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Vegetation Dynamics on the Virginia Barrier Islands

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ABSTRACT

The vegetation on the Virginia barrier islands is affected by oceanside erosion and accompanying salt spray which impact strand communities, and by bayside accretion which provides impetus for hydrarch succession. Controlling environmental complexes include: extent of flooding, soil moisture, soil nutrient levels and autogenic factors, as well as salt spray. A variety of vegetation patterns are found on stable dunes, unstable dunes, interdunal depressions, sand flats, relic dunes and bayside sites of various physiographic aspects. Succession can be progressive, retrogressive, chronic-patchy or cyclic. Historic, natural and anthropogenic impacts have disrupted communities and depauperized the flora.

Key words: barrier islands, plant succession, vegetation, strand communities.

INTRODUCTION

The barrier islands are continually subjected to the impacts of longshore currents, tides, waves, and wind. Consequently, shorelines and dunes undergo constant physiographic change which affects their vegetative composition. In addition, long-term transformations are caused by an oceanic rise amounting to about 2 mm/yr in the north near Metomkin Island and about 1.2 mm/yr near Fisherman's Island in the south (Rice, *et al.* 1980). Given a 0.05° beach slope, this seemingly slight rise can produce 2.2 to 1.4 horizontal meters of marine encroachment each year. Simultaneously on the bayside of the barrier islands, accretion is occurring due to wind and water action.

The vegetation of these islands, in addition to wetlands, includes hydric and xeric grasslands, and shrub and tree dominated communities. Local factors such as salt spray, soil salinity, nutrient availability, soil moisture, and time since last significant perturbation influence species' composition and distribution (Wells, 1928; Oosting and Billings, 1942).

Perturbations, both natural and anthropogenic, have had a profound impact on the vegetation in this system. Twelve major summer storms (hurricanes) have affected the system in the past 170 years. Those of 1821, 1857, 1903 and 1933 were especially destructive. In addition, strong winter storms (northeasters) such as those in January 1956, March 1962, and February 1988 have also had strong impact. Anthropogenic affects from the Amerind period to the recent past have produced significant changes, especially on the larger Islands. These impacts have included fire, lumbering, reforestation, farming, building, grazing, and plant and animal introductions. Although most of the introduced animal species have been removed or eradicated and many structures reduced, residual effects still remain (Dueser *et al.*, 1976). The most significant impact of the anthropogenic influences appears to have been quantitative and qualitative floristic depauperization.

PLANT SUCCESSION

The organismic successional concepts of Clements (1916,1936) and the opposing ideas of Gleason (1926) as well as the many related theories have been extensively reviewed (*e.g.*, Whittaker, 1953). Drury and Nisbet (1973) present a strong case in opposition to the unidirectional facilitated succession associated with Clements and more recent authors (*e.g.*, Odum, 1969). Horn (1976), after a succinct review of the alternative concepts, tersely identifies the conflict, "The idea of a stable community is not general in nature, if indeed it exists." He provides a series of models which have direct application to the interpretation of vegetation dynamics on the Virginia barrier islands. Horn's models include chronic, patchy disturbance. This model describes conditions in areas where frequent disruptions lead to shifting successional patches characterized by a random replacement of opportunistic species of similar tolerance. His second model, obligatory succession is Clements' (1916) organismic succession in which autogenic habitat changes produce a predictable climax via predictable seral stages. Usually the process proceeds from extreme conditions to more mesic ones. This is considered progressive succession. If the reverse is true (*i.e.*, development toward more xeric or hydric states) the sequence is considered retrogressive. Horn's two remaining models are, competitive hierarchy and quasi-reality. In the former, later arriving species out compete earlier ones, but can also invade in their absence. The latter model, quasi-reality, suggests that there is a probability that any species can replace another. However, the probability of each potential replacement varies from species to species. Thus, in the long term vegetation following this model approximates classical organismic succession. In addition, there are numerous examples in the literature of stagnant or cyclic succession (*e.g.*, Watt, 1947; Billings and Moony, 1959).

BARRIER ISLAND SUCCESSION

Wells (1928), Oosting and Billings (1942), Oosting (1945, 1954), Van Der Valk (1974), and Godfrey and Godfrey (1976), among others, have discussed the successional process and various factors which influence it in the North Carolina barrier islands. Dolan *et al.,* (1973) have evaluated human impacts in this system. The floristic complexity of this area has been studied by Hosier and Cleary (1979). In two related studies, Levy (1976) and Harris *et al.,* (1983), the vegetation on the Coastal Engineering Research Center Field Research Facility (CERC) near Duck, North Carolina was described and the changes that occurred over a seven year period documented.

Harvill's (1965) vegetation survey of Parramore Island provided descriptions of the major communities occurring there. In a follow up study, Levy (1983) discussed community dynamics on this island. McCaffrey (1980) included a consideration of vegetation and influencing factors for the whole Virginia barrier island chain in her significant baseline studies. In a related study, Tyndall and Levy (1979) described vegetative dynamics at False Cape in Virginia Beach.

The Virginia barrier islands range from Godwin Island which is completely covered by a cord grass (*Spartina alterniflora*) marsh to Wreck Island which has a dense covering of beach grass (*Ammophila breviligulata*) on the sandy dunes, a low salt marsh, and a central tall bayberry (*Myrica* spp.) thicket. (Taxonomy follows

Radford *et al.*, 1968). The much larger Parramore and Smith Islands, which are physiographically diverse, have correspondingly much greater community diversity.

The habitats on a greatly simplified, highly idealized transect of a typical large island can be identified physiographically and include the foredune, interdunal depressions, sand flats, the rear dune, rear dune troughs, relict dunes and bayside wetlands.

Of great significance throughout this system is a salt spray gradient. During storms, salt spray and accompanying sand scouring can cause significant mortality and necrosis to relatively intolerant species.

The community found on unstable foredunes has been characterized as sparse grasslands (community names generally follow McCaffrey, 1980). These grasslands consist primarily of chronically disturbed patches of beach grass and sea rocket (*Cakile edentula*). Seaside golden rod (*Solidago sempervirens*) is important in some places. The diversity of these communities is far less than similar ones which exist on the Fort Story dunes in Virginia Beach (per. obs.) or at the CERC Research Facility near Duck, N.C. (Harris *et al.*, 1983).

On stable foredunes is found a dense grassland dominated by beach grass. Stability here as elsewhere is only relative and depends upon storm patterns and the impact of long term sea rise. A further analysis of the Duck, North Carolina data of Levy (1976) and Harris *et al.*, (1983), which document the vegetative changes that occurred from 1975-1983, illustrate the dynamic nature of the foredune and adjacent communities. Using Sorenson's (1948) qualitative index of similarity ($IS_S = 2c/a+b$) to compare the earlier results with the later ones, it was found that after seven years the foredune community which was characterized by sea oats (*Uniola paniculata*), beach grass, and sea side goldenrod, had an $IS_S = 50\%$. This difference reflected a loss of two species and a gain of two other species. The adjacent communities, oceanside shrub, a bayberry (*Myrica pensylvanica*) dominated community and oceanside intershrub, a mixed grassland, underwent similar changes during this period. The former had an $IS_S = 33\%$ while the latter had an $IS_S = 30.4\%$. These changes, which were due to the addition of eight new species to each community's flora, document the dynamic nature of vegetation within a degrading zone.

Vegetative shifts similar to those documented for the North Carolina outer banks no doubt also occurred on various portions of the Virginia barrier islands. For example, Levy (1983) notes that on Parramore Island, lines of dead black cherry (*Prunus serotina*) trees some nine meters sea-ward of the summer flood-tide debris are strikingly evident. These trees, which grow a short distance inland with other severely damaged tree species, are interspersed with beach grass. Along the more northern section of this island's beach are lines of dead loblolly pines (*Pinus taeda*), a species which grows further inland where it is protected from salt spray. The rate of ocean incursion is obviously greater here. Since these changes are proceeding from more mesic to more xeric, the process could be described as retrogressive succession in the Clementian sense, however, given the prevailing conditions, Horn's chronic patchy disturbance model would appear to be more appropriate in this case.

The successional patterns in interdunal depressions are more complex. These communities seem to be responding to a soil moisture-flooding gradient (Tyndall and Levy, 1979). Salt spray, however, does play a role here too. Without significant animal impact, an American three square (*Scirpus americanus*) - waterpenny wort (*Hydrocotyl umbellata*) community develops in the deepest, most frequently flooded areas. As these areas fill with wind blown sand and/or organic matter, salt meadow cord grass (*Spartina patens*) first replaces waterpenny wort and ultimately American three square. As conditions become drier and flooding infrequent, little blue stem (*Andropogon virginicus*) dominates. Subsequently a bayberry (*Myrica* spp.) dominated thicket becomes established on the driest sites, often extending on to the rear dune.

Areas impacted by migratory waterfowl have communities dominated by *Centella asiatica* and rushes (*Juncus* spp.) in the wettest, most frequently flooded sites. With decreased frequency of flooding and reduced soil moisture, salt meadow cord grass and American three square replace the rushes. This in turn yields to the bayberry thicket community. Initial pioneers are of course dependent upon existing conditions.

The bayberry thicket serves as a nurse community for black cherry. Ultimately, black cherry can over-top and shade out the bayberry. On sites close enough to the ocean, black cherry eventually grows tall enough to become exposed to salt spray and succumbs. Subsequently, a bayberry thicket is reestablished. Thus, a cyclic succession occurs on these areas.

Where salt spray is not a significant factor, loblolly pine becomes established in areas previously dominated by thicket and black cherry. The pines are followed by oaks (*Quercus* spp.), characteristically live oak (*Q. virginiana*), which appears to represent a climax (*i.e.*, maritime forest). Currently live oak occurs only on Smith Island.

On rear dunes and relict dunes (Parramore Island for example), a nutrient gradient appears to be controlling the successional process. Where nutrient levels are excessively low, loblolly pine appears to replace itself. This is due in part to the depauperate seed rain available. In addition, loblolly pine seems to have a minimal autogenic impact on the soil which is easily eroded by the wind and has a low water holding capacity. The acid pine litter most likely helps to facilitate nutrient leaching. Thus, edaphic and biological conditions on such sites exclude all but those species tolerant of this nutrient poor, xeric, unstable habitat.

If significant amounts of bayberry are established, the cycle may be broken. This species would improve soil nutrient levels (Morris *et al.*, 1974) and thus allow the establishment of other species. Pine litter accumulation could ultimately prevent pine ecesis and lead to soil organic matter increase, thus improving water holding and ion-exchange capacities. Ultimately a maritime forest community might become established.

Sand flats are characterized by very sparse vegetation. Typical species include, beach spurge (*Euphorbia polygonifolia*), sand grass (*Triplasis purpurea*), buttonweed (*Diodia terres*) and evening primrose (*Oenothera humifusa*). Harris *et al.*, (1983) reported that 40% of the sand flat community present on the Duck, North Carolina Research Facility in 1975 had, in seven years, changed to what they called a low dune grass community characterized by the expansion of sand grass and the invasion and establishment of beach grass, and a few other species. Toward the ocean, oceanside shrub and oceanside intershrub communities evidenced significant expansion into what had been almost barren sand flats. It is likely that similar patterns of succession occur on the Virginia barrier islands as has been reported further south, as the same processes are impacting both areas.

In areas adjacent to the bay classical progressive succession is occurring. The cord grass dominated areas become mixed with salt grass (*Distichlis spicata*), salt meadow cord grass, and rushes. Interspecific competition, fluxtuating soil moisture and flooding produce relatively monotypic clumps of these species. As conditions become more mesic, marsh elder (*Iva frutescens*) and groundsel tree (*Baccharis halimifolia*) are established, producing a shrub carr community. Bayberry species form an important component in places.

Further development depends upon physiographic conditions. For example, if conditions become fairly well drained, wax myrtle (*Myrica cerifera*) becomes important and in places is invaded by red cedar (*Juniperus virginia*) followed by the establishment of loblolly pine. A build-up of sand, creating more xeric conditions, could lead to a maritime forest with sassafras (*Sassafras albidum*) and live oak as important species (as seed sources become available). On occasionally flooded sites a more complex forest consisting of oaks, sweetgum (*Liquidambar styraciflua*), red bay (*Persea borbonia*), holly (*Ilex opaca*), black cherry, and red maple (*Acer rubrum*) may become established. On more hydric sites, black willow (*Salix nigra*), swamp poplar (*Populus heterophylla*), and red maple can become important. Given conditions conducive to progressive succession, this latter community can be derived from a marsh elder-groundsel tree-bayberry seral stage. On the other hand, it could progress to the mesic forest type or retrogress to the more xeric, maritime forest community, depending upon seed sources and the balance between degrading erosional processes and accretional ones (Levy, 1983).

CONCLUSIONS

Previous studies and personal observations from the outer banks of North Carolina, coastal and Chesapeake Bay sites in Virginia Beach, as well as direct observations in the Virginia barrier island system tend to support the validity of the successional patterns proposed above. These successional patterns must be categorized as tentative, however, as a great deal of on-site quantification is still lacking. North Carolina patterns, although instructive, may not be transferred without hazard. The diversity of successional patterns detected throughout the coastal barrier islands tends to support concepts of Drury and Nisbet (1973) and Horn (1976) who have rather recently added fuel to the "nature of succession controversy" that has continued throughout most of this century. The Virginia barrier islands would appear to be an ideal site for studies which might help to clarify this fundamental dispute.

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