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Disturbance and coastal forests: A strategic approach to forest management in hurricane impact zones

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Abstract

The Indian Ocean Tsunami focused world attention on societal responses to environmental hazards and the potential of natural systems to moderate disturbance effects. Coastal areas are critical to the welfare of up to 50% of the world's population. Coastal systems in the southern United States are adapted to specific disturbance regimes of tropical cyclones (hurricanes) and fire. In August and September 2005, Hurricanes Katrina and Rita caused what has been termed the most costly natural disaster in U.S. history, including an estimated $2 billion to $3 billion in damage from wind alone. A total of 2.23 million ha of timberland in the coastal states of Texas, Louisiana, Mississippi, and Alabama was damaged. Although financial loss estimates are incomplete, there is little doubt that these hurricanes caused extensive damage and their effects on the landscape will linger for years to come. Crafting a strategy for incorporating large, infrequent disturbances into a managed landscape such as the forested coastal plain of the southern U.S. must balance the desirable with the possible. We advance an adaptive strategy that distinguishes event risk (hurricane occurrence) from vulnerability of coastal forests and outcome risk (hurricane severity). Our strategy focuses on managing the disturbance event, the system after disturbance, and the recovery process, followed by modifying initial conditions to reduce vulnerability. We apply these concepts to a case study of the effects of recent Hurricanes Katrina and Rita on forests of the coastal plain of the northern Gulf of Mexico.
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1. Introduction

A salient feature of coastal systems is their dynamic nature, which makes them vulnerable to natural and anthropogenically induced climate change (Syvitski et al., 2005). Coastal systems in the southeastern United States, for example, are adapted to specific disturbance regimes of sea level rise in the Holocene and tropical cyclone activity (Michener et al., 1997) and would be drastically affected by even modest alteration of these disturbance regimes. The nature of specific changes at local scales will depend upon interactions of altered disturbance regimes and human responses to modification of coastal environments. Tropical cyclones, or hurricanes as they are called in the North Atlantic, are a fact of life in the southern United States. The past 10 hurricane seasons have been the most active on record (Emanuel et al., 2006) and the consensus among climatologists is that greater hurricane activity could persist for another 10–40 years (Goldenberg et al., 2001).

On 29August 2005, Hurricane Katrina hit the Gulf Coast 55 km east of New Orleans after crossing over southern Florida, causing what has been termed the most costly natural disaster in U.S. history. In addition to the wind, storm surge, and flooding damage along the Gulf Coast of Louisiana, Mississippi, and Alabama, levees surrounding the metropolitan area of New Orleans were undermined and collapsed the next day causing extensive flooding damage. One month later, on 24 September 2005, Hurricane Rita made landfall on the southwest coast of Louisiana between Sabine Pass and Johnson's Bayou, damaging forests throughout east Texas. Because forests provide market as well as non-market goods and services, extreme disturbance events such as hurricanes are often followed by attempts to recover value from damaged timber through salvage logging, a practice that is increasingly questioned by the public because of its presumed negative effects on biodiversity (Lindenmayer et al., 2004). Even in a predominantly managed forest landscape such as the coastal plain of the southern United States, such questions are relevant. Our objective in this paper is to focus on the effects of hurricanes on coastal forests as a study in incorporating disturbance into managed forests. Specifically, we will present a conceptual approach to incorporating disturbance into forest

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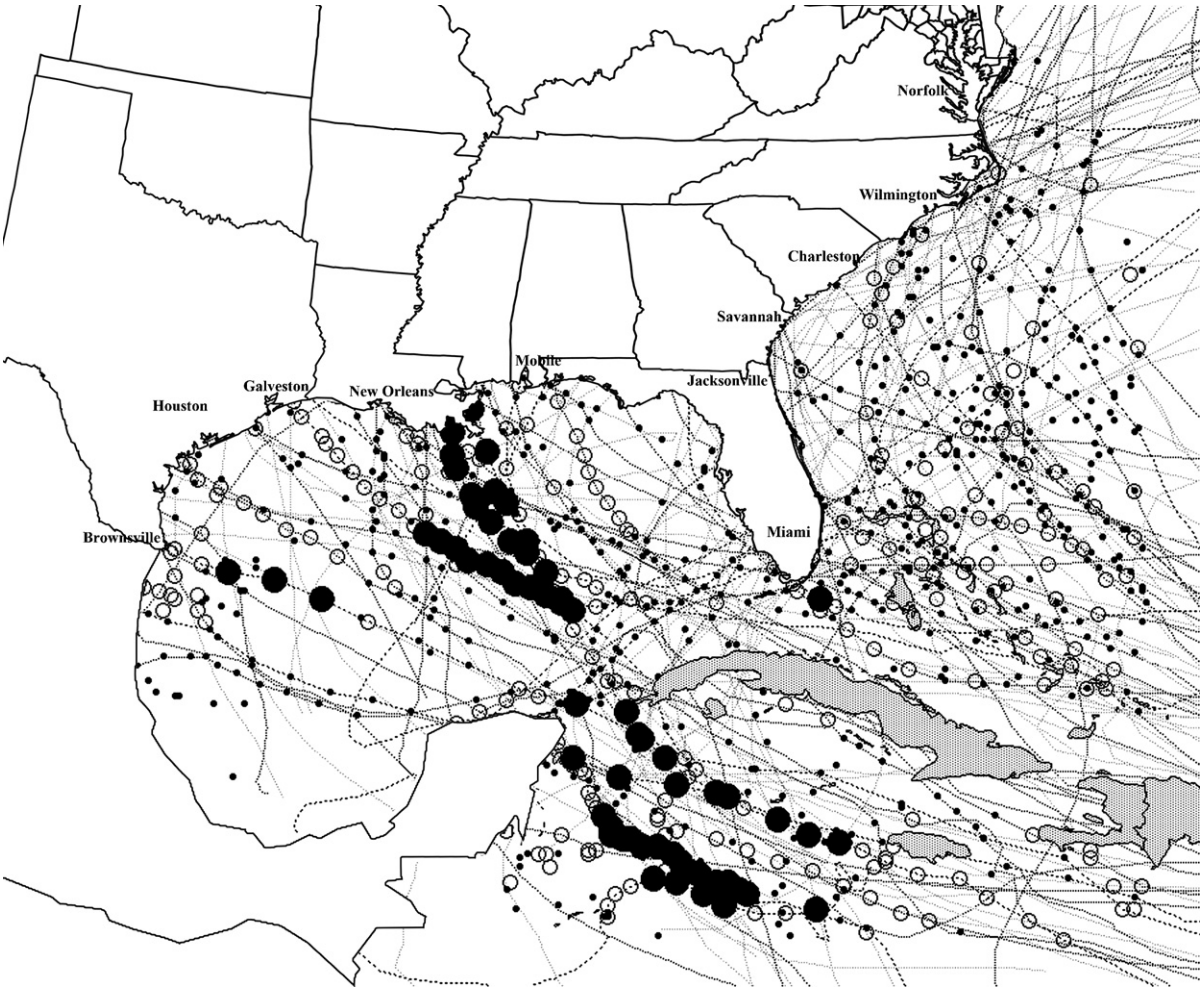

Fig. 1. Major (categories 3–5) hurricanes making landfall in the eastern United States (1851–2005). The circles represent storm intensity during its lifetime (small filled circles are category 3, large open circles are category 4, and large filled circles are category 5). The tracks are for those storms that were categories 3–5 at some point in their lifecycle. The hurricane track map is derived from NOAA's HURDAT data set for 1851–2005, the 'best track' data set (so named as it is the 'best' track and intensity estimates of tropical cyclones as determined in a post-analysis of all available data) for the North Atlantic maintained by the forecasters and researchers at the National Hurricane Center in Miami, Florida. *Source*: Jarvinen et al. (1984).

management and apply these concepts to a case study of the effects of recent Hurricanes Katrina and Rita on coastal forests of the northern Gulf of Mexico, USA.

2. Conceptual approach

2.1. Strategies for managed landscapes

Strategies for incorporating disturbance regimes into forest management must account for the multiplicity of landownership characteristics, landowner objectives and attitudes toward risk, as well as financial and operational constraints on management. Although it would seem that public ownership and a large contiguous landbase should provide the greatest opportunity to pursue management that emulates coarse-scale natural disturbance processes, statutory constraints often limit the flexibility of public managers to manipulate vegetation over large areas, and therefore constrain efforts to emulate large infrequent disturbances. Small private landowners have few opportunities, by virtue of their limited holdings, to emulate coarse-scale events such as hurricanes. Therefore, crafting a strategy for incorporating hurricane disturbance into a managed landscape must balance what is desirable with what is possible, and managers should be prepared to take advantage of opportunities provided by severe hurricanes to institute changes in composition, structure, or both.

2.2. Risk assessment approach

In order to better understand the risks of damage to coastal forests posed by severe hurricanes, we will distinguish between the risk of a severe hurricane occurring (event risk), the vulnerability of coastal ecosystems, and the significance of an event (outcome risk), which combines event risk and vulnerability (Sarewitz et al., 2003; Pielke et al., 2005). Fig. 1 is a simplistic depiction of event risk for the southern United States that attempts to show both the frequency of hurricane events as well as their intensity with a degree of spatial explicitness. Recent modeling work (Jagger and Elsner, 2006) supports the visual impression that the greatest event risk