

THE EFFECT OF HURRICANE HUGO
ON
THE VASCULAR FLORA OF FORT MOULTRIE, SOUTH CAROLINA

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ABSTRACT

Stalter, R. (Dept. Biol. Sci., St. John's Univ., Jamaica, NY 11439) and E. E. Lamont, E.E. (N.Y. Botanical Garden, Bronx, NY 10458). The effect of Hurricane Hugo on the vascular flora of Fort Moultrie, South Carolina, Bull. Torrey Bot. Club XXX: 000-000. 199X. - The vascular flora of Fort Moultrie, South Carolina, is based exclusively on collections made by the authors from March 1990 to October 1990. Altogether, XXX vascular plant species in XX genera and XX families are here reported. Largest families are Poaceae (xx species) and Asteraceae (XX species), and largest genera are Aster and Panicum. Natural plant communities are described and discussed. X plant species are reported for Charleston County, South Carolina for the first time.

Key words: Flora, Fort Moultrie, South Carolina, Hurricane Hugo, maritime vegetation.

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Introduction:

Hurricane Hugo was one of the most powerful hurricanes ever to strike the South Carolina coast since European settlement. The storm slammed into the coast at Charleston, South Carolina on the night of Thursday 21, 1989, with winds of 135 per hour; gusts up to 150 miles per hour were recorded at the battery in Charleston approximately 36 percent of South Carolina's ^{4.94 ha} ~~12.2 million acres~~ of forested land was damaged by this hurricane. On the Francis Marion National Forest. Approximately ^{40,500 ha} ~~100,000 acres~~ of forest lands were devastated (Gould 1990 pers. communication).

Hurricanes such as Hugo may generate waves 40-50 feet ^(12.2 m to 15.24 m) or higher over deep ocean water. As the hurricane approaches the coast, the level of the water may rise 5, 10 or 15 feet ^(1.5 m, 3 m or 4.6 m) or more (Stubbs 1966). Hurricane Hugo's storm surge, the marked rise in water level associated with the storm, was approximately 12 feet ^(3.7 m) at Charleston, and reached 18 feet ^(5.5 m) at Cape Romain, ^{50 km} ~~30 miles~~ northeast of Charleston. The aforementioned values refer to feet above normal high tide (Gould 1990 personal communication). Fort Moultrie experienced a storm surge of approximately ^{4 m} ~~12 feet~~. Water breached the primary dune and flooded the ^{60 acre} ~~220 acre~~ ^(89 ha) site; water was ^{1 m} ~~3-4 feet~~ deep in places.

Damage to vegetation during hurricanes can occur in one or more of the following ways: inundation by the storm surge; erosion due to wave action and currents, deposition of soil and rafts of vegetation; salt water immersion, (and residual affect of salt water dessication) and wind damage. Damage to the vegetation at Fort Moultrie was the result of all of the above factors though each habitat at Fort Moultrie was affected by the aforementioned factors in different ways.

The primary dune in the vicinity of Fort Moultrie was flattened by Hugo and the existing vegetation was washed away. Sand was deposited on vegetation in back of the primary dunes killing and smothering the plants growing there. Salt water initially covered large portions of the land in back of the primary dunes; however the deleterious affect of salt damage was mitigated by heavy rains that followed the storm. The fierce winds associated with Hugo uprooted or broke many trees. Trees left standing had their branches ripped away and few trees and shrubs had any leaves remaining by the morning of September 22, 1989.

*On Sunday
24 Sept*

The present study describes the vegetation present at Fort Moultrie, South Carolina, one growing season after Hurricane Hugo. The information recorded in the present study will be used as baseline data for comparison of the vegetation present at Fort Moultrie in the years 2000 and 20015.

Fort Moultrie ~~National Monument~~, Charleston Co., South Carolina, is located on the western tip of Sullivan's Island just north of Charleston, South Carolina (Lat. 32°56'N. 80° 02'W, U.S. Geol. Serv.). The park consists of ~~220~~ ^{89 ha} acres bordering ~~xxxxxxx Road~~ ^{the intracoastal waterway} on the ~~south~~ ^{north} and the Atlantic Ocean on the ~~north~~ ^{South}.

*59.87
Acres*

Fort Moultrie is part of Fort Sumter National Monument and reflects the history of ¹⁷¹ ~~100~~ years of seacoast defense (Stokeley 1985). The fort was named after Charleston born William Moultrie, who commanded the patriot forces in the 1776 defense of Charleston. The original fort, hastily constructed in 1776, consisted of a fort of palmetto logs ^{deliberate} and sand-perfect construction material to absorb a cannon bombardment from ^a the British ^{fleet} who hoped to capture Charleston in 1776. The British fleet, commanded by ^{admiral} Peter Parker, attacked the fort on the 28th of June, 1776. After a fruitless bombardment costing the British 32,000 pounds of powder, ~~Commander~~ Peter Parker withdrew. The American victory over Britain

just prior to the signing of the Declaration of Independence upset British plans to conquer the South and brought thousands of Carolinians to the American cause for independence. The fort remained in American hands until May 7, 1780, when besieged Charleston surrendered to the British. The fort was reoccupied by the Americans when the British evacuated Charleston in December 1783.

A second five sided earth and timber fort was erected on the original site in 1798 as part of the fledgling nation's first organized defense system. This fort was destroyed by a severe hurricane on September 7, 1804. A third more formidable masonry structure was completed in 1809. A hurricane on August 27, 1813 flooded the newly built fort to a height of 4 feet on the parade ground and to 2.5 feet in the officers quarters (Stokeley 1985). Beach erosion continually plagued Fort Moultrie, and by 1831, the southwest angle of the fort ^{was on the verge of crumbling} crumbled. By constructing a costly network of jetties and breakwaters (made of brush and rock filled cribs parallelling the beach front) enough sand accumulated to save the fort. Jetties continue to impede beach erosion in the vicinity of the fort today.

Little is known about the original vegetation in the vicinity of Ft. Moultrie with the exception of the presence of the ubiquitous cabbage palm, Sabal palmetto, which was used in the construction the fort which saved Charleston from the British invasion in June, 1776. Sabal palmetto is also mentioned in the vicinity of Fort Moultrie by ^{Edgar Allan} Poe. ~~Edgar Allen~~ Poe served at Fort Moultrie as a private in Company H, 1st U.S. Artillery, from November 1827 to December 1828. Later, when he became a famous writer, Poe drew upon his experience as a soldier at Moultrie in his tale of pirate treasure, "The Gold Bug" (Stokeley 1985). A passage from the Gold Bug reveals that the woody vegetation on Sullivan's Island in the vicinity of Fort Moultrie in 1828 was similar to the vegetation there today, "The

vegetation, as might be supposed, is scant, or at least dwarfish. No trees of any magnitude are to be seen." "Near the western extremity, where Fort Moultrie stands.... may be found the bristly palmetto (Sabal palmetto) and a line of hard white beach of the seacoast, is covered with a dense undergrowth of the sweet myrtle (Myrica cerifera). The shrub here often attains the heights of fifteen or twenty feet, and forms an almost impenetrable coppice burdening the air with its fragrance."

Fort Moultrie figured prominently in the Civil War. (Stokeley 1985). After a period of neglect following the Civil War, the fort was strengthened in the late 1890's when war with Spain was imminent. The fort was ~~refurbished~~ ^{and greatly modified} during World War I; later it ^{was also associated with} ~~served as~~ a Citizens Military Training Camp (1927-1933), and ~~as a~~ ^{the} CCC (Civilian Conservation Corp) (1933-1939). The fort played a prominent role in America's coastal defenses during WWII. In 1947 the military post was deactivated and all the land formerly owned by the U.S. government ^{was} sold to private individuals or turned over to the State of South Carolina. On the 7th of September, 1960, South Carolina transferred the old fort along with Battery Jasper and an unfinished WWII gun battery to the National Park Service. The National Park Service completed a major restoration of the site in 1976 as part of the Bicentennial celebration.

Today, Fort Moultrie is visited by approximately 100,000 visitors annually. The grass within Fort Moultrie is cut once a week and much of the fields surrounding the fort were bush hogged 3 times a year from 1961 - 1989. With the acquisition of a new mower in the spring of 1990, the fields are cut once a month. The herbicide Roundup is used to kill weeds in the brick walk ways. Weeds are pulled out of the masonry walls of the fort by hand.

Ft. Moultrie
Military
Reservator
which
encompassed
a third of
Sullivan's
Island,

CLIMATE

Climatological data for Fort Moultrie is similar to that of nearby Charleston, South Carolina. Mean January temperature is ^{10.5° C}~~51.5° F~~ while July, the hottest month has a mean of ^{27.2° C}~~81.5° F~~. The growing season averages 294 days. The last killing frost in the spring occurs on February 19 while the first killing frost in the fall occurs on December 10. Most rainfall occurs during the summer and early fall. July is the wettest month with ^{197.6 mm}~~7.78 inches~~ of rain. November is the driest month averaging ^{48.8 mm}~~1.92 inches~~. The driest period of the year is November through February. Average annual rainfall is ^{1183 mm}~~46.59 inches~~ (Anonymous 1974).

METHODS

Fort Moultrie was sampled four times in 1990; March 29, June 13, August 27th and October 26. Herbarium voucher specimens of each taxon were prepared and deposited at Fort Moultrie National Monument (FMNM).

The species checklist of Appendix I contains an inventory of the vascular plants of FMNM that reproduce spontaneously and persist for more than one year without cultivation, including native taxa, naturalized and adventive weeds, and escapes from cultivation. All non-native species are designated by an asterisk (*). New county records are designated in the checklist by a dagger (†). The checklist (Appendix 1) is divided into four categories, Pteridophyta, Pinophyta, Magnoliophyta: Magnoliopsida, and Magnoliophyta: Liliopsida. Nomenclature follows that of Radford et al. (1968) and the concept of families follows that of Cronquist (1981).

RESULTS

The current vascular flora of FMNM consists of XX families, XX genera, and XXX species of which XX (XX%) are native (Table 1). Twenty three species are new records for Charleston County; of the twenty three species XX (XX%) are non-native. The Poaceae with XX genera and XX species and Asteraceae with XX genera and XX species are the largest families. Together they comprise 35% of all genera and 30 percent of all species. Other large families are Rosaceae (X gen. and XX spp.), Fabaceae (X gen., X species) and Brassicaceae (X gen., X species). The largest genera are: Aster Solidago and Panicum (each with 5 spp.). When the flora is analyzed by habitat, it is noted that xx species are present in the beach community, xx occur in the swale community; xx occur in the salt marsh community while the great majority, xx occur in various disturbed habitats such as roadsides, parking lots, lawns, fields and near buildings. A statistical summary of the vascular flora of FMNM is presented in Table 1.

DISCUSSION

The vegetation of Fort Moultrie National Monument can be classified into three general plant communities: Maritime beach & Maritime swale, coastal salt marsh, man-altered communities.

MARITIME BEACH. Drift lines and areas washed by storm tides are sparsely vegetated by annual plant species, most notably Cakile harperi, Salsola Kali, Chamaesyce polygonifolia and the perennial Ipomoea stolonifera.

The transitory primary dune located above the normal high-tide level is inhabited by Uniola paniculata, Iva imbricata, Panicum amarum, Solidago sempervirens, and Ipomoea stolonifera. Ipomoea, is extremely abundant; it was

was also abundant on the Isle of Palms approximately 100 years ago when Coker (1905) examined the vegetation there in 1903.

Uniola paniculata is the dominant plant on the ocean facing side and top of the primary dune. Uniola can tolerate salt spray (Oosting and Billings 1942) and is instrumental in dune formation. Other species that favor the rigorous environment of wind and salt spray are Panicum amarum, Iva imbricata and Spartina patens. These species appear to have weathered the affects of Hurricane Hugo and are thriving on the primary dune of Fort Moultrie National Monument.

Diodia teres, Oenothera drummondii, O. humifusa or Strophostyles helvola, Heterotheca subaxillaris, Triplasis purpurea, Cenchrus tribuloides and Erigeron canadensis favor protected sites behind the primary and secondary dunes where the concentration of salt spray is lower. The above plants were noted by Coker (1905) and Stalter (1975) on the Isle of Palms, South Carolina, located immediately northeast of Sullivan's Island.

SWALE COMMUNITY

The swale community is inhabited by some of the same species found on the primary dunes. Salt spray is less intense in the protected Swale (Oosting and Billings 1942, Oosting 1945, Boyce 1954, Stalter 1975) permitting a greater number of species to grow here most notably: Yucca spp., Smilax auriculata, Cenchrus spp., Uniola paniculata, Strophostyles helvola, Toxicodendron radicans, Myrica cerifera and Ilex vomitoria. Many of the plants here have survived and/or recovered from the ravages of Hurricane Hugo as this area was under water during the height of the storm on the night of September 21, 1990.

SALT MARSHES

Salicornias

Salt marsh species at Fort Moultrie are distributed in accordance to their tolerance of tidal flooding and soil salinity (Stalter 1968). Spartina alterniflora, the most flood tolerant species, occupies the lowest zone of the salt marsh. Salicornia virginica and Salicornia bigelovii occupy the zone above S. alterniflora. Above the mixture of S. alterniflora and the Salicornias is Borrchia frutescens. Borrchia is turn is bordered by Iva frutescens the occupant of the upper rarely flooded fringe of the salt marsh. Baccharis halimifolia grows just above Iva, but is not a strict salt marsh associate. At Fort Moultrie it also occupies disturbed sites and interdunal swales. Scirpus robustus, a plant of brackish marshes was observed at the upper rarely flooded portion of the salt marsh.

Man-Altered Communities

Man-altered communities, lawns and mowed fields, account for the greatest amount of acreage at Fort Moultrie, and contain the greatest number of species. The lawns here are a mixture of numerous native and introduced grasses most notably Stenotaphrum secundatum, Cynodon dactylon, Paspalum spp., Digitaria ischaemum, Sporobolus poiretii, and many others. The ~~immediate~~ ^{disturbed} area ^{p.e. the gardens and} surrounding the Visitors Center provide a habitat for species found nowhere else at Fort Moultrie. Artemisia vulgaris, mugwort, ^{which is common on disturbed sites in New York} is reported in Charleston County for the first time. This noxious weed was observed by Stalter (1972) at Brookgreen Gardens, South Carolina is reported by Radford et al (1968) to be "widely scattered across the northern piedmont of South Carolina."

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Table 1. Checklist of the Vascular Flora of Fort Moultrie, South Carolina. Nomenclature follows that of Radford et al (1968) and the concept of families follows that of Cronquist (1981). As asterisk (*) indicates a non-native taxon; an exclamation sign (!) indicates a new record for Charleston County.

PTERIDOPHYTA

POLYPODIACEAE

Polypodium polypodioides

PINOPHYTA

CUPRESSACEAE

Juniperus silicicola

PINACEAE

Pinus taeda

MAGNOLIOPHYTA - MAGNOLIOPSIDA

AMARANTHACEAE

Alternanthera philoxeroides

ANACARDIACEAE

Rhus copallina

R. radicans

AQUIFOLIACEAE

Ilex vomitoria

APIACEAE

Centella erecta

Chaerophyllum tainturieri

Daucus carota

Hydrocotyle bonariensis

H. umbellata

Ptilimmon capillaceum

ASTERACEAE

Achillea millefolium

Ambrosia artemisiifolia

Artemisia vulgaris

Aster dumosus

Aster subulatus

Aster tenuifolius

Baccharis halimifolia

Borrichia frutescens

Coreopsis sp.

Erectites hieracifolia

Conyza canadensis var. *pusillus*

Eupatorium capillifolium

Gaillardia pulchella
Gnaphalium obtusifolium
Gnaphalium purpureum var. spathulatum
Heterotheca subaxillaris
Hieracium sp.
Iva frutescens
I. imbricata
Lactuca canadensis
Pluchea purpurascens
Pyrrhopappus carolinianus
Senecio vulgaris
Solidago sempervirens
S. stricta
Solidago tenuifolia
Sonchus asper
Taraxacum officinale

BIGNONIACEAE

Campsis radicans

BRASSICACEAE

Cakile edentula
Cardamine hirsuta
C. pennsylvanica
Coronopus didymus
Descurainia pinnata
Lepidium virginicum

CACTACEAE

Opuntia compressa
O. drummondii

CAMPANULACEAE

Triodenum perfoliata

CAPRI FOLIACEAE

Lonicera japonica

CANNACEAE

Canna indica
Caprifoliaceae
Lonicera japonica

CARYOPHYLLACEAE

Arenaria serpyllifolia
Cerastium sp.
Stellaria media

CHENOPODIACEAE

Atriplex arenaria
Atriplex patula
Chenopodium album
C. ambrosioides
Salsola kali
Suaeda linaria

CONVOLVULACEAE

Ipomoea lacunosa
I. pandurata
I. sagittata
I. stolonifera

CUCURBITACEAE

Citrullus vulgaris
Melothria pendula

EBENACEAE

Diospyros americana

EUPHORBIACEAE

Acalypha gracilens
Croton punctatus
Crotonopsis elliptica
Euphorbia heterophylla
E. maculata
E. polygonifolia

FABACEAE

Melilotus alba
M. officinalis
Medicago lupulina
M. polymorpha
Strophostyles helvola
Trifolium dubium
Vicia angustifolia
V. hirsuta

FAGACEAE

Quercus virginiana

GENTIANACEAE

Sabatia stellaris

GERANIACEAE

Geranium carolinianum

HYPERICACEAE

Hypericum gentianoides
H. hypericoides

JUGLANDACEAE

Carya pecan

LAMIACEAE

Lamium amplexicaule
Stachys hyssopifolia
Salvia lyrata

LAURACEAE

Persea borbonia

MALVACEAE*Sida Rhombifolia***MORACEAE***Morus rubra***MYRICACEAE***Myrica cerifera***ONAGRACEAE***Ludwigia maritima**Oenothera biennis**Oenothera laciniata**O. drummondii**O. speciosa***OXALIDACEAE***Oxalis dillenii***PHYTOLACCACEAE***Phytolacca americana***PLANTAGINACEAE***Plantago aristata**P. virginica***POLAMONCEAE***Phlox drummondii***POLYGONACEAE***Polygonum sp.**Rumex hastatulus***ROSACEAE***Prunus caroliniana**P. serotina**Rubus trivialis**Rubus sp.***RUBIACEAE***Diodia teres**Galium sp.***RUTACEAE***Zanthoxylum clava-herculis***SALICACEAE***Populus alba**?P. tremuloides***SAPOTACEAE***Bumelia lyciodes*

SCROPHURIACEAE

Linaria canadensis

Veronica arvensis

SOLANACEAE

Physalis viscosa spp. maritima

Solanum americanum

S. carolinense

S. nigrum

S. rostratum

ULMACEAE

Celtis laevigata

TAMARICACEAE

Tamarix gallica

VERBENACEAE

Callicarpa americana

Verbena hastata

VITACEAE

Ampelopsis arborea

Parthenocissus quinquefolia

Vitis aestivalis

LILIOPSIDA

AREACEAE

Sabal palmetto

CANNACEAE

Canna indica

CYPERACEAE

Cyperus odoratus

Eleocharis sp.

Fimbristylis spadicea

Fimbristylis sp.

Scirpus robustus

JUNCACEAE

Juncus roemerianus

LILIACEAE

Allium vineale

Allium sp.

Asparagus officinalis

Ornithogalum umbellatum

Smilax auriculata

Smilax bona-nox

S. laurifolia

Yucca aloifolia

Y. filamentosa

POACEAE

Andropogon elliotii
A. virginicus
A. virginicus var. glomeratus
Briza minor
Bromus catharticus
Cenchrus tribuloides
Cynodon dactylon
Digitaria ischaemum var.
viola-scens
Distichlis spicata
Eleusine indica
Elymus virginicus
Festuca octoflora
Lolium perenne
Panicum amarum
P. commutatum
P. dichotomiflorum
P. lanuginosum
Poa annua
Paspalum dilatatum
P. notatum var. sauræ
Spartina alterniflora
S. patens
Sporobolus virginicus
Stenotaphrum secundatum
Uniola laxa
Uniola paniculata

TYPHACEAE

Typha latifolia