Broad-scale Response of Landbird Migration to the Immediate Effects of Hurricane Katrina

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It was the midst of songbird migration season when Hurricane Katrina hit the Louisiana coast in 2005. Typically these birds fatten up in Gulf Coast river bottomland forest for the long flight to Central and South America. After Katrina stripped plants of leaves, fruits, and insects in the fertile bottomlands of the Pearl River, weather radar indicated that migrant birds increased their use of adjacent pine woodlands.

Introduction

Forests of the river deltas around the Gulf of Mexico play an important role in the hemispheric-scale ecological phenomenon known as the Nearctic-Neotropical bird migration system (Gauthreaux and Belser, 2003; Barrow and others, 2005). Each year millions of landbirds migrate across or near the coast of the Gulf of Mexico moving between breeding and wintering grounds. During migration seasons, nearly all of the migratory landbird species of the Eastern United States, as well as some western species, use the coastal plains along the northern Gulf of Mexico (Barrow and others, 2000). The long migration between temperate and tropical areas is difficult, and mortality may be substantial (Wiedenfeld and Wiedenfeld, 1995; Butler, 2000). Wooded habitats along the Gulf of Mexico and up to 62 mi (100 km) inland (e.g., forested wetlands bordering rivers) are stopover habitats (Gauthreaux, 1975) that migrant birds use in spring to replenish energy and to sequester resources for the ensuing reproductive season. In autumn, the primary need is to store energy for continued migration and molt. Migratory birds are likely to encounter increasingly altered landscapes along their migration paths in the coming years because of two broad-scale phenomena: human development of habitat associated with rapid expansion of human populations along the northern coast of the Gulf of Mexico (Mills and others, 1989; National Oceanic and Atmospheric Administration, 1998) and projected changes in habitats caused by disturbances (e.g., hurricanes,

fire, and invasive plant species) associated with human-induced climate change (Emanuel, 1987, 1999; Dale and others, 2000).

Our Approach

To assess the vulnerability of the Nearctic-Neotropical bird migration system to human development and increasingly severe hurricanes and to develop effective management and restoration practices to accommodate such changes, new research tools that allow biologists to deal with broader spatial scales and complex interrelations are needed. We need the ability to predict the interactive effects of hurricanes and human development on the coastal habitat types of the northern Gulf of Mexico region and the migratory birds they support. Predictions of how migrating birds will respond to such changes at landscape and regional scales will be essential for anticipating and countering environmental impacts. To begin to meet these needs, we assembled a team of ecologists, radar ornithologists, and a remote sensing specialist. The team used a combined remote-sensing and field-sampling effort in the lower Pearl River region of Louisiana and Mississippi to accomplish the following objectives: (1) develop a geographic information system (GIS) land-cover map for the lower Pearl River bottomlands and surrounding uplands by using the Louisiana Gap Analysis Program data (at 0.62 mi (1 km) resolution), (2) develop a "departure from 5-year average" statistic for vegetation greenness (density, health, and vigor index) by using archived Normalized Difference Vegetation Index (NDVI) (2000–2005, at 0.62 mi (1 km) resolution; see Faulkner, Barrow, Couvillion, and others, this volume, for more information about how NDVI data characterizes change to forest structure and canopy foliage), (3) develop a "departure from 5-year average" statistic for migrant landbird distribution by using archived Doppler weather radar data (2000–2005, also at 0.62 mi (1 km) resolution), and (4) determine if there is a correlation between hurricane-induced changes to vegetation and patterns of migrant landbird use of stopover habitat during autumn migration of 2005. Patterns of migrant landbird distribution were determined by using archived Doppler weather radar data collected by the Slidell, La., station for the period of August 15–October 31 for the years 2000–2005. To ensure that migrant birds were detected above their stopover habitat, we limited analyses to data collected 5–10 minutes after migratory liftoff from locations within 31 mi (50 km) from the radar.

Preliminary Findings

Coastal riparian forests are known to be important stopover habitats for autumn migrants prior to migratory flights around or over the Gulf of Mexico (Gauthreaux and Belser, 2005). For example, a recent radar-based study of stopover habitat patterns (Buler, 2006) and our preliminary findings suggest that stopover areas associated with the forested wetlands of the Pearl River bottoms are consistently used by high densities of en route migrant birds during autumn migration and that upland pine-dominated woodlands are used less (fig. 1*A*). Katrina made landfall near the Pearl River Delta during autumn migration and wreaked havoc on the river's forested wetlands by toppling forest over vast areas and by stripping away canopy foliage, vine tangles, epiphytes, and the insects and fruits migrant landbirds depend on (see Faulkner, Barrow, Couvillion, and others, this volume; fig. 1*E* and fig. 2). Response of migrant birds stopping over in the region just after Katrina's landfall and up to several weeks after hurricane passage was to increase their use of the surrounding less-disturbed, pine-dominated woodlands (fig. 1*B*). About 5 weeks after Katrina, much of the surviving forest canopy in the Pearl River bottoms began to resprout new foliage (fig. 1*F*), and we observed a corresponding increase in migrant use of the forested wetlands (fig. 1*C*). Changes in pattern of habitat use at these landscape and regional scales may be attributed to changes in foraging substrates or vegetation structure. For instance, earlier field studies in this region have suggested that spring migrant birds exhibit selective use of forested wetlands compared to pine-dominated woodlands because of food availability (Simons and others, 2000). Based on more than 1,000 foraging observations of 49 autumn migrant bird species stopping over in coastal woodlands of Louisiana, Barrow (unpub. data) found that 90 percent of the primary foraging sites (more than 50 percent of foraging observations for a given species) were located in canopy foliage (55.1 percent), vine tangles (24.5 percent), and on the ground (10.2 percent). Understory thickets and the air space accounted for the other 10 percent of primary foraging locations. As we have noted, the canopies of Pearl River's bottomland hardwoods were denuded for up to 5 weeks and most vine tangles stripped from trees; flood waters from the storm surge blanketed the forest floor in the lower basin. We, of course, would like to know the consequences of such sudden broad-scale shifts in migrant distribution to unsuitable or less familiar habitats. Sillett and Holmes (2002) developed a population model that indicated more than 85 percent of the annual mortality of a Nearctic-Neotropical migrant landbird, the black-throated blue warbler (*Dendroica caerulescens*), occurs during migration rather than in breeding or wintering habitat. If surviving the migration period depends on the birds' abilities to rapidly find favorable habitat and sequester sufficient fat reserves (the fuel used by migrants for long distance flights) for continued migration, factors associated with broad-scale habitat changes must be considered in any planning for gulf coastal restoration.

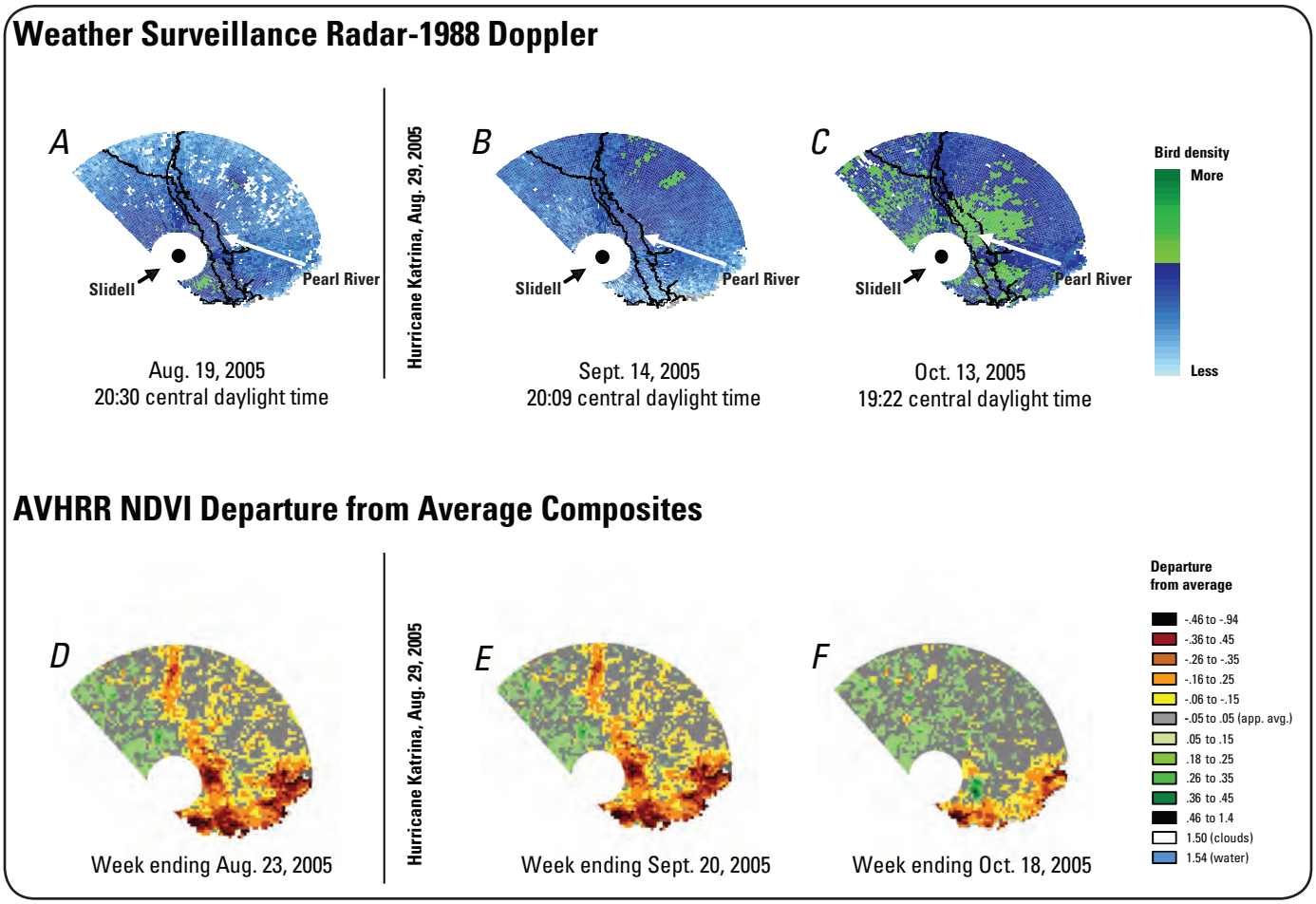

Figure 1. Weather Surveillance Radar-1988 Doppler (WSR-88D) data collected by the Slidell, La., station were used to discern patterns of stopover habitat use by migrant landbirds before and after Hurricane Katrina. Images *A*–*C* illustrate the evening departure of migrant landbirds from stopover habitat. Migratory flights are depicted by green and dark blue hues. Prior to Katrina, preliminary data suggest that migrant landbirds used the forested wetlands of the Pearl River bottoms (*A*). After Hurricane Katrina, preliminary data suggest that migrant birds increased their use of the surrounding pine woodlands (*B*). By mid-October, radar data indicate that a greater proportion of migrants was using the Pearl River bottoms (*C*). This distributional change coincided with the leaf out of vegetation in the Pearl River bottoms. Normalized Difference Vegetation Index (NDVI) data (collected by the Advanced Very High Resolution Radiometer (AVHRR)) are commonly used to assess the density and health of vegetation. The NDVI data collected in 2005 were compared to a 5-year average to assess changes in the canopy foliage of the Pearl River bottoms (*D*–*F*). The departure from average measurement indicates whether there was an increase in canopy foliage (positive values), no change in foliage (average value), or a decrease in canopy foliage (negative values). NDVI data indicate that the amount of canopy foliage prior to Katrina was average to above average in late August 2005. Katrina stripped the canopy of foliage as indicated by NDVI data collected in September 2005 (*E*). By October 2005, woody vegetation of the Pearl River bottoms had begun to leaf out as is evident in the NDVI data (*F*). "App. avg." refers to approximate average.

The Need for New Technologies

Given the current rate of coastal habitat loss in Louisiana, the projected increase in hurricane frequency and severity, and the restoration planning that is currently underway, it is important to identify and protect stopover sites that are vital to migratory birds. There is a general consensus among conservation planners that landscape-scale planning is key to migratory bird conservation (Baxter, 2005). Determining the importance of landscape features to migratory birds via ground-based surveys is difficult along Louisiana's coast, if not impossible. The gulfwide network of Weather Surveillance Radar-1988 Doppler (WSR-88D) or Next Generation Radar (NEXRAD) is a tool that can remotely identify stopover sites at broader landscape scales. Through the use of weather radar technology to monitor bird movements, biologists can remotely identify birds' use of stopover sites and obtain an instantaneous, broad-scale, and quantitative measurement of migrant density in relation to landscape features (Diehl and others, 2003; Gauthreaux and Belser, 2003). These radars detect the weak reflections or echoes produced by biological targets such as birds, bats, and insects, and they provide data on the direction and speed of targets in the atmosphere. Thus, the radar easily detects the evening departure of nocturnal migrant birds and can reveal locations where they concentrate during the day. Location data can then be coupled with GIS land-cover data to determine landscape- and regional-scale bird-habitat relations. Scientists at the National Wetlands Research Center are collaborating with colleagues at universities (e.g., University of Southern Mississippi) and U.S. Geological Survey research centers to develop radar research capabilities.

The Need for Further Work

The locations where migratory birds make landfall along the northern coast of the Gulf of Mexico change depending on weather conditions. Historically, the spatial dynamics of landfall were not a problem for migrant birds because forests and woodland patches were numerous and widespread. Because of human-induced changes to coastal habitats (e.g., development, agriculture, livestock grazing, timber industry activities, and the spread of exotic species), remnant patches are now more common than intact coastal forests. As coastal stopover habitats continue to be lost or degraded, there is likely to be an associated increase in risks posed to migrating birds.

Plans for further work should include adding an ecological modeler and geographer to the team and using results from this study to (1) develop models to assess causal relations among environmental variables and bird densities,

Figure 2. Aerial view of Hurricane Katrina damage in the Pearl River bottoms. The hurricane toppled vast areas of forest and stripped away the canopy foliage, vine tangles, epiphytes, and insects and fruits that migrant landbirds depend on.

(2) use simulation models to predict spatial and temporal dynamics of vegetation associated with hurricanes and human developments, (3) incorporate bird-landscape models into the vegetation simulation model to project how use of landscapes by migrating landbirds will be influenced by vegetation changes induced by hurricanes and human development, (4) use this overall simulation model to assess effects of hurricane scenarios and human-development scenarios on the capacity of coastal habitats in the northern Gulf of Mexico region to support en route landbirds, and (5) rapidly disseminate results to Department of the Interior National Park and National Wildlife Refuge land managers and decision makers.

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