration of wetlands in cities and towns is increasingly viewed as a high priority, with wetland restoration projects being implemented across the U.S. and elsewhere (Niering, 1997; Middleton, 1999; Zedler, 2001; Bakker *et al.*, 2002).

Coastal regions have historically been prime locations for development of urban centers, and populations along coastlines continue to rise (Ehrenfeld, 2000). This has resulted in extensive wetland loss in coastal regions (Brady and Flather, 1994) and, recently, expansion of coastal wetland restoration projects, the majority of which have centered on restoration of brackish or salt mashes (e.g., Zedler, 1996; Niering, 1997; Bakker *et al.*, 2002; Crooks *et al.*, 2002; Craft *et al.*, 2003). While many saline marsh projects have not been successful in restoring wetlands that are functionally equivalent to natural marshes (Zedler, 1996; Simenstad and Thom, 1996; Craft *et al.*, 2003), at least some eventually developed vegetation typical of their natural counterparts (Niering, 1997; Crooks *et al.*, 2002; Craft *et al.*, 2003). I am aware of only three locations where tidal freshwater marshes have been restored, all in urban areas. These are adjacent to the Anacostia River in Washington, DC (Baldwin and DeRico, 1999; Neff, 2002), the Delaware River in New Jersey (Leck, 2003), and the Patuxent River in Maryland (Verhoeven *et al*., 2001).

Tidal freshwater wetlands occur in the upper reaches of estuaries where topographic gradients are weak, resulting in wetlands with tidal hydrology but salinities generally <0.5 parts per thousand (ppt) (Cowardin *et al.*, 1979; Mitsch and Gosselink, 2000a). In the USA, these wetlands occur primarily along the Atlantic and Gulf of Mexico coastlines (Mitsch and Gosselink, 2000a), and were historically abundant along major rivers in urban centers such as Washington, DC (Syphax and Hammerschlag, 1995). Although historically less studied than salt marshes, they exhibit higher species richness and temporal variability of plants (Odum *et al.*, 1984, 1995; Odum, 1988; Mitsch and Gosselink, 2000a). Some of these wetlands are forested (swamps), while marshes, the focus of this paper, are dominated by herbaceous vegetation. Because of the complexity of the vegetation in tidal freshwater marshes, restoring plant communities similar to those of natural marshes poses special challenges, particularly in urban settings.

My goal in writing this paper is to convey the ecological and environmental issues I believe are relevant to restoring the complex plant communities of tidal freshwater marshes in urban areas. To do this, I first describe the temporally dynamic and spatially complex vegetation typical of natural tidal freshwater marshes. Assuming that the reestablishment of vegetation with the spatial and temporal complexity of natural, relatively undisturbed systems is a logical goal of restoration, then this initial overview is one standard against which to judge restoration success (although this is not the only standard; restorations in urban areas may require different success criteria than those in less developed areas, as suggested by Ehrenfeld (2000)). Second, I review the constraints imposed on wetland vegetation in undisturbed and urbanized environments, which must be understood if complex wetland vegetation is to be successfully created in an urban area. Third, I summarize restoration literature relevant to creating complex wetland vegetation in urban areas, emphasizing ecological models of plant community development. Fourth, to illustrate important factors relevant to restoring complex wetland vegetation in urban environments, I present a case study of Kingman Marsh, a wetland restoration project in Washington, DC that my research group has been studying for several years. Finally, I synthesize the literature and case study findings to highlight challenges and future directions for research and restoration in urban wetlands.

In the paper I use the term "natural" to indicate a recognizable type of plant community in relatively undisturbed wetlands that are not created or restored by humans. In reality, every wetland is different, and all wetlands, including created and restored wetlands, can be considered "natural" because plants are part of nature. Alternatively, all wetlands can be considered "not natural," "disturbed," or "perturbed" because of direct or indirect human influence on them. Also, no wetland is technically "undisturbed" because they are all subjected to "natural" disturbances such as flooding, ice scouring, and herbivory.

Characteristics of natural marsh vegetation

At the landscape scale, tidal freshwater marshes occur in depositional areas along coastal rivers, between upland areas and open water, sometimes with tidal freshwater swamps occurring between the uplands and the marsh. While community dominants such as *Polygonum arifolium* L. or *Acorus calamus* L. may occur across the landscape, many species exist at only a few locations. Diversity can also vary across the tidal freshwater landscape, with some sites having higher species density than others (Baldwin, unpublished data).

At a smaller spatial scale, tidal freshwater marshes, like most types of wetlands, exhibit horizontal zonation of vegetation along elevation/hydroperiod gradients. As in salt marshes, tidal freshwater marsh vegetation is often divided into two zones, high marsh and low marsh. However, the boundary between zones is often less distinct than that which occurs in salt marshes, having greater overlap of species across zones (Odum, 1988). The indistinct boundaries may be due an absence of salinity, sulfide, and other gradients that can occur in salt marshes, as well as to the greater number of species that can grow in tidal freshwater marsh habitats because of their low salinity. The low marsh community of Atlantic coast marshes is typically dominated by *Nuphar luteum* (L.) Sm. and *Peltandra virginica* (L.) Schott, while the high marsh is much more species-rich, containing an assemblage of annual and perennial emergent plants (Simpson *et al.*, 1983; Odum *et al.*, 1984; Parker and Leck, 1985; Leck and Simpson, 1995; Baldwin *et al.*, 2001).

Vegetation in these marshes also exhibits vertical variation, both above and below ground. Tall (1–2 m) canopy plants such as *Polygonum arifolium* and *Acorus calamus* are often underlain by a mid-canopy (0.5–1 m) of *Peltandra virginica* and *Sagittaria latifolia* Willd., with shade-tolerant species such as *Pilea pumila* (L.) Gray in the understory (<0.5 m). Below ground, differences in root morphology create a complex weave of structures, with the shallow, fine roots of annuals at the surface and the roots of most perennials below them. The vertical variation, and to some extent horizontal zonation as well, results from the differences in architecture of the constituent species. Some are graminoids (*Leersia oryzoides* (L.) Sw., *Schoenoplectus fluviatilis* (Torr.) M.T. Strong) while others are broadleaved (*Peltandra virginica*, *Amaranthus cannabinus* (L.) Sauer). Some species persist after senescence

(*Typha latifolia* L.), while others deteriorate rapidly after flowering (*Ptilimnium capillaceum* (Michx.) Raf.).

Marsh plant communities vary considerably across the growing season. Early in the year (e.g., March-April in the mid-Atlantic), the marsh vegetation consists of seedlings of annuals and emerging shoots of perennials. There is little standing detritus present, and much of the soil surface is exposed. The perennials, such as *Acorus calamus* and *Peltandra virginica*, grow quickly, forming a fairly open canopy below which the seedlings continue to grow. Some of the annual species flower and die early in the season (e.g., *Ptilimnium capillaceum*), while others continue growing to ultimately overtop the perennials later in the season (e.g. *Polygonum arifolium* in August). A few species are inconspicuous throughout the season, emerging as dominants and flowering at the end of the growing season (e.g., *Amaranthus cannabinus*, *Bidens laevis* (L.) B.S.P. and *Symphyotrichum puniceum* (L.) A. & D. Löve in October).

The seasonal pattern of variation occurs within the greater context of interannual variation. I noted considerable variation in plots in tidal freshwater marshes over a five-year period (figure 1), and longer-term studies in tidal freshwater marshes have also shown considerable fluctuation of species composition between years (Leck and Simpson, 1995).

Constraints on vegetation structure

To restore complex wetland vegetation, it is critical to understand not only the spatiotemporal variation of vegetation but also the environmental or biological factors responsible

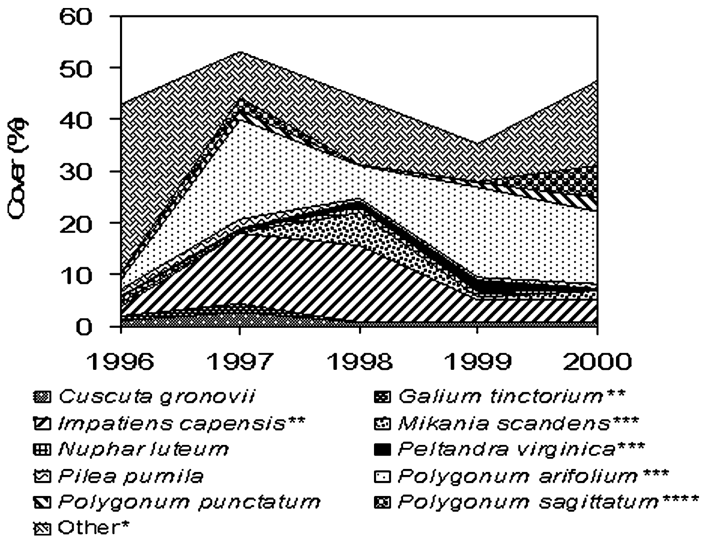

Figure 1. Mean plant cover in haphazardly-located plots in tidal freshwater marshes at Jug Bay, Patuxent Wetland Park, Maryland. Means are based on a total of 16–20 1 m^2 plots sampled by graduate and undergraduate students in my Wetland Ecology class in early October of each year (during senescence of vegetation, which is why total cover is well below 100%). Significant differences between years according to repeated measures ANOVA indicated as $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$, and $^{****}P < 0.0001$.

for establishing and maintaining that variation. As in all types of wetlands, hydrology is a dominant influence in tidal freshwater marshes, affecting plant productivity, soil redox potential, salinity, soil organic matter content, and nutrient concentrations (Mitsch and Gosselink, 2000a). More importantly for vegetation structure, individual species differ in their capacity for seed germination, establishment, and growth under flooded conditions (Parker and Leck, 1985; Leck and Simpson, 1993; Leck, 1996; Baldwin *et al.*, 2001). Variation in flooding along elevation gradients is therefore a major cause of the development and maintenance of horizontal zonation in tidal freshwater marshes. Much of the interannual variation in community composition described previously is likely due to hydrologic variation between years. The annual species in tidal freshwater marshes, which typically comprise about half of the species, depend on seed germination and seedling recruitment early in the growing season to become established in vegetation. However, flooding with even a few cm of water inhibits seed germination in most seed bank species of tidal freshwater marshes (Baldwin and DeRico, 1999; Baldwin *et al.*, 2001; Peterson and Baldwin, 2004). An experiment where my research group manipulated the pattern of flooding during the growing season indicates that early-season flooding has little effect on perennials but reduces the abundance of annual species (Baldwin *et al.*, 2001), suggesting that years with above-average water levels early in the growing season will lead to marshes with fewer annual species than would occur in drier years.

An additional cause of interannual variation in community composition related to hydrology is intrusion of saline water due to a reduction in freshwater flow into estuaries. During 2002, a drought year, I noted a marked decline in *Polygonum arifolium* compared with 2000 and 2001 in tidal freshwater marshes along the Nanticoke River during a saltwater intrusion event where soil porewater salinities increased to more than 7 ppt.

Another important variable in tidal freshwater marshes is animal activity, which can affect vegetation via both herbivory and physical disturbance during walking or swimming. Herbivores in Atlantic coast marshes include muskrat (*Ondatra zibethicus* Linnaeus), resident Canada geese (*Branta canadensis* Linnaeus), and European or common carp (*Carpinus carpio* Linnaeus). Exclosure studies indicate that animal herbivory or physical disturbance has strong impacts on tidal freshwater marsh vegetation, with annuals being affected more than perennials (Baldwin and Pendleton, 2003). Seedlings of the shallow-rooted annuals are easily dislodged from the marsh substrate by animal activity, while perennials remain rooted and can resprout rapidly from rhizomes after trampling or herbivory.

Successful restoration of complex wetland vegetation requires an appreciation that substantial deviation from typical levels in any constraint on wetland vegetation will result in a type of vegetation different from that of natural wetlands. Therefore it is critical to understand how hydrology and animal disturbance (and other variables affecting wetland vegetation such as nutrient and sediment loads) are altered by human activity and differ between urban and rural or undeveloped areas. For example, watershed urbanization increases the extent of impermeable surfaces, creating high-energy "flashy" hydroperiods that can scour stream or wetland sediment. Non-native species or genotypes like resident Canada goose may result in higher grazing pressure than existed before development. Studies of various types of wetlands indicate that, relative to undeveloped areas, wetlands in urban areas have more non-native and non-hydrophytic (i.e., nonwetland) plant species (Ehrenfeld and Schneider, 1993; Magee *et al.*, 1999), higher sedimentation rates (Hupp *et al.*, 1993), and higher sediment concentrations of heavy metals and organic chemicals (Hupp *et al.*, 1993; Sanger *et al.*, 1999 a, b). Additionally, wetlands in urban areas are affected by noise, littering, grazing, altered hydrology, and mowing (Holland *et al.*, 1995). Road salt runoff can increase wetland salinity (Panno *et al.*, 1999), as can diking, ditching and impoundment of upstream fresh water (Ehrenfeld, 2000). Urbanization can also decrease salinity due to increased freshwater runoff (Greer and Stow, 2003). Both increases and decreases in salinity can strongly alter plant species composition (Panno *et al.*, 1999; Ehrenfeld, 2000; Greer and Stow, 2003). These urbanization-altered parameters may therefore preclude restoration of natural complex vegetation in urban areas.

Applying ecological knowledge to restore urban wetlands

Anthony Bradshaw has said that restoration is an "acid test" of our ecological understanding (Bradshaw, 1987), and the importance of ecological knowledge in restoring ecosystems has been stressed by many others (e.g., Zedler, 1996; Palmer *et al.*, 1997; Parker and Pickett, 1997; Ewel *et al.*, 2001). Ecological restoration projects are by definition a "process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER, 2002). Because human activities usually caused the ecological damage, restoration projects often take place in areas where humans have altered not only the ecosystem targeted for restoration, but also the surrounding watershed and its ecosystems (and thereby the constraints on vegetation discussed previously). Therefore, while ecological knowledge is important in successful restoration, that knowledge must encompass the structure and function of the restored ecosystem in both urban and less developed areas.

Because the constraints of the urban environment on ecosystem development are often not well understood or considered, the goal of restoring natural wetland vegetation in urban areas may be unrealistic (Grayson *et al.*, 1999). This point is underscored by the observation that existing urban wetlands differ in species composition from the same type of ecosystem in rural or undeveloped areas. For example, they are sometimes described as "degraded" or "low-quality" because they are populated by non-native, non-hydrophyte, or "invasive" species. However, because the vegetation structure in these natural urban wetlands integrates the effects of the urban environment, restoring vegetation similar to that of these urban wetlands is a much more realistic goal than attempting to create vegetation like that of a rural wetland. Ehrenfeld (2000) summarizes a number of factors that may affect the success of wetland restoration in urban areas, and that should be considered in realistically evaluating the success of urban wetland restoration projects. She points out that in urban wetland restorations, human values may be more important than ecological functions, natural disturbance regimes may be difficult or impossible to restore, nutrients may be overabundant, habitat patches are typically small and isolated, and hydrology is often drastically altered.

These constraints in urban restored wetlands can alter vegetation development, which can be viewed as a successional process modified or accelerated by human actions (van der Valk, 1998; Middleton, 1999). Like natural wetlands, seeds can enter restored wetland sites via wind, water, and animal dispersal (figure 2). Similarly, vegetative propagules can

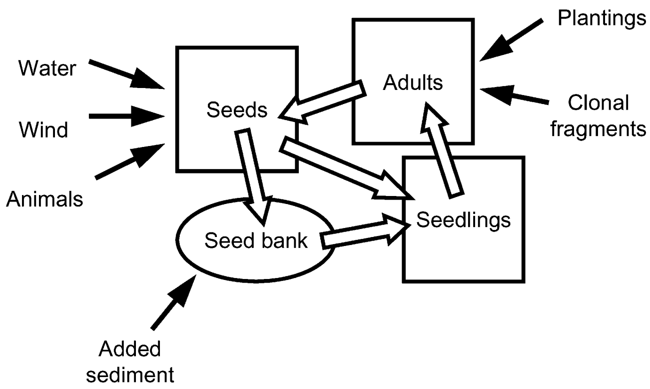

Figure 2. A life history model of succession in restored wetlands, inspired by models presented in figure 1 of Leck (1989) and figure 2 of van der Valk (1998). The solid arrows indicate input of seeds or vegetative propagules, while the thick open arrows indicate transitions between life history stages that are affected by biotic or abiotic conditions (inundation, competition, disturbance, etc.).

be dispersed to natural and restored sites via water and possibly other pathways. Seeds dispersing into a site may germinate immediately or enter the seed bank, possibly germinating at a later time if germination cues are met. Seedlings from these seeds can then grow into adult plants, flower, and reproduce, closing the cycle. In restoration, sediment may be added to increase elevation or to provide a seed bank for regeneration of vegetation, and often plantings are included, which are typically introduced to the system as large seedlings or adults. While this model is simple in structure, the reality it describes is complicated by the effect of biotic and abiotic factors on transitions between seed, seedling, and adult life stages for all of the component species in the restored wetland. As discussed previously, biotic and abiotic factors can differ markedly between urbanized and less developed areas, thereby resulting in different successional trajectories and ultimately different plant communities. To better understand how these factors affect the development of vegetation in restored tidal freshwater marshes, my research group has been studying soil seed banks, seed dispersal mechanisms, and vegetation development at Kingman Marsh and other restored and natural wetlands in the Washington, DC region.

Case study: Kingman Marsh

Historically there were about 1,000 ha of tidal freshwater marsh along the Anacostia River in Washington, DC (Hitchcock and Standley, 1919; Bernstein and Shepp, 1992; Bowers, 1995). Today less than 40 ha remain (U.S. EPA, 1997). In early 2000, the U.S. Army Corps of Engineers restored marshes at the Kingman site by adding sediment hydraulically dredged from the adjacent Anacostia River channel and planting seven species of wetland plants, creating about 13 hectares of vegetated wetland (Neff, 2002). Water tubes were installed until August 2000 to contain sediment while it dewatered and consolidated, but these essentially eliminated tidal influence into the wetland. Temporary fencing was installed during planting to reduce grazing by the population of resident (i.e. non-migratory) Canada geese during the first growing season (2000), but was removed by early 2001, since vegetation seemed well established (Neff, 2002). While my group's emphasis was on Kingman Marsh, to provide a context for our results we also studied seed banks and vegetation at a previously restored urban marsh (Kenilworth Marsh), a natural urban marsh (Dueling Creek), and a natural rural marsh (Patuxent Wetland Park).

The soil seed bank at Kingman Marsh developed rapidly during the first year following restoration, as evidenced by much greater species richness and density of seedlings emerging from soil samples in 2001 than in 2000 (Neff, 2002). The rapid development of seed banks has also been noted in a restored tidal freshwater marsh in New Jersey (Leck, 2003). Low density and richness in 2000 indicated that dredge material used to restore sediment elevation contained few seeds and was therefore not an important source of propagules for regeneration. Therefore, vegetation development at the site can essentially be considered primary succession (modified by plantings) on mineral soils containing few seeds or propagules. As in a previous study (Baldwin and DeRico, 1999), higher density and diversity of seed banks occurred at the restored than at the natural sites, possibly due to extensive colonization by weedy species (ruderals *sensu* Grime, 1979). These plants establish and reproduce quickly, depositing their abundant seeds into the seed bank. Sampling of dispersal pathways indicated that water is the primary seed dispersal pathway for colonizers at the Kingman Marsh site (Neff, 2002), a finding consistent with other studies (Smith and Kadlec, 1985; Smits *et al.*, 1989; Middleton, 1999; Wolters and Bakker, 2002; Leck, 2003).

Plant cover developed rapidly at Kingman during the first growing season due to colonization and planting, but declined after the goose fencing and water tubes were removed (which increased grazing pressure and possibly flooding stress on plants, respectively). The negative impact of animals on vegetation abundance at Kingman Marsh was documented in a fencing experiment at Kingman Marsh (P. May and R.S. Hammerschlag, unpublished), and there was a negative relationship between proportion of time inundated and vegetation cover (Neff, 2002). It is also possible that the goose disturbance and flooding interacted in their effect on vegetation; Baldwin and Pendleton (2003) found that animals impacted vegetation more in low marsh than in high marsh vegetation.

Interestingly, Patuxent Wetland Park and Dueling Creek, the rural and urban natural sites, respectively, showed similar plant cover and species density despite differences in species composition. Notably, the invasive native *Phalaris arundinacea* L. and invasive non-native *Lythrum salicaria* L. were abundant at the urban Dueling Creek site but absent at the rural Patuxent site (Neff, 2002). This difference highlights the effects of the urban environment on natural wetlands and suggests that Dueling Creek is a more appropriate reference site for evaluating the success of vegetation restoration at Kingman and Kenilworth than is the Patuxent site. This finding also shows that urban sites can have diversity similar to natural sites, even while they differ in species composition.

Because so few tidal freshwater marshes have been restored, and these systems are intrinsically variable on spatial and temporal scales, the ultimate composition of vegetation at Kingman and Kenilworth is uncertain. My group's research indicates that, based on numbers of species, seed banks of the restored marsh sites are more complex than those

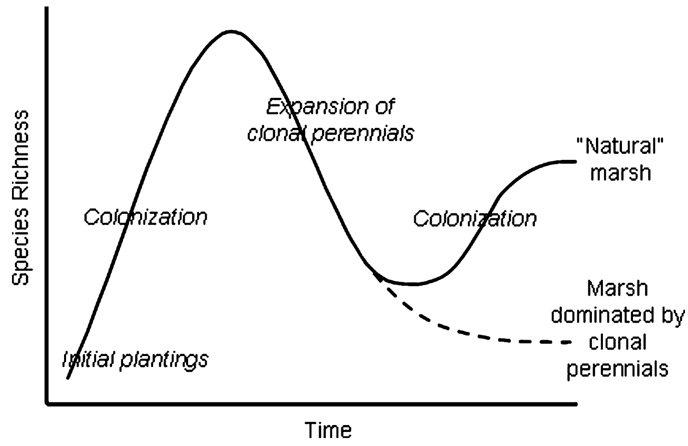

Figure 3. A conceptual model of variation in species richness over time in restored tidal freshwater marshes. The dashed and solid lines show two possible future species richness trajectories.

of natural marshes, while vegetation tends to be less complex in restored than in natural marshes. While the vegetation of the restored marshes exhibited seasonal variation and large differences between the first and second growing seasons, there are insufficient data to evaluate long-term interannual variation in species composition. Given that many of the dominant species in the restored wetlands are perennials, I would speculate that interannual variation will be less in the restored than in the natural marshes. The negative relationship between flooding and vegetation cover indicates that spatial complexity in the form of horizontal zonation develops rapidly in response to elevation gradients in restored marshes.

What does this case study teach us about restoring the complex vegetation of tidal freshwater marshes? Based on research to date, we can expect species richness of vegetation to increase rapidly initially due to colonization from seeds or vegetative propagules dispersed to the site via wind, water, or animals (figure 3). However, as clonal perennials that were planted or colonized expand, species richness will decline. These clonal perennials may persist indefinitely resulting in a low-diversity marsh such as currently exists at the Kenilworth site. Alternatively, if colonization by species more typical of natural marshes occurs, eventually the marsh vegetation may come to resemble that of natural wetlands. Perhaps the most likely scenario is one where community composition develops into something dissimilar to that of natural marshes or wetlands dominated by monocultures of invasive perennials, such as the plant community that currently exists at the Dueling Creek natural, urban wetland. Such a wetland would have the species richness and some of the typical dominant species of natural, rural wetlands, but also contain populations of invasive perennials promoted by altered hydrology, physical disturbance, excess nutrients, or other influences of the urban environment.

Synthesis and conclusions

Urban and restored ecosystems are often viewed as degraded and ecologically simple ecosystems compared to their less disturbed rural or wild counterparts, and this is undoubtedly true for some parameters (e.g., Magee *et al.*, 1999). However, the case can be made that urban, restored wetlands are in some ways more complex than natural wetlands. Species richness of both plants and animals in urban wetlands may be similar to or even higher than in rural wetlands because of the invasion of exotic species, changes in hydroperiod or nutrient regime that allow colonization of less flood-tolerant or previously nutrient-limited plants, alterations in microtopography or substrate composition due to physical disturbance, or increased sedimentation rates (Ehrenfeld, 2000). Studies by my research group have shown that the Kingman and Kenilworth restored marshes have seed banks of higher density and diversity than nearby natural marshes. Vegetation development at Kingman displayed strong temporal variation during the first two years following restoration, and its hydrology and geomorphology are in a dynamic state due to channel development, sedimentation, consolidation, and erosion. Patterns of succession and assemblages of species are new, as they are a result of plantings by humans and colonization of seeds and clonal fragments of native and nonnative species from an urbanized watershed onto coarse mineral sediment in the presence of herbivory from nonmigratory geese, conditions under which no natural tidal freshwater marsh developed. Hence, these dynamic, complicated ecosystems offer an interesting and productive opportunity for ecological research (also see McDonnell and Pickett, 1990).

Studies on restored wetlands in urban environments indicate that they require many years to resemble pristine natural wetlands, if they ever do (Kusler and Kentula, 1990; Simenstad and Thom, 1996; Niering, 1997; Ehrenfeld, 2000). This may have led (or is leading) to a sense of discouragement in the ecological restoration community. However, while restoration to natural conditions may never be achieved, creation of wetlands with valuable ecological and socioeconomic functions can be enhanced through better ecological knowledge (Palmer *et al.*, 1997; Ewel *et al.*, 2001). Based on the Kingman case study and work by others, there is evidence that, in restored urban wetlands, seed banks develop rapidly, seed dispersal into restored sites is prolific, resident Canada geese can decimate vegetation, and hydrology strongly affects plant cover. All of this information is valuable in designing future wetland restoration projects in urban areas. While vegetation composition in the distant future is uncertain, and may never resemble that of "pristine" wetlands, perhaps, as suggested earlier, the goals of restoration have indeed been unrealistic. The vegetation of restored urban wetlands can be complex, even if it is not compositionally the same as that of natural wetlands. Spatial and temporal variation is a feature of these restored wetlands, and I would submit that to be satisfied with our urban wetland restoration projects, we must appreciate the complex interactions of biological, chemical, and physical factors that shape vegetation development, even in seemingly "unnatural" places like our cities and towns.

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