

## LARGE KILL OF NEOTROPICAL MIGRANTS BY TORNADO AND STORM IN LOUISIANA, APRIL 1993

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**Abstract.**—A tornado and storm on 8 Apr. 1993 at Grand Isle, Louisiana, killed an estimated 40,000 birds of 45 species. The ten species killed in greatest numbers accounted for about half of the birds killed. Species of concern because of their already declining numbers included the Wood Thrush (*Hylocichla mustelina*) and Cerulean (*Dendroica cerulea*) and Swainson's Warblers (*Limnothlypis swainsonii*). This kill is the largest one recorded on the Gulf of Mexico coast. It may have been so severe because the storm occurred at the time of day when the greatest number of birds was arriving at the coast after having migrated all night northward across the Gulf.

### ALTA MORTANDAD DE MIGRATORIOS NEOTROPICALES CAUSADO POR UN TORNADO Y UNA TORMENTA EN LUISIANA

**Sinopsis.**—Un tornado y una tormenta que ocurrieron el 8 de abril de 1993 en Grand Isle, Luisiana, causó la muerte aproximadamente de 40,000 aves representando a 45 especies. Las diez especies más afectadas estuvieron representadas por el 50% de las aves muertas. Entre las especies que más preocupan porque sus números se han ido reduciendo, se encuentran *Hylocichla mustelina*, *Dendroica cerulea* y *Limnothlypis swainsonii*. La mortandad de aves es la mayor informada en la costa del Golfo de México. Es posible que ésta haya sido tan severa debido a que la tormenta ocurrió a la hora del día en que la gran mayoría de las aves estaban llegando después de volar durante toda la noche a través del Golfo.

On 8 Apr. 1993, a large storm roared across Grand Isle, Louisiana, spawning a tornado that killed three people and seriously injured 14 others. The same storm killed an estimated 40,000 birds of at least 45 species, most of which were neotropical migrants that had almost reached the end of their spring trans-Gulf flight.

Grand Isle (29°13'N, 90°0'W) is a low barrier island off the coast of Louisiana, approximately 80 km south of New Orleans. The island is covered by sand dunes, marsh and the low, scrubby, Live Oak (*Quercus virginiana*) woodland known in Louisiana as "chenier," and has a human community of about 1500 residents. The island has long been recognized as an important stopover area for neotropical migrants; much of George Lowery's important early work on the trans-Gulf migration was conducted at Grand Isle (e.g., Lowery 1945).

#### THE STORM

During the week of 4-10 Apr. 1993, slow-moving weather fronts advanced southward across Mississippi and Louisiana, drenching the Missis-

ssippi Delta with 10–18 cm of rain (Climate Analysis Center 1993). The fronts produced violent thunderstorms, tornadoes and hail from Texas to the Atlantic coast (Climate Analysis Center 1993). On 8 Apr. 1993 at about 1430 hours a severe storm at the leading edge of the front, with gusts of 110–130 km/h, spawned a tornado that passed over Grand Isle. Damage to the community of Grand Isle was extensive (Walsh and Barbier 1993).

On the day following the storm, B. Mac Myers and David P. Muth (pers. comm.) reported that many dead birds were washing up on the beach at Grand Isle, and especially at Elmer's Island (29°10'N, 90°4'W), about 9 km southwest of where the tornado struck. The following morning (10 April) we arrived to search the beaches in the area for dead birds, to determine the magnitude of the kill and to salvage specimens. We here report on the details of the bird kill and compare it with previous kills from similar storms.

#### METHODS

We spent about 6 h searching the beaches of Grand Isle, Elmer's Island and Port Fourchon (approximately 24 km southwest of Grand Isle), and identified 936 dead birds. At each of these beaches we counted and identified (when possible) all birds found along a measured sample section of beach. On Grand Isle we searched 1.69 km of beach. At Elmer's Island, because of the very high number of dead birds, we were able to search only 60.4 m of beach. We also counted the number of birds along a second sample section of Elmer's Island beach 79.5 m long, but without classifying the birds to species. Only about 2 km of Elmer's Island beach and its adjacent mainland beach/marsh (Cheniere Caminada) is accessible. As few birds were found at Port Fourchon, we only searched about 80 m of beach intensively, although we did briefly cover a larger area to ascertain that few birds had washed up there.

The number of dead birds counted was probably conservative. It was not possible to find all birds that had washed up on the beach because some were covered with detritus or completely buried in the sand. We did, however, make every effort to search all detritus piles as thoroughly as possible. In addition, Elmer's Island is very low, and some birds may have washed completely over the island during the storm surge and high waves that followed the storm. We did spend some time searching the inland side of the island, but found few birds.

Finally, of course it is unlikely that all birds killed washed up on the beach at all, or lasted long once there. Some birds probably sank or were eaten by fish scavengers before they could wash up on shore. Many scavengers (gulls, crabs) were also actively eating, carrying away, or burying the birds that had washed up.

We also spent about 1 h searching the chenier and coastal scrub on Grand Isle for live birds, to determine which birds had survived or arrived since the kill. We did not attempt to census the live birds because migrants were constantly arriving during the day; thus, a census would have been

TABLE 1. Length of beaches and total estimates of numbers of dead birds on the beach. For densities of birds per km, see the Appendix and Methods.

Beach	Length (km)	Birds/km	# birds
Grand Isle	14.4	225.5	3247
Elmer's Island	5.7	4401.8	25,090
First 4 km from Elmer's Island to Port Fourchon	4.0	2200.9*	8804*
Second 4 km from Elmer's Island to Port Fourchon	4.0	225.5*	902*
Four km nearest Port Fourchon	4.0	88.0	352
Birds that did not wash up on shore at all			?
Total			38,395*

\* Estimate.

valid for only a particular hour of the day. We did, however, record relative abundance.

From our counts we are able to estimate the density of dead birds per km of beach for the three beach areas. As not all of the beaches are accessible or could be searched, we have estimated the density for those areas not covered. For all of Grand Isle and all of Elmer's Island we have used the density from our sample counts on those beaches. The section between Elmer's Island and Port Fourchon poses a problem, however, because the density of dead birds on Elmer's Island was high, and the density at Port Fourchon was very low. Therefore, we have divided the distance between Elmer's Island and Port Fourchon (about 12 km) into three equal-length segments of 4 km. For the 4 km nearest Elmer's Island, we estimated a dead-bird density of one-half that of Elmer's Island; for the next 4-km section of density equal to that of Grand Isle; and for the 4 km nearest Port Fourchon, we have used the value for birds counted at Port Fourchon.

## RESULTS

The greatest density of dead birds was at Elmer's Island, about 4402 birds per km of beach (Appendix). Our second sample of birds at Elmer's Island produced a similarly high number of 3634 birds per km of beach. On Grand Isle itself, the density of birds was only about 226 birds per km (Appendix). At Port Fourchon the density was even lower. We counted only seven Wood Thrushes (scientific names in Appendix and Table 3) and one Indigo Bunting on 80 m of beach, for a density of 88 birds per km.

The total number of birds that washed up was estimated to be 38,395 (Table 1). The weak part of the estimate is the section of beach between Port Fourchon and Elmer's Island. Although the estimate of birds washed up on that section of the beach may be high, we still consider our overall

TABLE 2. Estimate of number killed of the ten species encountered in greatest numbers, and for three species of special interest. The estimates only include the numbers on Grand Isle, Elmer's Island, and at Port Fourchon, and do not include an estimate for the section between Elmer's Island and Port Fourchon. Sexes and age classes have been combined.

Species	Estimated # killed
Ten species most frequently encountered	
Indigo Bunting	4207
Kentucky Warbler	2538
Wood Thrush	2362
Ovenbird	2280
Red-eyed Vireo	2255
Worm-eating Warbler	2185
Hooded Warbler	1809
White-eyed Vireo	1800
Gray Catbird	959
Orchard Oriole	823
Species of special concern	
Cerulean Warbler	583
Swainson's Warbler	214
Seaside Sparrow*	111

\* Not a neotropical migrant.

estimate to be conservative, because it may account for some birds that died but did not wash up on shore at all.

The ten species killed in greatest numbers (Table 2) represent about half (21,218) of the individuals killed, even when the section of beach between Elmer's Island and Port Fourchon is ignored. One of these ten species, Wood Thrush, is a species already widely recognized as having declining populations (Wiedenfeld et al. 1992); certainly a large kill does not help its population numbers.

We also found individuals of three other species of special concern because of their rarity or declining populations; Cerulean and Swainson's Warblers, and Seaside Sparrow (Table 2). Seaside Sparrows are not neotropical migrants, but were probably blown to sea by the storm.

While walking along the beach, we found individuals of six additional species or sexes that we did not find during our sample counts (Least Bittern *Ixobrychus exilis*, 2; Black-crowned Night-Heron *Nycticorax nycticorax*, 1; Yellow-billed Cuckoo *Coccyzus americanus*, 2; Blue-winged Warbler *Vermivora pinus*, 3; Scarlet Tanager female, 1). These individuals were not included in our estimate of the overall number of birds killed.

Daily turnover of birds at the coast is very high during migration, so the composition of the live birds on Grand Isle the day we arrived would not be expected to be similar to that on the day of the bird kill, two days previous. Comparing the relative abundances of the live birds on 10 April (Table 3) with the relative abundances of the ten most commonly found dead species on 8 April (Table 2), however, does show that different

TABLE 3. Species and relative abundances of birds encountered alive on Grand Isle on 10 Apr. 1993, during 1-h search. Rare = 1-3 seen; Uncommon = 4-10 seen; Common = 10-20 seen; Abundant = more than 20 seen.

Species	Abundance
Merlin <i>Falco columbarius</i> *	rare
Ruby-throated Hummingbird <i>Archilochus colubris</i>	rare
<i>Empidonax</i> spp.	rare
Loggerhead Shrike <i>Lanius ludovicianus</i> *	rare
Gray Catbird	abundant
Northern Mockingbird <i>Mimus polyglottos</i> *	uncommon
Wood Thrush	abundant
Swainson's Thrush	uncommon
European Starling <i>Sturnus vulgaris</i> *	common
Red-eyed Vireo	rare
White-eyed Vireo	rare
Common Yellowthroat	
Male	uncommon
Female	rare
Black-and-white Warbler	uncommon
Worm-eating Warbler	uncommon
Palm Warbler <i>Dendroica palmarum</i>	rare
Ovenbird	uncommon
Tennessee Warbler	rare
Hooded Warbler	
Male	common
Female	common
Kentucky Warbler	rare
Black-throated Green Warbler	rare
Northern Cardinal <i>Cardinalis cardinalis</i> *	uncommon
Common Grackle <i>Quiscalus quiscula</i> *	common
Orchard Oriole	
Adult male	common
1st-year male	abundant
Summer Tanager	
Male	rare
Female	none
Seaside Sparrow	rare
Indigo Bunting	
Male	abundant
Female	common

\* Not a neotropical migrant.

groups of birds apparently had migrated on the two different days. There was a much higher proportion of female-plumaged Indigo Buntings on the island on 10 April than were killed by the storm; in fact, of the 85 dead buntings we found, only two were female. Although many Kentucky Warblers, Red-eyed Vireos, and Worm-eating Warblers were killed by the storm, 2 d later these species were scarce in the chenier. The age classes also differed somewhat on the two dates. We found more dead adult male Orchard Orioles than first-year males, but we encountered more first-year males than adults alive in the chenier.

We also encountered eight species alive that we did not encounter dead on the beach (Table 3). These species are Merlin, Ruby-throated Hummingbird, Loggerhead Shrike, Northern Mockingbird, European Starling, Palm Warbler, Northern Cardinal and Common Grackle. Only two of these, the hummingbird and warbler, could be considered neotropical migrants. The absence of dead hummingbirds in our counts may perhaps be due to the difficulty of finding them on the beach because of their small size.

#### DISCUSSION

Few similar kills of spring migrants have been recorded in the literature, especially not of storms involving tornados. While on a boat off the Louisiana coast in 1880, Frazar (1881) reported a frontal storm downing and killing many thousands of northward migrating birds around the ship. Bennett (1909) reported on a storm of 14 Apr. 1909 that killed many birds at lighthouses on the Florida Keys and Dry Tortugas. Bennett did not believe the lightkeeper's estimate of thousands of birds, but did agree that hundreds had been killed and that many more had survived but had been temporarily grounded. He listed in order of abundance many of the same species we recorded, although our abundances were somewhat different: Summer Tanager, Indigo Bunting, Ovenbird, Orchard Oriole, Scarlet Tanager, and others. He also noted as we did that male Indigo Buntings far outnumbered the females. The high preponderance of male buntings in both bird kills may be attributable to both kills having occurred early in the season.

In early May 1951, James (1956) reported a kill of an estimated 10,000 birds on Padre Island, Texas, by storms resulting from a severe cold front. Nearly half of the individuals were of a single species, Magnolia Warbler (*Dendroica magnolia*). King (1976) described a kill of about 5000 birds, 62% passerines, that washed up on Galveston Island, also in Texas, following a frontal storm on 5 May 1974.

Although these events are difficult to compare, the estimates of numbers made by Bennett (1909), James (1956) and King (1976) all seem lower than for the Grand Isle event. In addition, no tornado was reported in any of the other events. In an interesting coincidence, 56 yr to the day before the 1993 storm, on 7 Apr. 1937, Lowery (1945) reported that a "norther" caused many birds to arrive on Grand Isle exhausted and flying low. Lowery (1945) did not, however, mention that any birds were killed by the storm.

One reason why the 1993 storm may have had such a severe impact on migrating birds was its timing during the day. From their arrival times and flight speeds, Gauthreaux (1971) inferred that most trans-Gulf migrants leave Central America or the Yucatan Peninsula at dusk on their northward journey. The distance across the Gulf of Mexico is such that most migrants arrive on the Gulf coast the following day during the daylight hours. Swifter species of course arrive earlier than slower fliers, but during normal weather conditions, the majority of the migrants arrived

at the Louisiana coast at about 1400 hours. On the night and morning of 7–8 Apr. 1993, if weather conditions across the Gulf had been normal until the birds almost reached Grand Isle, the peak of migration would have just been reaching the island at the time of the storm and tornado, which occurred at 1430 hours. Consequently, due to the coincidence of storm timing and the arrival of the majority of migrants, this storm may have had the maximum possible impact on the migrants. Had the storm arrived either 4 h earlier or later, it might have killed many fewer birds (cf. Gauthreaux 1971).

Almost all birds we found had washed up on the beach, as evidenced by their matted plumage and often being partially buried in the sand. Although it is possible that some birds died on land, it seems most likely that most of the birds had died nearby offshore and drifted southwest to come ashore at Elmer's Island. Drowning therefore seems the most likely cause of death, after the birds were forced into the water by the tornado and extremely strong winds that accompanied the storm. The presence of some dead Seaside Sparrows on the beach does suggest that some birds may have been blown from shore to sea. The absence of most non-migratory terrestrial birds known to be present on the island (for example, Northern Cardinal, Northern Mockingbird, Common Grackle), however, suggests that few birds that had already landed were blown back out.

The differences in relative abundances of species, sexes and age classes killed probably indicate that these groups migrate on different days, or perhaps in groups of like individuals. Such differences are widely known to ornithologists, but from the data here presented it is not possible to rule out the possibility that different groups were able to survive the storm differentially. In fact, it seems likely that not all species would be able to withstand such a storm equally, because of different flight characteristics. Different age classes or sexes also may have different abilities to survive such a storm. For example, older adults might be more experienced in avoiding storms compared to first-year birds, or one sex might have more fat reserves than the other, leaving them with more reserves to fight a strong wind near the end of their long flight. Whatever the selection mechanism, the birds killed were not a randomly selected group of individuals from the species that migrate across the Gulf of Mexico.

We also have one bit of interesting anecdotal information regarding the distribution of birds along the beaches. Early in our searches it was our impression that species were clumped. That is, if we found one Ovenbird, it was very likely that the next bird we would find would also be an Ovenbird, and we subsequently might not then find another one for a long stretch of beach. Although this just may be a misperception, the only two Chestnut-sided Warblers we found all day were within 13 m of one another; both Yellow-billed Cuckoos we found were within about 30 m, and all three Blue-winged Warblers were within 60 m. As these birds had died at sea and drifted to shore, this would suggest that the birds had to have gone into the water close together and at almost exactly the same time. This lends credence to the idea that it was the tornado that

killed many of the birds, because the tornado is a very localized phenomenon relative to the larger storm. This evidence also suggests that birds of a single species or class migrate together in very close flocks, as also proposed by Moore (1990).

Although there is now much concern about declining populations in some neotropical migrants, it seems unlikely that the Grand Isle bird kill will have much effect on overall populations of any of the species affected. A loss of any individuals of a declining species of course does not help the species' situation. Even though a few species took large losses, most of the 45 species we found lost only a few hundred individuals, not a large number compared to their overall population size. These were, however, individuals of relatively high value to the populations, because they would have been part of the 1993 breeding population and had already overwintered and (almost) survived the migration across the Gulf both ways. Just before they reached the end of their long, difficult trans-Gulf flight, the tremendous storm of 8 Apr. 1993 slammed into the flock just offshore from Grand Isle, killing many thousands of the birds.

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## APPENDIX

Number of birds counted at Grand Isle and Elmer's Island. The number of individuals is given, along with the estimated number of birds per km of beach. In instances where no members of one sex were found (for example, female Orchard Oriole and female Cerulean Warbler), we have used zeros to indicate that the group was not accidentally omitted.

Species	Grand Isle		Elmer's Is.		Total
	#	Birds/km	#	Birds/km	
Green heron <i>Butorides virescens</i>	22	13.0	2	33.1	24
Cattle Egret <i>Bubulcus ibis</i>	8	4.7	0	0	8
Tricolored Heron <i>Egretta tricolor</i>	1	0.6	0	0	1
Little Blue Heron <i>Egretta caerulea</i>	1	0.6	0	0	1
Snowy Egret <i>Egretta thula</i>	0	0	1	16.6	1
Great Egret <i>Casmerodius albus</i>	1	0.6	0	0	1
Sora <i>Porzana carolina</i>	2	1.2	0	0	2
Purple Gallinule <i>Porphyryla martinica</i>	1	0.6	0	0	1
Eastern Kingbird <i>Tyrannus tyrannus</i>	1	0.6	0	0	1
<i>Empidonax</i> spp.	7	4.1	3	49.6	10
Wood Thrush <i>Hylocichla mustelina</i>	70	41.4	15	248.2	85
Swainson's Thrush <i>Catharus ustulatus</i>	7	4.1	2	33.1	9
Gray Catbird <i>Dumetella carolinensis</i>	24	14.2	8	132.4	32
White-eyed Vireo <i>Vireo griseus</i>	12	7.1	18	297.9	30
Yellow-throated Vireo <i>Vireo flavifrons</i>	2	1.2	5	82.7	7
Red-eyed Vireo <i>Vireo olivaceus</i>	10	5.9	23	380.6	33
Prothonotary Warbler <i>Protonotaria citrea</i>	1	0.6	0	0	1
Tennessee Warbler <i>Vermivora peregrina</i>	6	3.6	4	66.2	10
Northern Parula <i>Parula americana</i>	1	0.6	1	16.6	2
Black-and-white Warbler <i>Mniotilta varia</i>					
Male	0	0	2	33.1	2
Female	0	0	2	33.1	2
Unsexed	10	5.9	0	0	10
Cerulean Warbler <i>Dendroica cerulea</i>					
Male	2	1.2	6	99.3	8
Female	0	0	0	0	

## APPENDIX. Continued

Species	Grand Isle		Elmer's Is.		Total
	#	Birds/km	#	Birds/km	
Chestnut-sided Warbler <i>Dendroica pensylvanica</i>			2	33.1	2
Black-throated Green Warbler <i>Dendroica virens</i>	1	0.6	0	0	1
Yellow-throated Warbler <i>Dendroica dominica</i>	1	0.6	0	0	1
Yellow Warbler <i>Dendroica petechia</i>					
Male	0	0	1	16.6	1
Female	0	0	0	0	
Kentucky Warbler <i>Oporornis formosus</i>	10	5.9	26	430.3	36
Hooded Warbler <i>Wilsonia citrina</i>					
Male	8	4.7	10	165.5	18
Female	3	1.8	8	132.4	11
Unsexed	2	1.2	0	0	2
Worm-eating Warbler <i>Helmitheros vermivorus</i>	24	14.2	21	347.5	45
Swainson's Warbler <i>Limnothlypis swainsonii</i>	3	1.8	2	33.1	5
Ovenbird <i>Seiurus aurocapillus</i>	24	14.2	22	364.1	46
Common Yellowthroat <i>Geothlypis trichas</i>					
Male	8	4.7	7	115.8	15
Female	2	1.2	0	0	2
American Redstart <i>Setophaga ruticilla</i>					
Male	1	0.6	1	16.6	2
Female	0	0	0	0	0
Rose-breasted Grosbeak <i>Pheucticus ludovicianus</i>					
Male	0	0	4	66.2	4
Female	1	0.6	0	0	1
Blue Grosbeak <i>Guiraca caerulea</i>					
Male	9	5.3	5	82.7	14
Female	1	0.6	0	0	1
Indigo Bunting <i>Passerina cyanea</i>					
Male	43	25.4	40	661.9	83
Female	2	1.2	0	0	2
Painted Bunting <i>Passerina ciris</i>					
Male	1	0.6	0	0	1
Female	0	0	0	0	0
Seaside Sparrow <i>Ammodramus maritimus</i>	2	1.2	1	16.6	3

## APPENDIX. Continued

Species	Grand Isle		Elmer's Is.		Total
	#	Birds/km	#	Birds/km	
Orchard Oriole					
<i>Icterus spurius</i>					
Adult male	8	4.7	4	66.2	12
1st-year male	0	0	4	66.2	4
Female					
Northern (Baltimore) Oriole					
<i>Icterus galbula</i>					
Male	2	1.2	0	0	2
Female	1	0.6	0	0	1
Scarlet Tanager					
<i>Piranga olivacea</i>					
Male	3	1.8	1	16.6	4
Female	0	0	0	0	0
Summer Tanager					
<i>Piranga rubra</i>					
Male	8	4.7	3	49.6	11
Female	1	0.6	1	16.6	2
Unidentified	23	13.6	11	182.0	34
Total	381	225.5	266	4401.8	647