



Cheniere Forest as Stopover Habitat for Migrant Landbirds: Immediate Effects of Hurricane Rita

By Wylie Barrow, Jr., Paul Chadwick, Brady Couvillion, Thomas Doyle, Stephen Faulkner, Clint Jeske, Tommy Michot, Lori Randall, Chris Wells, and Scott Wilson

It is not known whether en route fall migratory birds (August–October) are likely to suffer more from direct or secondary effects of hurricanes. On September 24, 2005, Hurricane Rita wreaked havoc on Louisiana’s coast by toppling trees over vast areas and by stripping away microhabitats that harbor the invertebrates and produce the fruits upon which migrant landbirds depend (e.g., canopy foliage, vine tangles, epiphytes, leaf litter, and thickets of perennial plant species). Such transient effects of a hurricane on wildlife food resources are poorly understood, but these effects may have long-term consequences for some wildlife species.

Introduction

Many species of landbirds that breed in eastern North America migrate over the western Atlantic Ocean or the Gulf of Mexico to winter in the West Indies, Central America, or South America. Because the continent-wide

Many large flocks of birds flew over, coming from the north and flying to the southwest. They were more varied in kind than any we had seen before and they were landbirds. . . . I know that most of the islands discovered by the Portuguese have been found because of birds.

Christopher Columbus, east of Bermuda, October 7, 1492 (Butler, 2000)

pattern of migration concentrates these birds in relation to ecological barriers, such as the Gulf of Mexico (Moore and others, 1993), coastal woodlands have been identified as stopover sites or staging areas of special concern to migratory landbirds (Barrow and others, 2005).

Stopover Habitat

Chenieres play an important role in the Nearctic–Neotropical bird migration system by virtue of their geographic position along important migration pathways. Twice each year, millions of songbirds, most all species of the eastern United States, swarm Louisiana’s coast as they migrate across and around the Gulf of Mexico. These chenieres serve as safe havens that migrating landbirds use in spring and autumn to rest and replenish energy reserves before continuing migration (Barrow and others, 2000a). At least 75 species of migratory birds regularly use these scarce wooded habitats prior to or immediately after crossing the Gulf of Mexico (an additional

30 species overwinter in the coastal plains of Louisiana and Texas) (Barrow and others, 2000b).

Our Approach

To rapidly assess the effects of Hurricane Rita on the suitability of cheniere forest as stopover habitat, we assembled a team of wildlife biologists (including a research wildlife biologist who is an aircraft pilot), geographers, a biogeochemist, a dendroecologist, a radar ornithologist, and an electronics engineer. A reconnaissance flight 2 days post-Rita landfall revealed extensive flooding as a result of a massive storm surge, toppled trees, debris and trash entangled in all chenieres, and several major beach overwashes that partially buried some cheniere forests (fig. 1) (see Faulkner, Barrow, Doyle, and others, this volume; Michot and others, this volume).

Because Rita made landfall near the peak of autumn migration, U.S. Department of the Interior land managers needed to know if cheniere forests were still capable of providing food resources to meet the energetic demands of migrant landbirds prior to long gulf crossings. We used a combined approach of remote sensing (Normalized Difference Vegetation Index; see Faulkner, Barrow, Doyle, and others, this volume), weather radar (see Barrow, Buler, and others, this volume), aerial digital videography survey (high-

resolution color infrared imagery), and field sampling (branch clippings to quantify arthropods and fruits) to assess loss of forest cover, to quantify canopy defoliation and recovery, to identify types of disturbance (hemispherical photography), and to determine if known food resources (invertebrates and fruits) were still available to staging autumn migrant landbirds (by taking branch clippings) (fig. 2).

Aerial Videography

Aerial transects followed cheniere ridges from Rockefeller Wildlife Refuge to the Louisiana-Texas border. East of the Calcasieu River, cheniere sample sites were located on Little Pecan Island-Little Chenier complex (about 2,800 years old and dominated by live oak (*Quercus virginiana*)), Grand Cheniere-Oak Grove Ridge-Front Ridge complex (about 1,200 years old and dominated by live oak), and Hackberry Beach chenier (about 600–800 years old and dominated by sugarberry (*Celtis laevigata*)). West of the Calcasieu River, sample sites were located on the Peveto Beach-Constance Beach-Hackberry Ridge complex (about 600 years old and dominated by sugarberry or toothache tree (*Zanthoxylum clava-herculis*) and sweet acacia (*Acacia farnesiana*)) (fig. 2). Flights were conducted at 3,500 ft (1,067 m), and transect width was 1,400 ft (427 m).



Figure 1. Hurricane Rita produced a significant storm surge that pushed flood waters inland as far as 25 mi (40 km). This aerial view taken 2 days after the storm shows the extensive flooding of Grand Chenier, La., a site located 4.6 mi (7.4 km) from the coast. Some sites remained inundated for as long as 4–6 weeks after the storm.

Digital Aerial Photography

Frames of aerial photography were selected for analysis to correspond with the ground-sampling sites. Each frame was interpreted for characteristics that were biologically relevant for birds, relatively easy to measure and interpret, and readily recognizable in the field by those who would need to identify vegetation conditions for future hurricane assessments: forest cover, shrub cover, vegetation type (evergreen versus deciduous), debris cover, and presence/absence of sediment/erosion. Assessment of change in forest cover at Hackberry Beach chenier caused by Hurricane Rita was accomplished by comparing prehurricane and posthurricane digital aerial photographs (fig. 3).

Food Resources

One month after Hurricane Rita made landfall, we sampled abundance of invertebrates on chenieres to assess food resources for migrating and wintering landbirds. Field

sampling focused on the five common canopy species of Louisiana's chenieres: live oak, sugarberry, sweet acacia, toothache tree, and Chinese tallow (*Triadica sebifera*). For each of 10 sites sampled (Global Positioning System coordinates were selected prior to field visits), we selected the nearest three individuals of each focus species. We clipped an 8-inch (20-cm) sample from the end of branches of trees with resprouting leaves and of trees with branches not showing resprouting, placed them in a plastic bag, and applied an all-purpose insecticide. The branches were vigorously shaken, and all invertebrates and fruits were sorted from the vegetation after returning to the laboratory. For each sample, we counted leaves and determined dry mass for invertebrates, foliage, and woody material. Notes were taken on direct visual observations of invertebrates and fruits seen in chenieres.

Broad-scale Vegetation Changes

Normalized Difference Vegetation Index (NDVI) is calculated from data (wavelengths and intensity of visible

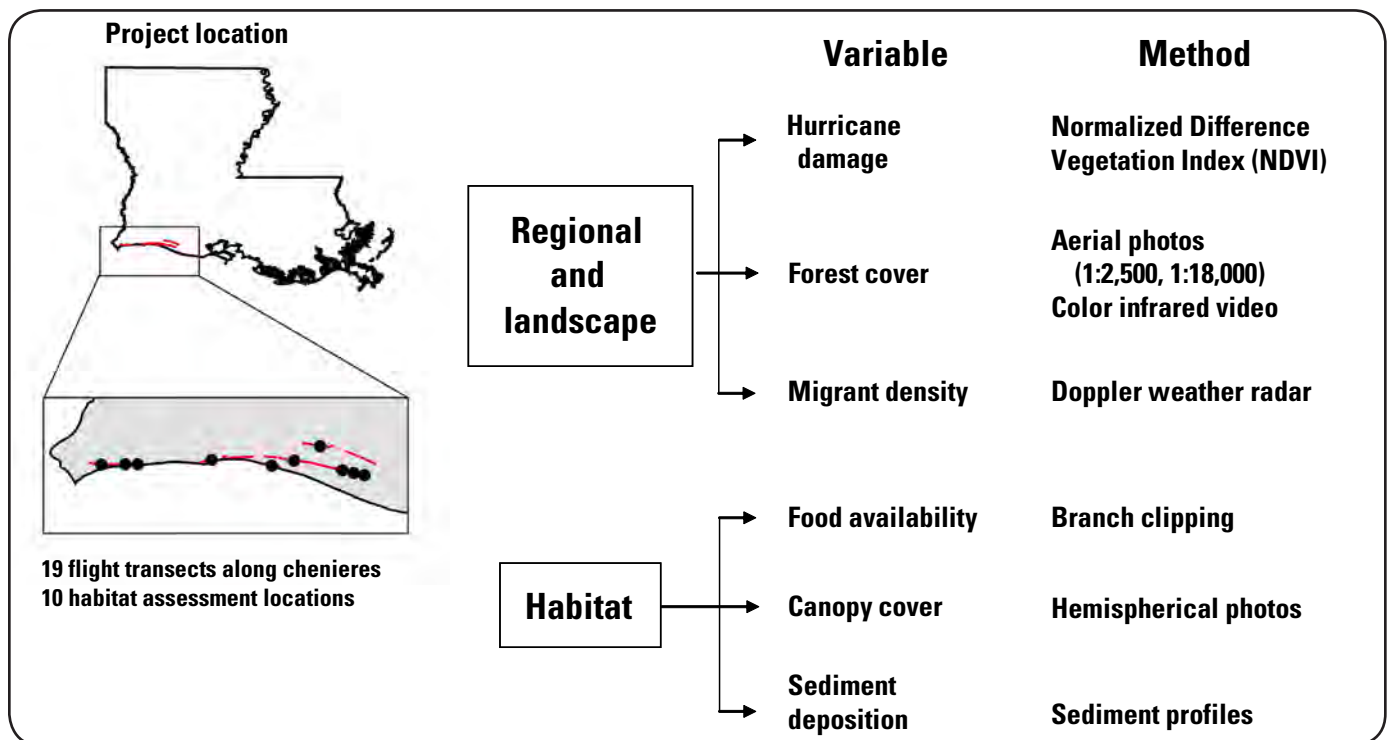


Figure 2. A multiscale approach was used to assess the effects of Hurricane Rita on stopover habitats in southwest Louisiana used by Nearctic-Neotropical migratory landbirds. Remote sensing methods were used to assess the health (Normalized Difference Vegetation Index (NDVI)), loss of forest cover (color infrared video laid over aerial photographs), and migrant bird use of cheniere forests (Doppler weather radar) at regional and landscape scales. The quality of cheniere habitats was also assessed at 10 locations across the region. At each site, branch clippings were collected to determine the availability of food resources (insects), and hemispherical photographs were taken to estimate canopy cover. At Hackberry Beach chenier, Rita altered the structure of the chenier by removing forest cover and by depositing a substantial amount of sediment. An additional assessment of sediment deposition was conducted at this site (see Faulkner, Barrow, Doyle, and others, this volume).

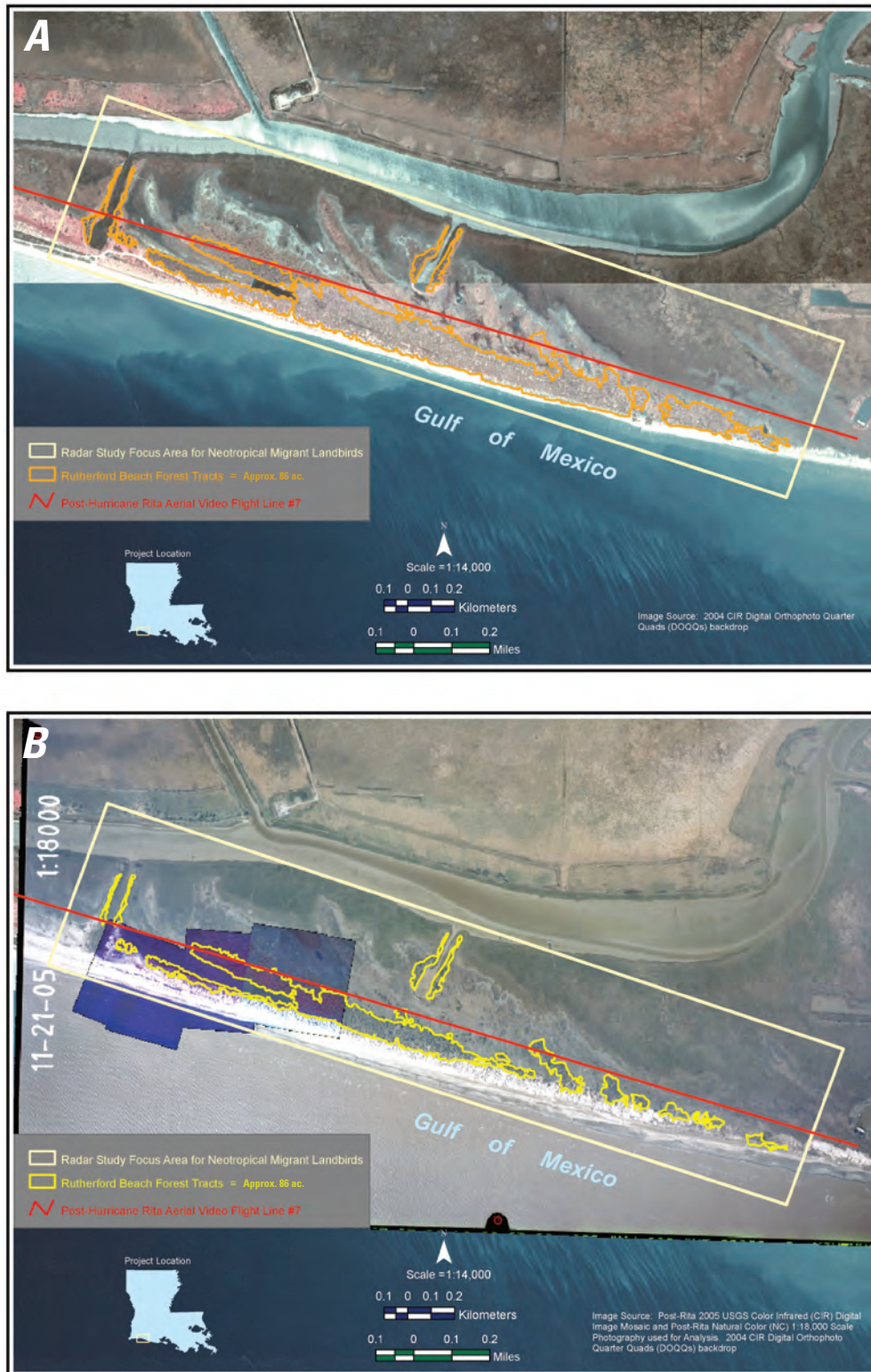


Figure 3. Estimates of forest cover on Hackberry Beach chenier in Louisiana before and after Hurricane Rita. Estimates of forest cover (86 acres (0.35 km²)) prior to Rita (*A*) were derived by delineating forest edges from 2004 color infrared digital orthophoto quarter quadrangles. Estimates of forest cover (46 acres (0.19 km²)) after Rita (*B*) were derived by delineating forest edges from post-Rita U.S. Geological Survey 2005 color infrared video rectified image mosaic and rectified U.S. Geological Survey post-Rita 2005 natural color photography (1:18,000 scale).

and near-infrared light) collected by the Advanced Very High Resolution Radiometer (AVHRR) multispectral sensor. Normalized Difference Vegetation Index data are commonly used to assess the density and health of vegetation. Regional scale NDVI analyses suggested that storm winds and saltwater surge affected vegetation throughout southwest Louisiana (figs. 4A–4D). At the landscape scale, hurricane damage was extensive and was not confined to a particular habitat type. At the habitat level, the exact nature of the hurricane's effects was uncertain—were trees stripped of foliage, was foliage burned by saltwater inundation, or were trees felled or buried under debris and sediments?

Interpretation of aerial video from our Hackberry Beach chenier site, eastern Cameron Parish (0.06 mi (0.10 km) from the gulf), determined that more than half of the forest had been swept away or buried by sand deposits induced by storm surge (fig. 3). The depth of sand deposited in the forest ranged from several inches to over 8 ft (2.4 m). For details on how this beach overwash may affect the remaining forest cover, see Faulkner, Barrow, Doyle, and others, this volume.

All cheniere sites we visited had either sediment or debris deposits throughout the forest floor (sediment type and depth varied across chenières), making the leaf litter unavailable to ground-foraging migrant birds (e.g., Swainson's warbler (*Limnithlypis swainsonii*)). For instance, a sediment layer about 0.5 inches (1.3 cm) deep was deposited at Hackberry Ridge in western Cameron Parish (0.09 mi (0.14 km) from the gulf). At Grand Chenier (4.6 mi (7.40 km) from the gulf), more than 4 ft (1.2 m) of debris (predominantly canes of *Phragmites* with marsh and trash interspersed throughout) were deposited within the forest (fig. 5).

Saltwater inundation was still extensive on some chenières for several weeks after hurricane passage. All cheniere forest canopies were damaged; most trees had their foliage stripped, and others retained leaves killed by salt water (fig. 6). On our initial field visits 4 days after storm passage, we found no live foliage; many trees did, however, exhibit leaf regrowth about 2–5 weeks after Rita's landfall. The consequences of sediment deposits, saltwater inundation, and canopy damage for some of these forests may not be understood for several years, and then only if long-term monitoring plots are established.

Changing Food Resources

Hurricanes are significant contributors to the population dynamics of migratory birds and other wildlife (Butler, 2000). These storms are known to cause mortality in migrant landbirds during passage through the northern Gulf of Mexico region (Weidenfeld and Weidenfeld, 1995; Barrow and Jeske, personal observations after Rita). It is not known whether en route fall migratory birds (August–October) are likely to suffer more from direct or secondary effects of hurricanes.

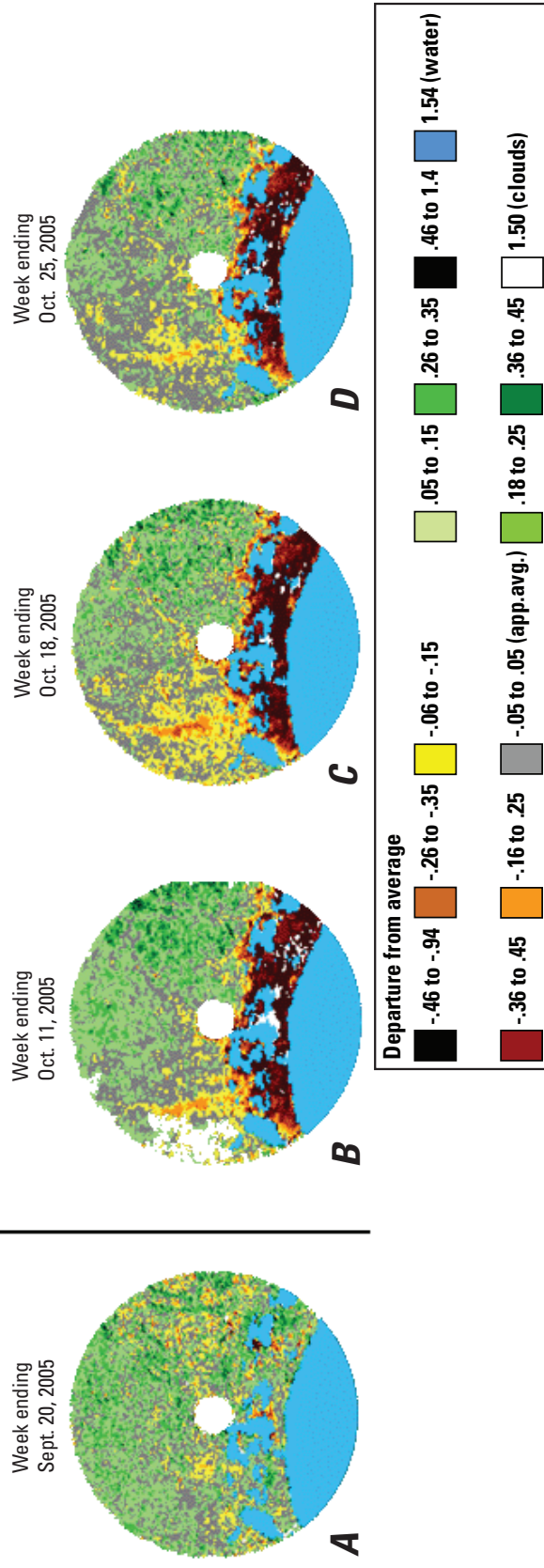
On September 24, 2005, Hurricane Rita wreaked havoc on Louisiana's coast by toppling trees over vast areas and stripping away microhabitats that harbor the invertebrates and produce the fruits upon which migrant landbirds depend (e.g., canopy foliage, vine tangles, epiphytes, leaf litter, and thickets of perennial plant species). Such transient effects of a hurricane on wildlife food resources are poorly understood, but these effects may have long-term consequences for some wildlife species. Butler (2000) used the U.S. Geological Survey Breeding Bird Survey database, 1967–96, to test the hypothesis that abundance of eastern North American migrants is negatively related to the severity of storms during autumn passage over oceanic waters. Abundances of mourning warblers (*Oporornis philadelphia*), rose-breasted grosbeaks (*Pheucticus ludovicianus*), and especially blackpoll warblers (*Dendroica striata*), a well-known transoceanic migrant, were all influenced by storms.

Invertebrate samples collected 1 month after Hurricane Rita revealed that food resources were scarce (table 1). Almost half of the invertebrates (25 of 45) in our samples are rarely eaten or were too small to be useful for migrant landbirds: ants (10), early instar beetle larvae (4, too small), and mites (11, too small). There were no significant differences among the invertebrates associated with plant species or between trees with dead foliage and trees that exhibited leaf out following the storm. Apparently, invertebrates known to be associated with these plant species were not available to recolonize them (Barrow and others, 2000a, 2000b). It is unknown whether important prey items will be available to birds during spring migration of 2006.

Fruit, known to facilitate fat deposition during migration (Parrish, 2000), remained on some individual trees of hackberry and Chinese tallow. Salt matrimony-vine (*Lycium carolinianum*), a low shrub common in the coastal fringes of Louisiana and Texas (especially where the soil and water are slightly salty), survived complete inundation by the storm surge. The fruit of this plant is available throughout the year and is eaten by waterfowl, the larger landbird migrants (e.g., gray catbird (*Dumetella carolinensis*) and mourning dove (*Zenaida macroura*)), and large overwintering migrants, such as sandhill crane (*Grus canadensis*) and whooping crane (*Grus americana*) (Martin and others, 1951; Everitt and Drawe, 1993). Individual plants appeared healthy and had retained their leaves, and most individuals we observed were producing both flowers and fruit.

Other fruits known to be consumed by migrant birds during migration and winter (e.g., toothache tree, swamp dogwood (*Cornus drummondii*), bird pepper (*Capsicum annuum* var. *annuum* L.), pigeonberry (*Rivinia humilis*), poison ivy (*Toxicodendron radicans*), muscadine (*Vitis rotundifolia*), peppervine (*Ampelopsis arborea*), green hawthorn (*Crataegus viridis*), greenbrier (*Smilax* spp.), yaupon (*Ilex vomitoria*), and deciduous holly (*Ilex deciduas*)) perished in the storm surge. The question remains: what happens to

AVHRR NDVI departure-from-average composites



Weather Surveillance Radar-1988 Doppler

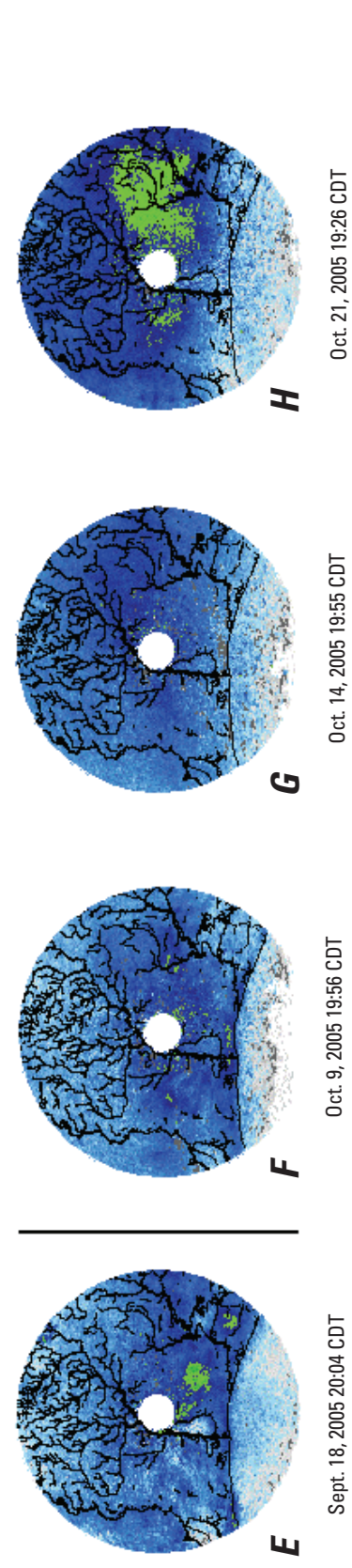


Figure 4. Normalized Difference Vegetation Index (NDVI) data collected in 2005 were compared to a 5-year average to assess changes in the canopy foliage of the chenier forests (A–D). The departure from average measurement indicates whether there was an increase in canopy foliage (positive values), no change in foliage (average value), or a decrease in canopy foliage (negative values). Normalized Difference Vegetation Index (NDVI) data indicate that the amount of canopy foliage prior to Hurricane Rita was near average in late September 2005 (A). Rita stripped the canopy of foliage, as indicated by NDVI data collected in October 2005 (B–D). Weather Surveillance Radar-1988 Doppler (WSR-88D) data collected by the Lake Charles, La., station were used to discern patterns of stopover habitat use by migrant landbirds before and after Rita. Images E–H illustrate the evening departure of migrant landbirds from stopover habitat. Birds are depicted by green and dark blue hues. Prior to Rita, preliminary data suggest that migrant landbirds used chenieres (forests) and the forested wetlands of the Calcasieu, Mermantau, and Sabine River bottoms (E). After Rita, preliminary data suggest that overall migrants were using the forested wetlands of the Calcasieu, Mermantau, and Sabine River bottoms (G–H).



Figure 5. Debris deposited by Hurricane Rita within the forest on Grand Chenier, La.

the distribution of migrant birds when food resources are diminished at the scale of an entire geographic region?

Changing Migrant Distributions

Migration pathways over or around the Gulf of Mexico are affected, in large part, by the prevailing wind patterns when birds are aloft (Gauthreaux, 1999). In autumn, prevailing southerly winds over the gulf are less conducive to transgulf flight, and the majority of migration movement from southwest Louisiana is toward the southwest (Able, 1972). Depending on weather, the movement may be a flight across the northwest gulf, or migrant birds may move along the Texas coast. As the season progresses, cold fronts push southward, increasing the likelihood of transgulf flights. The scarce cheniere forests of southwest Louisiana provide important stopover habitat for migrants, but the frequency of their use is partially determined by weather.

We monitored autumn migration stopover patterns along the southwest Louisiana coast by using Weather Surveillance Radar-1988 Doppler (WSR-88D) data archived by the National Weather Service for the period of August 15 through October 31, 2005. Migrant landbirds resume migration just after sunset, and this evening departure is easily

detected by radar. Preliminary data from September 2005 suggest that migrants departed from the chenieres throughout the month, but use of these areas increased toward late September (fig. 4E). After Rita made landfall on September 24, departures from the chenieres were sporadic, and very little activity was detected in these areas after October 14. The forests of the Sabine, Calcasieu, and Mermantau River bottoms, located north of the chenieres, were routinely used throughout the autumn migration season, with an increase in their use after Rita (figs. 4F–4H).

Hurricane-induced habitat shifts may not be an option for resident birds or foraging specialists. During multiple visits to more than 10 chenieres over a 3-month period after Rita, we did not observe a single northern cardinal (*Cardinalis cardinalis*), the most common resident species inhabiting cheniere forests (Barrow, unpub. data). Few other resident or overwintering migrant birds were observed during the course of our field sampling in the winter of 2005–06.

Acknowledgments

We thank Chad Case and Holly Ramey for their assistance with fieldwork at Hackberry Beach chenier, Melissa Collins and Margaret Luent for their assistance in the lab, and



Figure 6. View of Hackberry Ridge, La., before (A) and after (B) Hurricane Rita. Hurricane-force winds and the storm surge downed trees, stripped foliage from the vegetation, and deposited sediment and debris on the forest floor. (Photograph in A is copyright of Bill Goulet and used with permission.)

Table 1. Preliminary data of invertebrates on branches clipped from trees on Louisiana cheniers impacted by Hurricane Rita. Samples were collected from November 2 to 4, 2005.

[n, number of samples; dry wt., dry weight. See text for scientific names of tree species]

Tree Species	Status ¹	n	Number of leaves	Leaf dry mass	Number of invertebrates ²	Invertebrates/100 g leaves dry wt.
Hackberry	L	28	3,230	76.70	11	14.34
Hackberry	D	19	1,884	68.63	15	21.85
Live Oak	L	13	948	64.95	3	4.62
Live Oak	D	18	1,291	118.01	3	2.54
Tallow	L	13	1,394	26.37	4	15.17
Tallow	D	12	875	60.94	2	3.28
Acacia	L	6	3,648	12.33	6	48.66
Acacia	D	2	158	0.05	0	0.0
Toothache	D	3	540	6.79	1	14.72

¹ Branches exhibited posthurricane leaf out: L, majority of leaves are new, and D, majority of leaves are dead.

² Includes 8 spiders, 10 ants, and 27 other insects.

all the landowners of Cameron Parish, La., who allowed us to work on their property.

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What's in a Name? Chenier or Cheniere?

By Gaye S. Farris

Coastal Louisiana is divided into two major regions: (1) the Deltaic Plain of southeast Louisiana, dominated by the Mississippi River and its delta, and (2) the Chenier Plain of southwest Louisiana, dominated by *cheniers* (Saucier, 1994). John Barras (this report) also describes a middle area, the Marginal Deltaic Plain, between the Atchafalaya River and Freshwater Bayou.

A *chenier* is a long, narrow former beach ridge or sandy or shelly hummock (rounded mound) that runs parallel to the shoreline and rises 3–18 ft (1–6 m) above the marshes and mudflats. These ridges are well drained and fertile, often supporting large evergreen live oaks (*Quercus virginiana*); cheniers range from 148 ft to 1,476 ft (45 to 450 m) wide and several miles (tens of kilometers) long (Neuendorf and others, 2005).

The spelling *cheniere* is found in place names (U.S. Geological Survey, 2006) and is used by some scientists to describe the oak forest itself (Barrow and others, 2006). *Chenier* or *cheniere* is roughly translated “oak grove” and was a name given by the early French settlers based on the French word “chêne,” meaning oak. Both spellings can be found in this report, in many maps, and in the scientific literature.



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