Biodiversity of Saline and Brackish Marshes of the Indian River Lagoon: Historic and Current Patterns

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Running Head: Historic and Current Marsh Biodiversity

Abstract

The Indian River Lagoon (IRL) crosses a zone of climatic transition. Historically, marshes dominated saline and brackish environments in the north of the lagoon, while mangroves became important to the south. Periodic freezes limited mangrove distribution and abundance. A unique feature of most IRL marshes was seasonal and wind-driven tidal inundation rather than daily tidal fluctuations; near inlets, tidally influenced marshes occurred. Distribution of marsh communities was influenced by hydrology, salinity, soil characteristics, and fire, as well as periodic freezes. Major marsh community types included cabbage palm (Sabal palmetto) savanna, sand cordgrass (Spartina bakeri) marsh, black rush (Juncus roemerianus) marsh, saltgrass marsh (Distichlis spicata, Paspalum distichum), and mixed halophyte (Batis maritima, Salicornia virginica) marsh. Mud flats occupied significant areas. Black (Avicennia germinans) and white (Languncularia racemosa) mangroves occurred in some areas in open to dense stands associated with saltgrasses and mixed halophytes. Many of these communities were marked by a few dominant species and relatively low within-community plant species diversity. The resulting landscape pattern was complex and diverse. Plant species diversity probably increased from saline to brackish and oligohaline marshes as salinity stress decreased.

Marshes of the IRL have been greatly modified since the 1940s. Impoundment or ditching for mosquito control has affected all but a few areas. Much of the low marsh was replaced by open water or by extensive cattail (Typha cf. domingensis) marshes. Loss of connection with the uplands and changed hydrology probably reduced fire frequency and intensity in the high marshes, favoring invasion by wetland shrubs (Salix caroliniana, Myrica cerifera, Baccharis spp.) and the exotic Brazilian pepper (Schinus terebinthifolius). Other impacts to marshes include dredging and filling and nutrient enrichment.

Dominant and characteristic plant species of these saline and brackish marshes are widespread. Few rare plants are associated with IRL marshes. Despite significant modifications, marsh plant species have not been lost from the region, but community and landscape patterns have been greatly modified and ecosystem processes altered. Vertebrates dependent on these marshes have not all faired as well, as evidenced by the extinction of the Dusky Seaside Sparrow (Ammodramus maritimus nigrescens) that depended on marshes of the IRL and the St. Johns River.

Introduction

The Indian River Lagoon (IRL) supports about 10% of the salt marshes in Florida (Montague and Wiegert, 1990). Marshes are concentrated in the northern IRL, while mangroves are of greater importance in similar sites to the south (Virnstein, 1990; Rey et al., 1991; Larson, 1994, this volume). Several features of the physical and biological environment make these marshes unique. The northern Indian River and Banana River are far from inlets such that semi-diurnal or diurnal tides are nearly absent (Provost, 1973; Smith, 1987). Sea-level and the level of the lagoon change seasonally (Provost, 1973; Smith, 1987), with high levels occurring in fall. Much of the circulation is wind-driven (Smith, 1993). In Mosquito Lagoon, diurnal tides decrease rapidly with distance from Ponce Inlet (Provancha et al., 1992). A sharp temperature gradient occurs along the IRL (Virnstein, 1990). Mangroves in the northern IRL are periodically impacted by freezes severe enough to cause mortality or damage (Provancha et al., 1986a). Despite their extent and unique features, marshes of the IRL have received little study (DeFreese, 1991).

Nearly all of the northern IRL marshes have been modified by impoundment or ditching for mosquito control (Rey and Kain, 1989; Rey et al., 1991). Most impoundment was conducted with little documentation of conditions existing before modification, making reconstruction of changes difficult.

In this paper, I give an overview of the current status of saline and brackish marshes of the IRL, examine past conditions from the historical record, and suggest what these changes may mean for biodiversity. I concentrate on landscape and community diversity (Noss, 1990), primarily of vascular plants, with some consideration of the processes needed to maintain diversity (Noss, 1990).

Current Patterns

The area considered is the northern IRL extending from Ponce Inlet to the southern end of Merritt Island. The general sequence of brackish and saline marsh communities (Schmalzer and Hinkle, 1985; Provancha et al., 1986b) from the upland interface toward the lagoon is as follows:

1. Cabbage palm savanna has a scattered canopy of cabbage palm (Sabal palmetto) and a graminoid layer of sand cordgrass (Spartina bakeri) and other grasses and forbs.
2. Sand cordgrass marsh is dominated by this robust clump grass.
3. Black rush (Juncus roemerianus) marsh occurs in similar landscape positions to sand cordgrass marsh. It may form nearly monotypic stands, but mixed stands of Spartina and Juncus also occur. Collectively, sand cordgrass and black rush marshes constitute "high" marsh.
4. Saltgrass marsh is dominated by salt tolerant grasses of low stature. Saltgrass (Distichlis spicata) is typical, but in some areas seashore paspalum (Paspalum distichum) is dominant.
5. Mixed halophyte marsh originally occupied much of the lagoonward fringe of the marshes and remains in some areas. Saltwort (Batis maritima) and glasswort (Salicornia virginica) are dominant species. Collectively, saltgrass and mixed halophyte marsh are termed "low" marsh.
6. Sea oxeye (Borrichia frutescens) occurs as nearly monotypic patches within high or low marshes.
7. Black (Avicennia germinans) and white (Languncularia racemosa) mangroves occur in some areas in open to dense stands, frequently of low stature and associated with saltgrasses and mixed halophytes. Red mangroves (Rhizophora mangle) occur within the northern IRL but generally as scattered individuals not forming stands.

8. Saltmarsh cordgrass (Spartina alterniflora) occurs as narrow strips along some shorelines.

9. Mud flats or salt flats occurred within the salt marsh landscape where accumulation of salt or hydrologic conditions prevented establishment of perennial vegetation. These areas remain in some impoundments and support stands of the annual glasswort (Salicornia biglovii).

10. Tidal creeks and isolated ponds occurred before impoundment in some areas. Impoundment frequently increased open water habitat, at least temporarily.

11. Cattail (Typha cf. domingensis) marsh was probably a minor component of salt marsh landscapes before impoundment, but it has greatly increased in impoundments where freshwater conditions have predominated.

Not all landscapes contain this entire sequence. Duration of inundation, salinity, soil characteristics, and fire frequency are important factors along this gradient. In the northern and central parts of Mosquito Lagoon, saltgrass and mixed halophyte marshes with and without mangroves predominate (Southeastern Wildlife Services, Inc., 1979; Provancha et al., 1986b). At the southern end of Mosquito Lagoon, there is greater representation of high marshes. Merritt Island supports the greatest area and diversity of salt marshes (Provancha et al., 1986b). The north end of the Indian River along Turnbull Creek contains most of the unimpounded marshes remaining (Environmentally Endangered Lands Program, 1992).

Commonly occurring plants of saline and brackish marshes are listed in Table 1; nomenclature follows Wunderlin (1982). This list is derived from Schmalzer and Hinkle (1985), Schmalzer et al. (1991), and unpublished data. It is not exhaustive and does not represent equal sampling in all types. There is a general decline in number of species with increasing salinity, i.e., from cabbage palm savanna to mixed halophyte or saltmarsh cordgrass marsh. Presence of typically freshwater marsh species in saline marsh types may be due to hydrological changes from impoundment.

Historic Patterns

Historical accounts provide insight into past vegetation patterns, but must be viewed with care (Forman and Russell, 1983). Access to the landscape was difficult for early explorers, and marshes were of little economic importance.

A Spanish expedition lead by Alvaro Mexia scouted east coast waterways from St. Augustine to the Indian River inlet in 1605. He noted mangroves along the shore of Mosquito Lagoon and on islands in the lagoon. Marshes occurred along Turnbull Creek and other drainages. Upland types included coastal strand, live oak forest, and pine flatwoods. Indian settlements were clustered around hammocks (Davison and Bratton, 1986).

British land grants of the 1780s noted the Great Swamp (Turnbull Hammock) at the head of the Indian River (swamps soils were prized for agriculture). Maps indicated mangroves in Mosquito Lagoon and marshes along Turnbull Creek. Hammocks and pine flatwoods occurred on the uplands (Davison and Bratton, 1986).

J.R. Motte, an Army surgeon during the Seminole Wars, traversed the IRL in the winter of 1837-38. Journeying from New Smyrna to Haulover he recorded in his journal (Motte, 1845):

"The first half of our way we had to thread our course through a labyrinth of low mangrove islands, partly inundated and inaccessible ... The scenery was anything but prepossessing; nothing visible but dried and tangled limbs of dead mangrove trees, which had been killed by a frost in the severe winter of 1835 ... Life of another kind abounded; vast numbers of aquatic birds covered the waters ... Innumerable species of wild ducks, pelicans, etc., floated around us ... the dark and leafless limbs of the closely growing mangroves were dotted with thousands of white cranes (egrets) ...

Ever and anon would a flock of Pink-Curlews (roseate spoonbills) ... hover over our heads ..." (p. 156).

South in Mosquito Lagoon he noted:

"In other spots,

Vast plains, spread out on every side,

Stretch to the sloping skies

These were covered with a tall rank grass or prairie reed; presenting a sea of grass in one unbroken expanse ... Nothing obstructed the eye, save here and there a melancholy looking palmetto tree ... " (p. 159)

Landing at Haulover (south of the present canal):

"We landed at last, after a long wade through the water, amidst a thick growth of prairie reed and sawgrass higher than our heads ... " (p. 160).

Other elements he noted included: scrub at Haulover (p. 161), gopher tortoises and indigo snakes (p. 165), wolves (p. 173), and at Fort Pierce:

"Inadequate are words to express the quantity and quality of fish that abounded in those waters ... " (p. 177).

Later in the 19th to early 20th century as settlement proceeded, impacts to natural communities included: logging of live oak, citrus agriculture, logging of pinelands, and free-ranging grazing of cattle with the burning of marshes, pinelands, and scrub to improve forage (Davison and Bratton, 1986). Only grazing and marsh burning among these activities would have had direct impacts to saline and brackish marshes, and these impacts were probably not great. Fire is a natural occurrence in these high marshes whose dominant species resprout readily (Schmalzer et al., 1991).

Roland Harper (1921) was the first plant ecologist to survey Merritt Island; wetland types he noted include palm savanna, salt marsh, and mangroves (p. 147). Common salt marsh species he listed are given in Table 2.

J.K. Small made several collecting trips through the IRL region (Small, 1919; 1921; 1922; 1923; 1927) but appears to have been more interested in hammocks, shell middens, and scrub than marshes. Near Turtle Mound along Mosquito Lagoon, he noted black, white, and red mangroves occurring; at a shell midden farther south along Mosquito Lagoon, he reported marsh and shoreline plants including Salicornia, Batis, Sesuvium, Philoxerus, Suaeda linearis, and Bacopa monnieri (Small, 1923, p. 203, 206). On a 1922 trip (Small, 1927, p. 12) at the south end of Merritt Island at the lagoon's edge, he noted red, black, and white mangroves, and Conocarpus (button mangrove).

These historical records suggest that salt and brackish marshes of the northern IRL remained largely intact well into the 20th century.

Marsh Impoundment

Organized efforts at mosquito control in the IRL began in the 1940s and intensified after World War II (Provost, 1959; 1977). Massive quantities of DDT were applied between 1946 and 1951; other insecticides were then adopted because salt marsh mosquitos had become resistant to DDT. There was no documentation of the effects of insecticide applications on marsh ecosystems. Effects on non-target insects and arthropods must have been substantial, as may have been effects on birds (Sykes, 1980). The population of the Dusky Seaside Sparrow on Merritt Island was estimated to have declined by 70% by 1957 due to aerial spraying of insecticides (Nicholson in Trost, 1968).

Concerns over massive insecticide application and development of insecticide resistance by mosquitos spurred consideration of alternative control measures (Provost, 1959; 1977). The life cycle of salt marsh mosquitos could be interrupted by maintaining flooded conditions in the irregularly flooded marshes that were primary breeding areas (Provost, 1959; Clements and Rogers, 1964). This was achieved by building perimeter dikes around salt marshes and flooding the marsh by either trapping rain water and runoff, pumping water from the lagoon, or tapping artesian wells (Provost, 1959). Although flooding was necessary only in the mosquito breeding season, continuous flooding was common early in the use of impoundments (Provost, 1959). Initial diking of marshes began in about 1955. The construction of higher, permanent dikes began in 1959, and nearly all marshes were impounded by 1970 (Rey and Kain, 1989).

Such drastic hydrologic alterations were bound to have major effects on these wetlands. The original marshes were heterogeneous, and management after impoundment varied in the source and salinity of water used for flooding, the duration of flooding, and the degree of exchange with the lagoon. There was a substantial loss of low marsh; mixed halophyte marsh was highly sensitive to overflooding, and saltgrass marsh was also reduced (Clements and Rogers, 1964; Harrington and Harrington, 1982). Black mangrove was sensitive to water levels exceeding its pneumatophores, and was often killed or damaged by overflooding (Clements and Rogers, 1964; Harrington and Harrington, 1982). High marshes were impacted in some impoundments and less so in others (Trost, 1964). Open water habitat increased and was used by wading birds and waterfowl (Provost, 1959; 1969; Trost, 1964). Where freshwater was used to flood impoundments, increased cover of cattail (Provost, 1959; Trost, 1964) and willow (Rey and Kain, 1989) frequently occurred. Where pumping from the lagoon or flows from saline wells was used, salt accumulation eliminated much vegetation (Bidlingmayer, 1982; Rey et al., 1990). The exotic Brazilian pepper (Schinus terebinthifolius) frequently established along dike roads, and dikes may facilitate its invasion into impounded marshes. Although it is possible to manage impoundments to reduce mosquito populations without such drastic effects on vegetation (O'Bryan et al., 1990), the resources to implement such management have often been lacking.

Some areas that could not be impounded, particularly low islands with mangroves or mixed halophytes, were ditched extensively. Along the mainland shore of the IRL some marshes were filled for development, but the extent of this is poorly documented. Some Merritt island shorelines, particularly along Sykes Creek, were filled in the 1960's (Larson, 1994, this volume)

Effects of these changes on biodiversity are not simple. Early advocates of impoundment (Provost, 1959) claimed that it converted "barren" high marshes into "bird-rich" permanent water habitats and that dikes greatly expanded marsh-edge habitat. This focused on only one element of diversity, wading birds and waterfowl, and ignored negative effects on other biota. Open water impoundments are now important to wading birds and waterfowl (Breininger and Smith, 1990; Smith and Breininger, 1994, this volume). However, wading birds and waterfowl had been abundant in the region historically. Impoundment increased wading bird use of previous high marsh (Trost, 1964), but no systematic surveys of plants, birds, mammals, other vertebrates, or invertebrates were conducted before marsh impoundment. Montague et al. (1985) argued that impoundment increased diversity by creating freshwater marshes and upland habitat (dikes) where there had been only salt marsh. One may question whether cattail monocultures or Brazilian pepper-lined dikes are of net benefit to biodiversity.

Distribution of plant communities and their areal extent have clearly been changed. Although historical aerial imagery dating from the 1940s to the present exists for much of the area, only qualitative assessments (Montague et al., 1984) have been made.

Native plant species of these saline and brackish marshes are widespread in distribution (Godfrey and Wooten, 1979; 1981). None have been eliminated from the region. None of the salt marsh flora is listed or under consideration for listing as threatened or endangered at the Federal level (Schmalzer and Hinkle, 1990; Wood, 1992). Mangroves are afforded some protection by state law but are not rare. Leather fern (Acrostichum danaeifolium) is listed as threatened by the Florida Department of Agriculture (Wood, 1992) but remains relatively common in appropriate habitat (Wunderlin, 1982).

One study (Harrington and Harrington, 1982) reported that insects and arthropod diversity was greatly reduced where flooding eliminated mixed halophyte vegetation. Chynoweth (1975) reported 75 families of foliage and soil macroinvertebrates in a six month study of a restored Spartina-Distichlis-Sesuvium marsh. No comparisons of insect diversity in impounded and unimpounded marshes are known.

The conspicuous element of regional biodiversity most negatively impacted by impoundment was the Dusky Seaside Sparrow, restricted to marshes of northern Merritt Island and the St. Johns River. Impoundment destroyed the low and high marsh habitat required by this species (Trost, 1968; Sykes, 1980). Although habitat restoration was carried out in one impoundment (Leenhouts and Baker, 1982), the Merritt Island population did not recover (Sykes, 1980). With the loss of the St. Johns River population and captive individuals, extinction occurred (Walters, 1992).

Functional attributes of salt marshes were affected by impoundment. Loss of connection to upland systems probably influenced fire frequencies, as may have increased hydroperiods. Invasion of woody species (Baccharis, Myrica, Salix, Schinus) is facilitated by reduced fire frequency (Wade, 1991). Fires affect nutrient dynamics as well as species composition (Levine et al., 1990; Schmalzer and Hinkle, 1992; 1993). Impoundment may have changed sedimentation rates (R. Parkinson, pers. com.). Loss or reduction of connection between marshes and the lagoons may have negatively affected fish and macrocrustaceans (e.g., Harrington and Harrington, 1982; Gilmore et al., 1982). Conclusive supporting data are lacking for this in northern IRL high marshes (Montague et al., 1985).

Recommendations

Restoration of impounded marshes is now a priority with several management agencies (Rey et al., 1991). Removal of dikes combined with prescribed burning and herbiciding of shrubs was successful in reducing cover of cattail and shrubs amd increasing that of saltmarsh species in the T-10-K impoundment (Leenhouts and Baker, 1982). However, dike removal is likely to be done in only a few impoundments, because mosquito control is still a priority. Complete restoration of "natural" (pre-impoundment) conditions may not be desirable in all impoundments, because it could have significant negative effects on populations of wading birds and waterfowl, particularly since there has been massive loss of wetlands in the St. Johns River Basin (Kushlan, 1990; Breininger and Smith, 1990). Increasing numbers of culverts and greater use of pumps are common strategies to improve impoundment management (Rey et al., 1991). Effectiveness of these techniques in the marshes of the northern IRL is not yet determined. Although it is recognized that impoundment management should be coordinated on a regional basis (Rey et al., 1991), that is not yet the case. Private ownership of many impoundments outside of Kennedy Space Center/Merritt Island National Wildlife Refuge/Canaveral National Seashore complicates regional management; public acquisition of these impoundments or development of conservation easements should be pursued. Clear goals need to be established for impoundment restoration and management. Monitoring needs to be tied closely to restoration and management, and monitoring needs to be of sufficient scope and duration to determine long-term changes in major components of the biota. Opportunities exist to determine ecosystem and landscape level changes from restoration. However, funding for monitoring and research is not sufficient to begin to address critical questions. Impoundment of IRL marshes was conducted with incomplete understanding of the consequences and inadequate monitoring of the results. Restoration should proceed with careful monitoring of its effects.

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Table 1. Commonly occurring vascular plants in brackish and saline marshes and inpounded marshes of the northern Indian River Lagoon.

Species	Community Type: Cabbage Palm Savanna	Sand Cordgrass Marsh	Black Rush Marsh	Saltgrass Marsh	Mixed Halophyte Marsh	Cattail Marsh	Satmarsh Cordgrass Marsh	Mixed Mangroves
Acrostichum danaeifolium		x	x	x	x	x		x
Amaranthus australis			x	x		x		
Andropogon spp.	x	x	x					
Aster tenuifolius			x					
Avicennia germinans							x	x
Baccharis halimifolia	x	x				x		
Bacopa monnieri	x	x		x				
Batis maritima					x		x	x
Blechnum serrulatum	x	x						
Boehmeria cylindrica	x							
Borrichia frutescens	x			x	x			x
Cladium jamaicense	x	x						x
Conocarpus erecta								x
Cyperus esculentus				x				
Cyperus odoratus				x		x		x
Diospyros virginiana	x							
Distichlis spicata			x	x	x	x		x
Echinochloa walteri		x		x		x		

Species	Community Type							
	Cabbage Palm Savanna	Sand Cordgrass Marsh	Black Rush Marsh	Saltgrass Marsh	Mixed Halophyte Marsh	Cattail Marsh	Satmarsh Cordgrass Marsh	Mixed Mangroves
Senecio glabellus	x							
Sesuvium portulacastrum				x	x			x
Setaria magna						x		x
Spartina alterniflora					x		x	x
Spartina bakeri	x	x	x	x				
Sporobolus virginicus				x				
Suaeda linearis								x
Typha domingensis				x		x		
Urena lobata	x	x	x	x				
Utricularia spp.		x	x			x		
Vicia acutifolia		x						
Vigna luteola				x		x		x
Vitis rotundifolia	x							
Woodwardia virginica	x							

Species	Community Type: Cabbage Palm Savanna	Sand Cordgrass Marsh	Black Rush Marsh	Saltgrass Marsh	Mixed Halophyte Marsh	Cattail Marsh	Satmarsh Cordgrass Marsh	Mixed Mangroves
Panicum rigidulum			x					
Panicum spp.	x	x	x					
Paspalum distichum				x				x
Physalis viscosa	x							
Pluchea odorata						x		
Pluchea rosea	x		x					
Polygonum hydropiperoides		x	x			x		
Polygonum punctatum		x				x		
Rhynchospora spp.	x		x					
Sabal palmetto	x							
Sacciolepis striata		x	x					
Sagittaria lancifolia	x	x	x					
Salicornia bigelovii					x			
Salicornia virginica					x		x	x
Salix caroliniana		x	x			x		
Sambucus canadensis	x							
Samolus valerandi	x							
Schinus terebinthifolius	x	x						x
Scirpus robustus		x		x				
Scleria reticulata		x	x					

Species	Community Type							
	Cabbage Palm Savanna	Sand Cordgrass Marsh	Black Rush Marsh	Saltgrass Marsh	Mixed Halophyte Marsh	Cattail Marsh	Satmarsh Cordgrass Marsh	Mixed Mangroves
Erectites hieracifolia	x							x
Erianthus giganteus	x	x	x					
Eriocaulon sp.		x	x					
Eupatorium capillifolium	x			x				
Fuierena breviseta			x					
Fimbristylis castanea	x			x				
Heliotropium curassavicum								x
Hydrocotyle sp.	x	x	x					
Ilex cassine	x							
Ipomoea sagittata		x	x					
Juncus roemerianus	x	x	x					x
Languncularia racemosa								x
Leptochloa fascicularis				x				
Ludwigia peruviana			x			x		
Ludwigia repens	x		x					
Lycium carolinianum					x			
Mikania scandens	x	x	x	x		x		
Myrica cerifera	x	x	x					
Osmunda regalis	x							
Oxypolis filiformis			x					

Table 2. Common Salt Marsh Species of the East Coast Strip Recorded by Harper (1921, p. 148).

Species	Habitat
Acrostichum aureum (= danaeifolium)	salt marsh
Avicennia nitida (= germinans)	salt marsh
Batis maritima	salt marsh
Borrichia frutescens	salt marsh
Cladium effusum (= jamaicense)	fresh marsh
Iva frutescens	salt marsh edge
Juncus roemerianus	salt marsh
Spartina bakeri	marshes, savannas