The Impact of Drought on Coastal Ecosystems in the Carolinas

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Introduction

The State of Knowledge Report provides a synthesis and analysis of the peer-reviewed literature regarding drought impacts on coastal ecosystems in the Carolinas (Fig. 1). Its objective is to expand current, limited understanding of drought impacts on coastal ecosystems, to identify critical gaps, to inform future research efforts, and to suggest measures to facilitate drought adaptation for ecosystems. The report centers on biological, chemical, and physical impacts and is not meant to address social impacts.

Droughts are a normal part of climate variability that occur at scales from days to years. Significant periods of widespread drought in the study area occurred in 1965-1971, 1980-82, 1985-88, 1998-2002, (USGS 2002, Weaver 2005) and 2007-2008. Many of the droughts of interest in this report were multi-year droughts typified by long-term rainfall deficits and declines in water availability. Of lesser concern are seasonal droughts that occur as regular periods of low flow.

Drought is discussed primarily in terms of the hydrology-related impacts that affect coastal ecosystems, such as changes to river discharge, freshwater inflows, water level, and water table depth. The severity of these effects depends upon the longevity and recurrence interval of drought event(s) and may be compounded by other anthropogenic stressors on the system. In addition, some drought-related research considers how sea level impacts these ecosystems through the quantity of saline waters delivered to estuarine systems, and, in concert with freshwater precipitation and runoff, influences the resultant salinity levels experienced by these systems. Salinity and flushing of pore water in estuarine marshes affects geochemical processes and productivity, and thereby the distribution and survival of these marshes.

Some potentially beneficial effects of drought were found in the literature. Such benefits include temporary changes in nutrient input into aquatic systems that may reduce potential for algal blooms and increase water clarity thereby enhancing macrophyte productivity and reducing hypoxia. However, these effects may only be short-term and their beneficial nature is strongly site dependent.

Coastal Ecosystems

A. Coastal Marine
Very little literature was found on coastal marine systems probably because most drought impacts to the near shore system are likely to be secondary in nature (e.g., drought induced change in estuarine discharges and estuarine habitat for marine species and anadromous fish).

B. Maritime
Maritime systems occur on barrier islands and contain numerous community types with very different hydrologies; hence the effects of drought will vary significantly depending on community type. Precipitation on barrier islands appears to be the only source of freshwater input and is therefore critical to several of these communities. Consequently, extended or repeated drought will likely cause significant community changes including potential successional community changes.

C. Estuarine
The estuarine system has by far the greatest literature coverage relative to drought and related freshwater inflow (Fig. 2). The report discusses drought effects associated with freshwater inflow, salt marsh dieback, community shifts and productivity, flushing and water quality, and fauna. The majority of ecological effects relate to changes in salinity, productivity, water quality, and circulation.

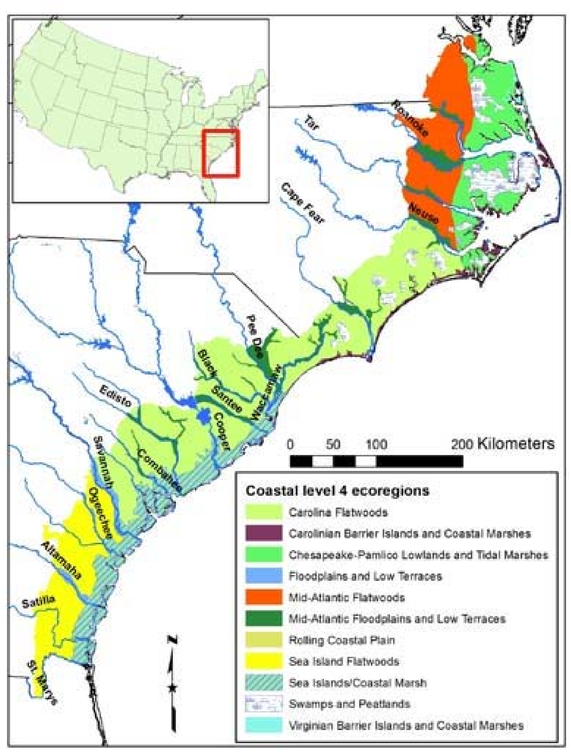

Figure 1. The study area includes parts of the Southeastern Coastal Plain, Southeastern Plains, and Southern Coastal Plain Level III ecoregions and the Level IV ecoregions indicated here. This report focuses on coastal ecosystems of North and South Carolina. There is significant ecological continuity between extreme southeastern Virginia and northeastern North Carolina and between coastal Georgia and the south coast of South Carolina. To ensure complete coverage of relevant research, we include work that was done in those parts of Virginia and Georgia. Within these coastal ecoregions, the report concentrates on the portion bordered inland by the extent of tidal freshwater.

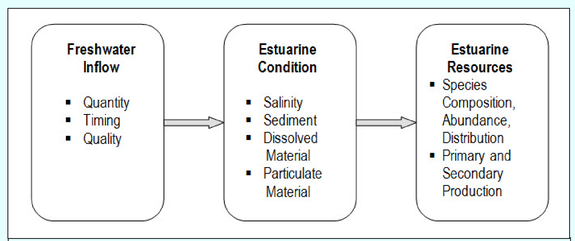

Figure 2. Schematic of the effects of freshwater inflow on estuaries (from Alber 2002).

Coastal Ecosystems - continued

D. Tidal Freshwater
Tidal freshwater systems occupy the upper ends of estuaries and are composed of tidal marshes, tidal swamps, and associated riverine conveyances (rivers, streams, and headwaters) (Fig. 3). These wetlands generally receive sufficient freshwater flows to keep surface water salinities less than 0.5 (Cowardin et al., 1979). Few ecosystems exist in a more vulnerable location for shifts in salinity and flood regime than tidal freshwater wetlands (Doyle et al., 2007). Differences in community type, swamp versus marsh, were clearly related to the penetration of saline water into swamps (Hackney et al., 2007).

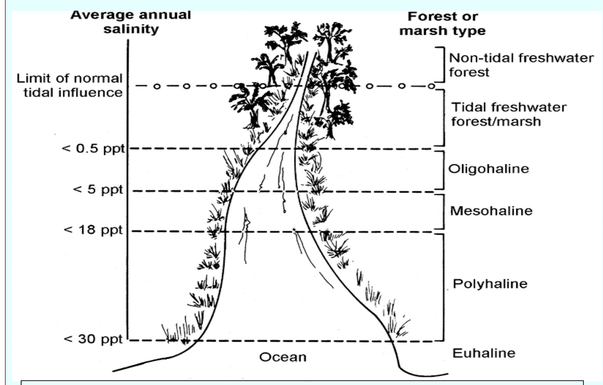

Figure 3. The location of tidal freshwater wetlands along an idealized riverine landscape (Odum et al. 1984).

E. Coastal Impoundments
Drought impacts on functioning coastal impoundments were not covered to any extent in the literature. However, such impoundments may be able to ameliorate some drought effects (especially those dealing with salinity) by management schemes that selectively preclude or limit exchange during high salinity events in the estuary.

F. Non-Alluvial Wetlands
The vulnerability of these wetlands to drought depends, in large part, on the sources of their water supply. Those fed by precipitation are the most vulnerable. Carolina bays and pocosins are dependent upon direct precipitation and evaporative water loss can result in the complete drying of shallow bays. Any deviation from normal precipitation will have an impact on their hydropatterns (Sun et al., 2006).

G. Coastal Upland Forests
Several studies in upland pine forests indicate that drought reduces root production and photosynthetic rates. Drought may also affect mast production thereby reducing forage for numerous wildlife species.

Literature gaps and research needs

The most critical needs include:

1) Examining drought impacts in ecosystems not studied by existing research: coastal upland forests, freshwater stream tributaries of tidal rivers, pocosins and other non-riverine wetlands, savannas, maritime (barrier island) systems, nearshore ocean, and estuarine high marshes.

2) Implementing long-term studies to identify and examine causal relationships, especially for ecosystem processes. It would be beneficial to take advantage of available sites with already established long-term data sets for different coastal ecosystem types.

3) Developing a set of indicators with which to monitor ecological change and impacts during drought. innovation in tools for discerning conclusive cause and effect relationships were somewhat limited. There is a need to improve understanding of key monitoring variables and to develop a set of indicators of ecological change that may be caused by drought.

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The full report can be downloaded as a pdf from:

http://www.cisa.sc.edu/resources.html

Acknowledgements

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