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Five-Year Post-Reconstruction Kingman Marsh Monitoring Project: Vegetation

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Background

A five-year post-reconstruction monitoring project (2000–2004), which was designed to track the development of the freshwater tidal Kingman Marsh in the urbanized Anacostia River estuary (Washington, D.C.) following reconstruction in 2000, was supported by funding from the Baltimore District of the Army Corps of Engineers (CoE), the Department of Health for the District of Columbia government (DHDC) and the U.S. Geological Survey Patuxent Wildlife Research Center (PWRC). The study was conducted by staff from PWRC and the University of Maryland Department of Biological Resources Engineering (Dr. Andy Baldwin and graduate students; Baldwin 2004). The concept of the study was to track the Kingman Marsh evolution and compare it with those of a series of other local wetlands (Figure 1) as references: Kenilworth Marsh (1993), a similarly reconstructed marsh just a half-mile upstream; Dueling Creek Marsh, the last, best remaining tidal marsh in the urban Anacostia area; and the Patuxent River Marsh, a rural freshwater tidal wetland in the adjacent Patuxent watershed. The Fringe Marsh was reconstructed in 2003, but data from it is not included in this paper. Reference wetlands were monitored concurrently with the reconstructed ones. The Anacostia once had over 2,000 acres of wetland, but most were removed by mandatory dredge-and-fill operations during the first half of the 20th century (Syphax and Hammerschlag 1995) . The urge to rebuild once-extant wetlands in the Anacostia was promoted by the National Park Service (NPS) ,which has management responsibility for the reconstructed landscapes. Further background, detail, and methodology may be garnered from PWRC annual reports prepared for CoE and DHDC for the years 2000–2003 inclusive, as well as from the scope of work.

This paper is designed to include important results from the vegetation portion of the study and synthesize results from all five years of the study. The scope of this study has provided an extraordinary opportunity to gain insights into the ramifications of wetland reconstruction, and perhaps most importantly to provide data that have been used to evaluate and guide, as well as document, adaptive management actions following unforeseen or uncontrollable interventions in the marsh restoration processes. Wetland restoration efforts rarely go just as planned because complications often develop. Thus what might have been naively envisioned as a rather straightforward process at Kingman, perhaps similar to the early years at Kenilworth, became convoluted as a result of vegetation depletion from intensive grazing by overabundant resident Canada geese along with concomitant effective lowering of marsh sediments, likely from a combination of erosion, consolidation, and compression forces as

Figure 1. Composite image of a portion of the tidal Anacostia River (September 2003) showing the study wetlands. The site dates indicate when the wetlands were reconstructed. The Patuxent River Marsh is not displayed since it is in an adjacent watershed. Photo courtesy of Kinard Boone, USGS.

well as from extended periods of considerably higher-than-normal water levels. Comparisons with Kenilworth Marsh have been affected by intensive invasion by the non-native form of phragmites *(Phragmites australis)* and purple loosestrife *(Lythrum salicaria)*, which ultimately triggered necessary herbicidal treatments by a special NPS vegetation management team, while comparisons to Patuxent River Wetlands have been distorted by the building of a beaver dam, which flooded a number of transects. As a result this study really is not poised to reflect a successful pattern of restoration success from the Kingman reconstruction, but can document well what has occurred both before and after complications and adopted management actions. Actually, to embellish the original study, which focused principally on vegetation, seed bank, and seed source, the project core has been amplified by the inclusion of a three-year funded benthic study, a three-year bird study, two years of surface elevation table (SET) measurements and hydrologger data, as well as associated information from four years of fenced exclusion plots and observations from fenced plantings by the Anacostia Watershed Society (AWS).

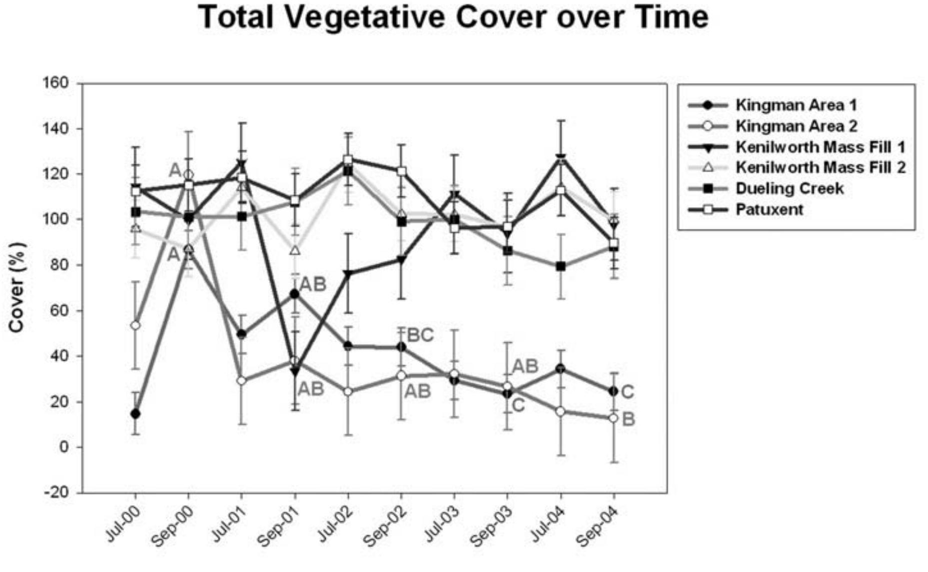
The vegetative community is recognized as a useful surrogate for such marsh functions as wetland habitat, sediment deposition, aesthetics, marsh stability, nutrient cycling, etc. Its establishment also reflects well the status of marsh hydrology, which is the key driver controlling wetland establishment under normal conditions.

Total vegetative cover

We started our scheduled monitoring in July 2000 just after planting was completed. Kingman Area 2 had been planted first, which likely accounts for vegetation cover being closer to 50%, while cover in Kingman Area 1 was less than 20%, much of which consisted of the new plantings. It is a testimony to the rapid establishment of these freshwater tidal marshes that total cover by September 2000 increased to roughly 100% (120% at Kingman Area 2 and 80% at Kingman Area 1), of which the planted species provided about 30% of the cover. Total cover in September 2000 at Kingman was similar to that of the other marshes. Thus, despite some lag in the completion of the plantings, partially due to the need to fence as well as plant, one would have to say the first-year revegetation process was successful in terms of cover, which comprised a solid component from the planted species along with an even stronger contribution by volunteer species. During the following winter of 2000–2001, the fencing was deliberately removed. The miscalculation about the fencing is evident in the 2001 cover data. Cover plummeted at Kingman Area 2 to less than 30% and at Kingman Area 1 to about 60% (Figure 2). The cover at Kingman Area 1 was significantly less (repeated measure analyses coupled with Tukey tests) than the Patuxent and the Kenilworth sites in July. The September 2001declines in cover at Kenilworth followed the first herbicide treatments to remove the invasive non-native species there—primarily the Phragmites and Lythrum. The cover decline continued at a lesser rate in the succeeding years, such that by September 2003 cover at Kingman Area 1 was significantly less than in September 2000 and at Kingman Area 2 cover was significantly less in 2002 than it was in 2000. It was good to see the rapid recovery in terms of cover, particularly at Kenilworth Mass Fill 1. Due to the marsh loss the CoE and DHDC funded a partial replanting in 2002 at Kingman.

Much of the marsh growth at Kenilworth tends to be luxuriant, with cover frequently exceeding 100% and proving almost impenetrable by summer's end. Cover at Dueling remained pretty stable over the five-year period as did that at Patuxent, with but a slight decline by September 2004, likely a result of flooding effects from the beaver dam along several transects. By September 2004 both Kingman Areas 1 and 2 were significantly different between the years from what they were in 2000 (repeated measures analyses), while Kingman Area 1 remained significantly different within the year for 2004 from the Kenilworth sites. The image depicted in Figure 2 is dramatic in portraying a persistent decline at Kingman from 2000 onward unmatched by any of the other sites (except Kenilworth Mass Fill 1,

Figure 2. Total vegetative cover of areas over time. Data points represent least square means +/- SE. Labels are based on Tukey test results (overall $\alpha = 0.05$). Within-areas means sharing the same uppercase letters are not significantly different from year to year. Unlabeled series have no significant differences.



as explained), which, overall, remained consistent, with cover near 100% or more. It is likely that the geese were responsible for the initial decline at Kingman but that in succeeding years eroding and consolidating sediment along with higher water levels in 2002 and 2003 made it difficult for the marsh to recover from grazing effects. Thus total vegetation cover that was near 100% initially has been reduced to close to 25% at Kingman while the reference areas all have been close to 100%.

It is interesting that most portions of Kenilworth Marsh, except for some edge areas, proved resilient to the goose population even though some grazing occurred early in the growing season. It just appears the marsh was able to outgrow the goose grazing pressure and produce enough vegetation so that the geese refrained from penetrating marsh areas.

Species richness

It is impressive how the number of species can be so high immediately following reconstruction. We identified 125 species at Kingman Marsh in 2000. A valuable point (Neff 2002) is that the 18 transects at Kingman picked up 75% of the total species identified there. This provides a rough efficiency of the transect cover. The number of species at Kingman Area 2 on a per-sector basis was higher in July than for any other time or for any of the other wetlands. Kingman Area 1, which was completed (final filling and grading) a couple months after Kingman Area 2, saw an increase in the number of species to a high level by September 2000. Clearly there are an important number of species that volunteer in the newly exposed sediments that would likely get competed down to a more normal level (as depicted by the other wetlands) thereafter. However, at Kingman this phenomenon did not have an opportunity to be expressed because the fence removal and consequent grazing by the geese reduced the species number in Year 2 (2001) at both Kingman areas below those of the other wetlands. By September 2001 the species per sector at Kingman was already significantly lower than the year before (Year 1). Apparently the herbicidal treatment by NPS directed at the Phragmites also affected other species at Kenilworth Mass Fill 1 because its number of species was also significantly reduced. The number of species at the other sites remained stable over the five-year period. By July 2002 the number of species at Kingman Area 2 was significantly lower than for Patuxent at the same time. The significant decline in Year 2 and the continued decline through Year 5 (2004) can be attributed to persistent grazing pressure and low sediment elevations that repress regeneration. Fewer species germinate at the lower elevations and those few that do are readily grazed in the exposed areas. Seed germination suppression due to flooding has been well documented in the literature (Leck 1995, 2003; Neff 2002; Peterson 2004; Smith et al. 2002). By 2004 there were but a few species per sector and these were growing at the higher elevations.

Contribution from planted versus unplanted species

The planting at Kingman in 2000 consisted of seven species: *Pontederia cordata* (200,000), *Peltandra virginica* (154,000), *Schoenoplectus tabernaemontani* (120,000), *Sagittaria latifolia* (120,00), *Juncus effusus* (43,000), *Schoenoplectus pungens* (40,000), and *Nuphar luteum*. This total of roughly 700,000 plants includes about 40,000 that had to be replanted due to initial goose grazing before fencing was installed to protect the new plantings. These species were pared down from the sixteen species planted at Kenilworth based on availability and survival. The expectation was that the plantings (on approximate 2-ft centers) would ensure rapid colonization cover of species that would be important to the ultimate marsh community structure. While it had been documented by Baldwin's project study that there was abundant waterborne seed available to help establish rapid cover, the investment in planting important plant species not in abundance in the seed bank was still considered a worthwhile investment to assure establishment of a vigorous and representative freshwater tidal marsh. A small portion of the marsh was left unplanted. What we determined from monitoring was that altogether the planted species provided about 40% of the cover by September 2000 (the first year) but that this contribution toward absolute cover declined by year two (2001) and remained at about 10% cover thereafter, even though there was partial replanting of *P. virginica* and *S. tabernaemontani* (both geese-unpalatable species) in 2002, some small portions of which happened to be in locations where our transects were located. What does need to be noted is that even though the cover by planted species remained low, they did provide about 50% of the vegetative cover that remained in 2003 and 2004. Almost none of the planted species, except less than 5% cover by *P. virginica* and *J. effusus* in 2004, were found in the unplanted transects during the study. By 2003 Peltandra and Nuphar were the only planted vegetation providing cover. The bottom line is that the situation of extensive goose grazing and minimal area left unplanted precluded the reconstructed Kingman Marsh from being a fair measure of the utility of heavily planting the newly reconstructed Anacostia wetlands.

Contribution by annuals and perennials

Annuals succeed by producing seeds which germinate and yield new plants on site each year. If conditions become less favorable for this process to occur, annuals will decline. For many annuals seed germination and seedling growth is dependent on aerobic respiration, which in turn needs at least modest oxygen levels in the sediment. The longer sediments are inundated, the more likely they will be anaerobic. What this means, then, for explaining the cover produced by annuals is that conditions that lower sediment elevations or raise water levels may lead to decline of annuals or make it more difficult for them to recover from grazing pressure. At Kingman Area 1 there has been a complete loss (significant) of annuals since 2000, when annuals provided as much as 30% cover. Annuals also collapsed at Kingman Area 2, although some of the higher elevations there may provide some refuge. A problem faced by annuals was that as soon as a few slower-responding annuals would sprout in the more open (grazed out) lower elevations, the geese and other herbivores could easily nip them off. Under this scenario there is little or no opportunity for the vegetation to outgrow the goose grazing pressure at Kingman, whereas successful out-competing growth seems to occur at the unfenced, but higher-elevation, Kenilworth Marsh. Kenilworth supports about 10–20% cover by annuals. Dueling Creek Marsh, as an unreconstructed wetland bench in the Anacostia, sustained about 30% annuals throughout the study. The Patuxent wetland, which is less urban and less disturbed, supported about 60% cover by annuals until flooding in 2002 by the newly constructed massive beaver dam caused a significant collapse of annuals there!

Perennials may be better adapted to lower sediment oxygen levels since many can transport oxygen down to the roots via their emergent tissues. Also, perennials that can regrow year-to-year from rhizomes and tubers are not as dependent for survival or spread by seeds. Perennials declined sharply with removal of fencing at Kingman Area 2 in early 2001 and have continued to slowly decline throughout the study to where they provide less than 20% cover in 2004, whereas they were as high as 80% in 2000 (however, this decline is not statistically significant). At Kingman Area 1, which has some higher elevations where some of the transects are located, the perennials declined significantly from 60% cover in 2000 to about 25% cover in 2004. Kenilworth seemed to experience some modest increase after 2002, possibly as a recolonization response following herbicide treatment for Phragmites. Perennial growth at Patuxent also increased after 2002, possibly partially taking advantage of the reduction in competition from the annuals lost to beaver dam flooding. Meanwhile, perennial cover at Dueling Creek, the one site in our study that didn't undergo any traumatic impacts, held steady throughout the study at about 70% cover. Thus, in this study the absolute cover by annuals and perennials seemed to reflect well the conditions under which they were forced to grow.

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