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Conservation Effects Assessment Project

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Weather Surveillance Radar Reveals Bird Response to the Migratory Bird Habitat Initiative

Summary Findings

In response to the 2010 Deepwater Horizon oil spill, NRCS implemented the Migratory Bird Habitat Initiative (MBHI) to provide temporary wetland habitat for migrating and wintering waterfowl, shorebirds, and other birds along the northern Gulf of Mexico inland from oil-impacted coastal wetlands.

Weather surveillance radar was used to assess bird response to MBHI activities. Complementary field studies of seasonal bird use of southwest Louisiana MBHI sites were conducted to ground-truth the larger-scale weather radar assessment.

Birds responded positively to MBHI management by exhibiting greater densities within sites relative to prior years and relative to surrounding non-flooded agricultural lands. Bird density at MBHI sites was generally greatest during winter.

The magnitude of bird response at sites compared to prior years and concurrently with non-flooded agricultural lands was generally related to the surrounding landscape context, such as proximity to areas of high bird density and landscape composition.

Greater increases in relative bird use were detected at sites in closer proximity to areas of high bird density and emergent marsh.

Weather radar observations provide strong evidence that MBHI sites that were inland from coastal wetlands potentially impacted by the oil spill provided wetland habitat used by a variety of birds.

Background

Extensive coastal wetlands along the northern Gulf of Mexico coastline serve as habitat for a wide variety of resident and migratory waterbirds. These wetlands have been significantly degraded by human-induced landscape alterations, sea level rise associated with climate change, powerful storms, and recently by the April 2010 Deepwater Horizon oil spill off the Gulf Coast.

In response to the oil spill, the Natural Resources Conservation Service (NRCS) implemented the Migratory Bird Habitat Initiative (MBHI) to provide migrating and wintering waterfowl, shorebirds, and other birds with alternative habitats inland of coastal wetlands potentially impacted by the oil spill. Beginning in the fall of 2010, MBHI incentivized landowners to flood existing croplands and idle catfish ponds and to enhance wetland habitats on existing Wetlands Reserve Program (WRP) sites. MBHI focal areas included the Mississippi Alluvial Valley (MAV) and West Gulf Coastal Plain (WGCP) ecoregions due to their importance to migrating and wintering waterbirds and their proximity to coastal wetlands potentially impacted by the oil spill.

Program activities continued through winter and spring 2010/2011 (or longer for sites with multi-year contracts). Approximately 465,000 acres were enrolled into the MBHI within the MAV and WGCP across five states (TX, LA, AR, MO, and MS; USDA NRCS 2012). Water levels at MBHI sites were managed for shallow water and mudflats to create or enhance seasonal habitat for waterfowl, shorebirds, and other waterbirds.

Bird use of MBHI sites prior to enrollment and management is largely unknown, limiting the usefulness of traditional field survey methods for assessing program effectiveness. Remotely-sensed weather surveillance radar observations of bird activity can provide a comprehensive assessment of bird use at numerous sites and, because they are archived, provide observations of bird use of sites prior to MBHI enrollment.

The national network of weather surveillance radars (model WSR-88D, commonly referred to as NEXRAD) has been used as a tool to study bird movements in a variety of settings (O'Neal et al. 2010; Buler et al. 2012a, 2012b). NEXRAD data have been used to depict bird distributions

Northern pintails on Vermilion Parish, La. MBHI site, October 2010.

PHOTO: JOHN PITRE, NRCS

"on the ground" as birds take flight en masse at the onset of highly-synchronized broad-scale movements, such as nocturnal feeding flights of wintering waterfowl and migratory flights of landbirds (Buler and Diehl 2009, Buler and Moore 2011, Buler et al. 2012a). Along the Gulf Coast during the winter, waterfowl and other associated species regularly undertake sunrise or sunset flights in large groups between roosting sites—usually wetlands and bodies of water—and feeding habitat such as agricultural fields (Buler et al. 2012a, Randall et al. 2011).

Assessment Partnership

Scientists at the Aeroecology Program at the University of Delaware (UD) and USGS National Wetlands Research Center (NWRC) have extensive experience using NEXRAD radar data in avian ecology studies. In 2011, a partnership was formed among NRCS, UD and NWRC to conduct an assessment of seasonal bird response following MBHI implementation. This partnership involved analysis of available NEXRAD weather surveillance data applicable to MBHI sites as well as detailed field studies of sites within NEXRAD radar coverage to verify remotely-sensed bird reflectivity data and classify bird use data by season and types of birds observed.

This assessment partnership was supported by the Wildlife Component of the Conservation Effects Assessment Project (CEAP), and this conservation insight summarizes the findings produced. Additional details are available in Sieges et al. (2014) and the final University of Delaware and USGS NWRC project reports available on the CEAP website (Buler et al. 2013, Barrow et al. 2013).

Under a separate partnership with NRCS, a team of scientists led by Mississippi State University is conducting more detailed and intensive field studies to quantify waterbird food availability and waterfowl habitat carrying capacity estimates attributable to MBHI. Preliminary findings of those studies are presented by Kaminski and Davis (2014).

Assessment Approach

Study Area

The MBHI was broadly applied throughout the MAV and areas of the WGCP. However, analysis of bird use of MBHI sites using NEXRAD data is limited to landscapes within 80 km of weather radar stations. Two radar stations in the MAV and two stations in the WGCP contained sufficient archived radar data near MBHI sites for useful analysis (Fig. 1). Individual MBHI tracts near these radars that were at least 1 acre in size were included in the assessment. Only Arkansas sites were within the effective radar detection range for radars within the MAV; therefore MAV sites in Mississippi and Missouri were excluded from analysis.

Timing and intensity of water level manipulation varied somewhat among states to meet local waterbird habitat objectives. Table 1 shows the season dates used for this assessment.

Acreage of MBHI sites included in the analysis is shown in Table 2. Variability in the area analyzed is due to differences in the amount of area enrolled between seasons and differences in the effective detection range of the radar among sampling days. Overall, approximately 10 percent of the area enrolled in MBHI within Arkansas (MAV) and 15 percent of the enrolled area in Texas and Louisiana (WGCP) were included in the assessment.

Table 1. Season dates used for assessment of waterbird habitat.

Season	Dates
Fall	October 1–October 31
Winter	November 1–February 28
Spring	March 1–March 31

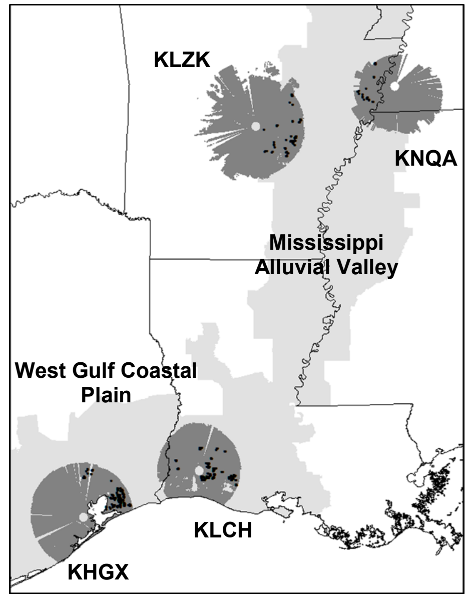

Figure 1. Locations of MBHI sites (black dots) within the effective observation areas (dark grey) of four weather surveillance radars (labeled by name). The light grey denotes counties included in the MBHI.

Weather surveillance radar data

The assessment team acquired weather radar data collected during time periods associated with migrating and wintering bird movements (August 15–May 31) for the years 2008–2011 at KLCH, KHGX, KLZK, and KNQA from the National Climatic Data Center data archive (http://www.ncdc.noaa.gov/nexradinv/). Radars measure reflectivity (Z) in the form of returned radiation, and the density of birds on the ground is positively correlated to radar reflectivity at the onset of flight exodus (Buler and Diehl 2009, Buler et al. 2012a). Radar data from nights with no discernible contamination

Table 2. Total area (acres) of managed MBHI sites within the radar detection range included in the assessment.

Season	Region		
	WGCP		MAV
	LA	TX	AR
Fall	15,925	19,105	6,303
Winter	15,078	14,922	6,224
Spring	1,294	15,814	—

from precipitation or other clutter were used to produce sample polygons representing bird activity for overlaying onto land cover maps within a Geographic Information System (GIS). Adjustments were made to account for sun angle and how birds are sampled in the airspace as the radar beam spreads with range to optimize how radar data represent bird activity in the vicinity of MBHI sites (Buler et al. 2013).

Ground-truthing NEXRAD bird detection

To ensure NEXRAD radar data reliably represented birds aloft, the USGS assessment team used weather surveillance and portable marine radar data, thermal infrared images, and visual observations of bird use of select MBHI sites in southwest Louisiana. By examining seasonal bird use of MBHI fields in fall, winter, and spring of 2011-2012, these field studies enabled the assessment team to associate NEXRAD radar echoes to bird species or species group.

To assess diurnal use, the field team conducted total area surveys of MBHI sites in the afternoon, collecting data on bird species composition, abundance, behavior, and habitat use. Evening bird use and flight behavior (i.e., birds landing in, departing from, circling, or flying over MBHI sites) was also documented. This field sampling captured the onset of evening flights and spanned the period of collection of the weather radar data analyzed. Pre- and post-dusk surveys were conducted using a portable radar system and a thermal infrared camera.

Soil wetness data

The assessment team used remotely-sensed Landsat Thematic Mapper (TM) data to quantify the extent of flooding during the MBHI management year (2010-2011) and two previous years via a soil wetness index (Crist 1985, Huang et al. 2002). Increasing values indicate increasing soil wetness. Index values greater than -0.05 indicate open surface water (flooded soil) based on visual inspection of imagery (Fig. 2). This threshold was used to determine the extent of flooding within MBHI areas.

Change in soil wetness from baseline years (2008-2009 and 2009-2010) to the management year (2010-2011) in fall and winter was also determined. During the spring of 2011, all TM images in the KHGX and KLCH radar ranges were obscured by clouds, preventing comparisons of site soil wetness during spring management to the baseline years.

Landscape composition data

Percent cover of agricultural land, emergent marsh, permanent open water, and forested wetlands surrounding individual radar sample polygons was determined at multiple scales using the 2006 National Land Cover Dataset (http://www.mrlc.gov/). Percent of surrounding agricultural land that was flooded versus non-flooded was also determined using the soil wetness index derived from TM imagery. Correlations between bird response at a sample of MBHI sites and each surrounding land cover type at various scales (0.3 to 2.8 miles) were assessed to look for patterns between bird response and surrounding land use.

Areas of high bird density during baseline years were defined as polygons having a seasonal mean reflectivity above the 90th percentile. This effectively identified areas with the highest bird density that occurred within each radar-observed area. Some of the identified areas were lo-

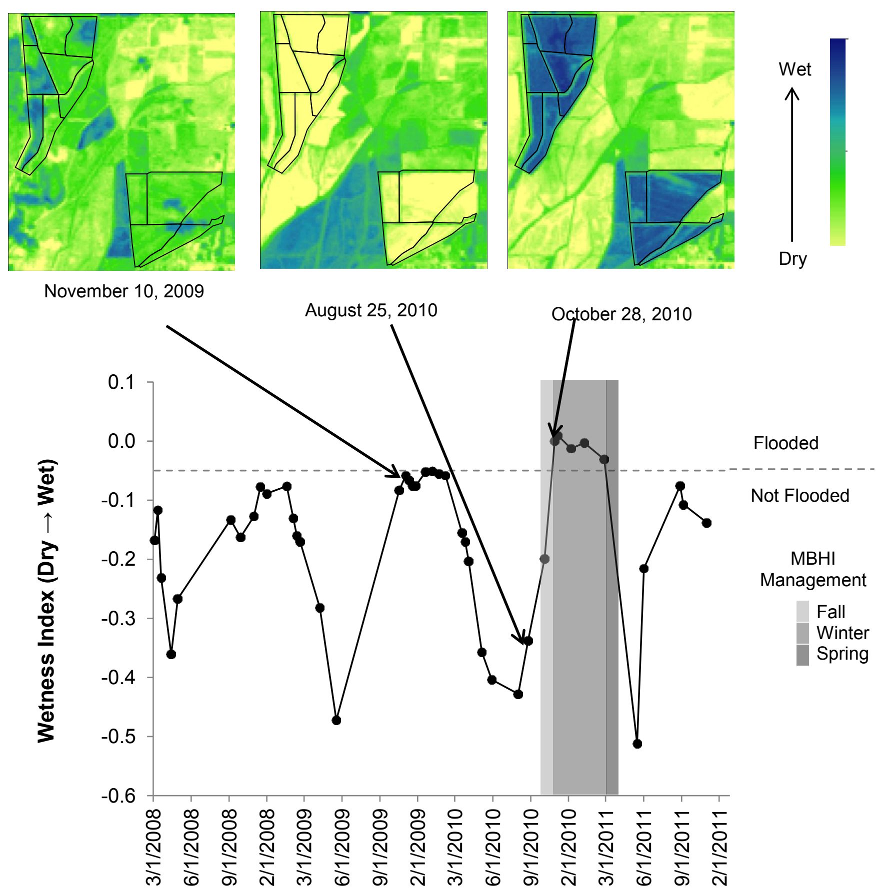

Figure 2. Mean soil wetness index values for several MBHI sites (black outlines) derived from TM data. Three TM images show temporal variation in soil wetness. Sites are completely flooded in the October 2010 image in accordance with MBHI management. Corresponding mean wetness index values are plotted for the entire study period illustrating the fall-winter-spring flooding regime. Shaded bars distinguish the periods of active management.

cations where birds are historically known to concentrate, such as wintering waterfowl at Lacassine National Wildlife Refuge (NWR) and Cameron Prairie NWR, in Louisiana.

Data analyses
To control for potential confounding year effects due to annual fluctuations in overall bird populations, reflectivity values during a given year were divided by the area-weighted mean reflectivity of all radar sample polygons dominated (>75% of area) by non-flooded agricultural lands during that same year for each radar and season combination. Thus, reflectivity was standardized to be the ratio of observed reflectivity relative to concurrent reflectivity at unmanaged fields and serve as an indicator of bird response to MBHI management. A value greater than one indicates that bird density was greater than concurrent bird density at unflooded agricultural fields. Standardized reflectivity was used as the response variable for modeling bird use of MBHI areas within the management year.

Bird response to MBHI activities was also assessed by comparing standardized bird density in the two years prior to management to bird density during the active management year (2010-2011). The proportion of MBHI areas that showed increases in mean wetness, mean reflectivity during the management year, and mean reflectivity relative to prior years was calculated to understand how management practices influenced the assessed area.

Findings

Bird response
Relative bird density at MBHI sites, as depicted by daily mean radar reflectivity, varied considerably among radars throughout the management periods, with the KLZK and KLCH radars showing much higher reflectivity overall (Fig. 3). For all radars, reflectivity peaked during winter management, although the timing differed among radars: KHGX showed an early winter peak, KLZK and KNQA a mid-winter peak, and KLCH a late winter peak.

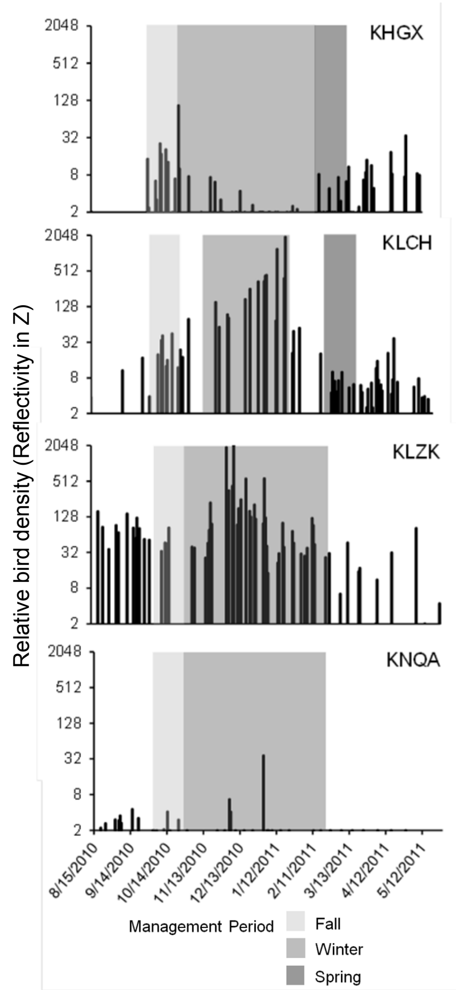

Figure 3. Daily mean relative bird density during the management year at MBHI sites for each radar. Shaded bars distinguish the periods of active management.

Overall, bird density at MBHI sites during the management year for nearly all seasons and radars was greater relative to prior years and relative to non-flooded agriculture (NFA) (Table 3). This is indicated by the mean standardized reflectivity and the ratio of reflectivity relative to prior years or NFA having values greater than one. The majority of MBHI sites exhibited greater bird use relative to NFA within the management year and relative to prior years for fall and winter, but not during spring. Exceptions for a majority increase in bird use relative to NFA in the management year by radar included KNQA during the fall and KLCH and KHGX in the spring. Additionally, a majority of the area around KHGX during the spring did not increase in bird use relative to prior years.

The greatest increases in the amount and extent of reflectivity (bird use) relative to prior years occurred during winter in Louisiana (KLCH) and easternmost Arkansas (KNQA) sites and during fall in Texas (KHGX) and western Arkansas (KLZK) sites

Table 3. Means for measures of soil wetness and relative bird density (i.e., standard reflectivity) during the year of active management and compared to prior years without management. Sample size is the number of sample MBHI polygons assessed.

	West Gulf Coastal Plain		Mississippi Alluvial Valley	
	KLCH	KHGX	KLZK	KNQA
Variables	Mean	Mean	Mean	Mean
Fall	*n = 2743*	*n =1616*	*n =534*	*n =171*
Soil wetness index during management year	-0.14	-0.13	-0.22	-0.19
Change in soil wetness index from prior years	-0.02	-0.01	-0.09	-0.08
Reflectivity relative to non-flooded agriculture	2.33	2.60	2.66	0.91
Reflectivity relative to prior years	2.7	9.44	7.82	1.21
Winter	*n = 2921*	*n =1531*	*n =534*	*n =148*
Soil wetness index during management year	-0.09	-0.07	-0.13	-0.05
Change in soil wetness index from prior years	0.00	0.01	-0.03	0.03
Reflectivity relative to non-flooded agriculture	1703.38	5.06	29.86	1.93
Reflectivity relative to prior years	10.27	5.71	1.64	2.80
Spring	*n = 206*	*n =1603*	—	—
Reflectivity relative to non-flooded agriculture	2.45	0.24	n/a	n/a
Reflectivity relative to prior years	2.21	1.97	n/a	n/a

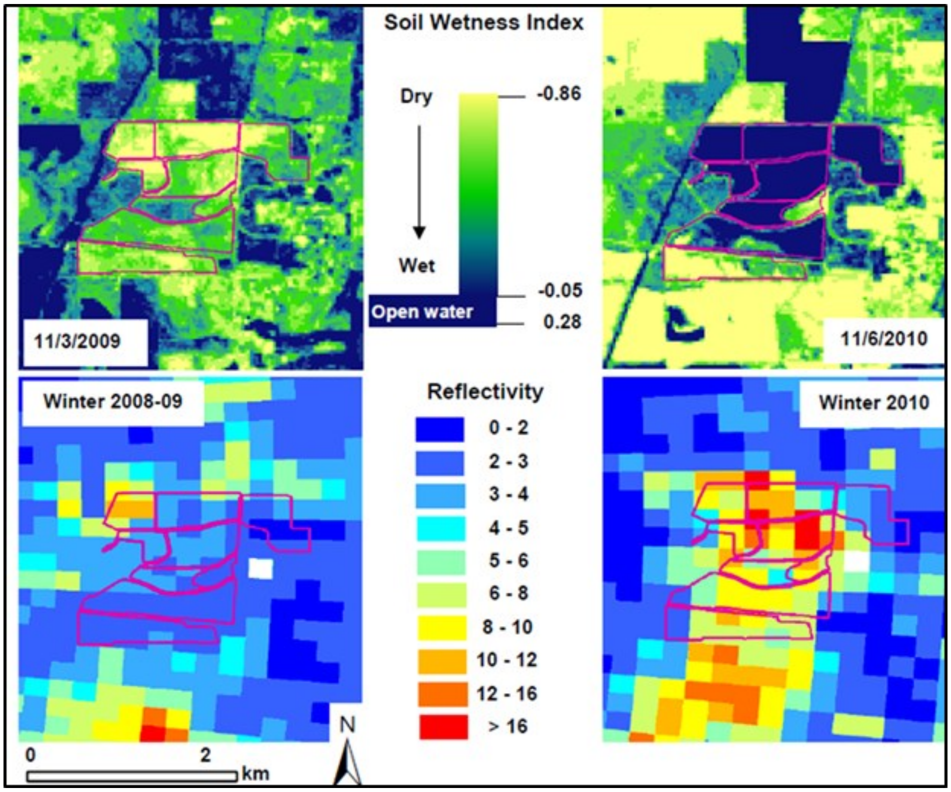

Figure 4. Images of remotely-sensed soil wetness and radar reflectivity data at a representative complex of MBHI sites (outlined). As depicted by TM imagery from single dates, MBHI sites are mostly flooded by surface water during the management year (top right panel) and relatively dry during a prior year (top left panel). Mean standardized radar reflectivity at the onset of evening flight (i.e., relative bird density) is greater within and around MBHI sites during the winter of the management year (bottom right panel) than during the previous two winters (bottom left panel).

(Table 3). The greatest use by birds of MBHI managed sites relative to NFA occurred during winter at all radars. The greatest responses to MBHI management both within and between years, across all radars and seasons, occurred at Louisiana sites during the winter. Here, over 90 percent of MBHI area had increased bird use relative to previous years and NFA such that the average bird density was over 10 times that from previous years and over 1,700 times that of NFA. An example of MBHI sites illustrating strong bird response during the management year relative to prior years is depicted in Fig. 4.

Different groups of birds migrate through the area at different times of the year, with landbirds and shorebirds passing through first in spring and fall followed by waterfowl that often stay through the winter. Fall management for this assessment occurred during the month of October, when the majority of shorebirds had already passed through the region and before the arrival of most migratory waterfowl. Thus, NEXRAD detected bird density at MBHI sites was considered lower during the fall. However, field surveys of MBHI sites in south Louisiana (near KLCH) detected shorebirds and other bird taxa using MBHI sites during all seasons (Fig 5).

The combined approach of using direct visual counts, portable marine radar data, and a thermal imaging camera for ground-truthing NEXRAD data was valuable for classifying and quantifying migrating and wintering bird use of MBHI sites in southwest Louisiana. Results of direct observations indicate that MBHI fields provided diurnal foraging habitat for shorebirds during fall migration and for multiple taxa in winter and spring. MBHI fields were also used as diurnal resting sites in fall, winter, and spring by ducks, geese, wading birds, and landbirds.

Soil wetness

Mean soil wetness index during the management year nearly always indicated non-flooded soil conditions on average (values < -0.05) at sites during fall and winter. However, there were usually areas that were flooded within MBHI site boundaries even if the entire site was not flooded (Fig 4). The change in mean soil wetness index from prior years in the fall was negative, indicating dryer soil in the management year. However, it was slightly positive for the KHGX and KNQA radars in winter. Soil wetness was greatest during winter, though only slightly more than half of the MBHI area was considered flooded with surface water in the WGCP. During winter in the MAV, nearly all of the MBHI area was flooded at KNQA, but less than a quarter was flooded at KLZK. The lower soil wetness during fall is consistent with fall moist soil management for shorebirds, and the higher soil wetness in winter is consistent with open water management for wintering waterfowl.

Bird density increased at MBHI sites despite detection of little or no increases in soil wetness. The remotely-sensed data used to calculate soil wetness indices may not have been robust enough to detect season-long surface water conditions. Few usable TM images were available for each radar and season with which to calculate the index. Additionally, the assessment team had no information about the extent of flooding within individual properties. Thus, a landowner's contract may require flooding on only a portion of a property, whereas this analysis may have included the whole property boundary. Moreover, drought conditions, restricted water supplies, or other circumstances may have prevented landowners from complying fully with their contracts. Arkansas was under drought conditions in 2010. Thus, these conditions complicated quantification of changes in site wetness (i.e.,

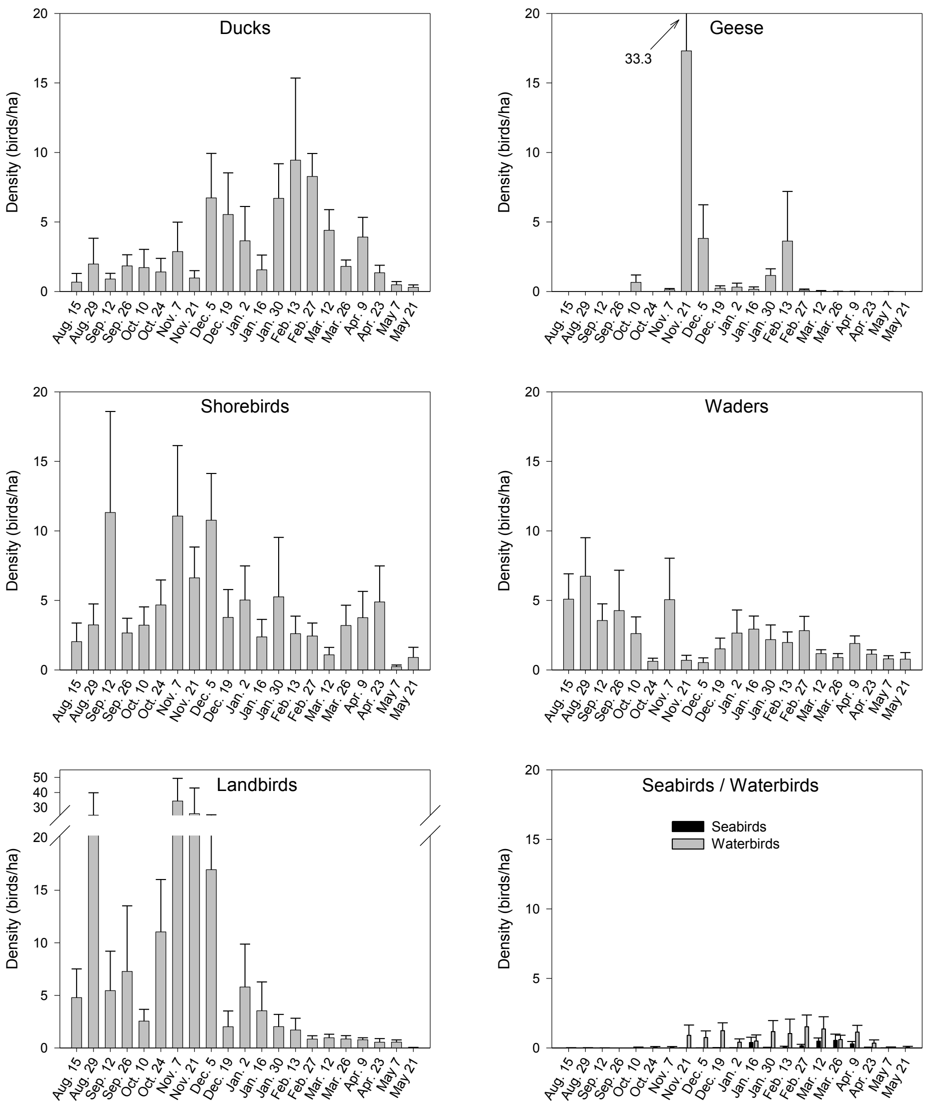

Figure 5. Biweekly bird use of MBHI fields (# of birds/ha) detected via ground-truthing surveys by taxa: ducks, geese, shorebirds, wading birds, landbirds, seabirds, and waterbirds.

flooding) during the management year. Management activities associated with the MBHI may have provided stopover habitat for migrating shorebirds, even where surface water was lacking. Landowners may have been unable to maintain winter flooding at such a depth that would benefit waterfowl, but any water on the fields likely benefited shorebirds because they are known to identify and use moist soils within days of being saturated.

Landscape attributes

The assessment team evaluated various landscape variables that may help explain observed bird response during the management year. Notable relationships detected include:

- At both WGCP radars in fall and all radars in winter, the most important variable in explaining standardized bird density within the management year was proximity to areas of high bird density, such that bird density increased in closer proximity to high bird density areas.
- Within the WGCP, bird density was positively related to greater amounts of emergent marsh in the surrounding area.
- In the WGCP, MBHI areas with more non-flooded agriculture in the landscape had greater bird density.
- In the MAV, bird densities at MBHI sites were positively associated with forested wetlands in the surrounding area. Field surveys revealed this relationship was likely due to large numbers of spring and fall migrating landbirds typically associated with forested habitats.

Proximity to bird concentrations

Within the WGCP during fall and winter, the only variable that exhibited a consistent relationship with bird density among the two radars was proximity to high bird density area. Established areas of high waterbird densities along with the tendency of waterbirds to form traditional large roosting flocks are two likely reasons for greater increases observed at sites close to high bird density areas. Within Louisiana, radar observations indicate birds are concentrated in marsh and agricultural areas within and around Lacassine and Cameron Prairie National Wildlife Refuges and the White Lake Wetlands Conservation Area. These areas are well-known roosting areas for wintering waterfowl (Link et al. 2011). These findings support the idea that birds use certain areas consistently during the winter and that these areas may be important predictors of waterbird activity.

Importance of surrounding wetlands

Regional habitat differences associated with emergent marsh influenced observed bird response. The importance of emergent marsh in predicting bird densities was apparent in the winter with the finding that increased bird densities at MBHI sites in the WGCP region were related to higher amounts of emergent marsh in the surrounding landscape. Emergent marshes are often part of large and diverse wetland complexes that support a diversity of birds (Brown and Dinsmore 1986). Wetland complexes in various stages of succession have proven to be the most beneficial to waterbirds (Fredrickson and Reid

1986, Kaminski et al. 2006, Van der Valk 2000, Webb et al. 2010, Pearse et al. 2012).

MAV and forested wetlands

Field surveys conducted around sunset (i.e., close to when NEXRAD sampled the airspace over MBHI sites) revealed a mix of landbirds, shorebirds, and early waterfowl engaging in evening migratory flights during October. This mix of evening flight activity from different bird groups may in part explain why less variability in fall bird density was explained by modeling in both the MAV and WGCP regions compared to the winter.

Since migrating landbirds contributed to the reflectivity detected in the MAV in the fall, bird densities at MBHI sites were positively associated with forested wetlands. Areas with more forested wetlands in the surrounding area had higher bird densities during the management year, likely indicating contamination of the airspace over areas by landbirds initiating migration from adjacent forested habitats, which are known to harbor high densities of migrating landbirds (Buler and Moore 2011). Additionally, some waterfowl such as green-winged teal, mallards and hooded mergansers use forested wetlands in the MAV throughout the spring and fall (Heitmeyer 1985). Soil wetness data also indicate that many sites in the MAV were not actually flooded in October and that drier sites were weakly associated with a greater increase in bird density in the management year relative to prior years. During fall management in the MAV, sites were drier than those in the Gulf and observed bird densities may reflect shorebirds using drier mudflat sites or, again, landbirds (blackbirds en route to their roosts or neotropical migrants departing the nearby forested wetlands) utilizing the landscape adjacent to the sites.

Influence of prior land use

The attractiveness of MBHI sites to waterfowl may have varied based on the land use prior to flooding.

Some fields were pastures (15% in the MAV, 20% in the WCGP) during the management year and may not have provided much forage in the form of wetland plant seed during the first year of the program. Rice seed persists longer in wetlands than other seeds associated with crop harvest waste, thereby potentially increasing available forage for waterbirds compared to other flooded crops (Nelms and Twedt 1996, Stafford et al. 2006).

However, only 20% of the MBHI sites in the MAV in this study were rice fields compared to 40% in the WGCP, which may account for greater positive changes in reflectivity values in the WCGP. Although waterfowl will feed on non-flooded waste grain, flooding rice fields increases habitat for waterfowl and other waterbirds (Elphick and Oring 1998).

Because portions of the MAV and WGCP have been farmed for rice over the past 150 years (Hobaugh et al. 1989), waterbirds may be dependent on flooded agricultural fields for wintering habitat, in which case the MBHI provided valuable areas that landowners may not have flooded in a drought year.

Conclusion

In the wake of a major environmental disaster, the MBHI provided waterbirds with temporary wetland habitats by flooding agricultural fields within the MAV and WGCP regions. Increases in bird densities were detected on the majority of MBHI sites during migration and wintering periods for waterfowl and shorebirds. The greatest relative responses by birds to MBHI sites occurred in the WGCP during the winter management period at sites closer to areas of high bird density and with more emergent marsh in the surrounding landscape.

Bird use of managed lands may be maximized if future enrollments are clustered into wetland mosaics that more closely resemble natural wetland complexes (Brown and Dinsmore 1986, Pearce et al. 2012). With predicted changing climactic conditions, providing habitat for migratory birds in the MAV and WGCP will continue to be important for all stakeholders, particularly with the knowledge that migration is a limiting factor for shorebirds and waterfowl (Alisauskas and Ankney 1992, Morrison et al. 2007).

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The Conservation Effects Assessment Project: Translating Science into Practice

The Conservation Effects Assessment Project (CEAP) is a multi-agency effort to build the science base for conservation. Project findings will help to guide USDA conservation policy and program development and help farmers and ranchers make informed conservation choices.

One of CEAP's objectives is to quantify the environmental benefits of conservation practices for reporting at the national and regional levels. Because fish and wildlife are affected by conservation actions taken on a variety of landscapes, the wildlife national assessment draws on and complements the national assessments for cropland, wetlands, and grazing lands. The wildlife national assessment works through numerous partnerships to support relevant studies and focuses on regional scientific priorities.

This assessment was conducted through a partnership among NRCS, the University of Delaware (UD) Aeroecology Program, and the USGS National Wetlands Research Center. Primary investigators on this project were Jeffery Buler and Mason Sieges (UD) and Wylie Barrow, Mike Baldwin and Lori Randall (USGS).

For more information: www.nrcs.usda.gov/technical/NRI/ceap/, or contact Charlie Rewa at charles.rewa@wdc.usda.gov.

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