Use of Habitats by Female Mallards Wintering in Southwestern Louisiana

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Abstract.—Habitat use by wintering Mallards (Anas platyrhynchos) on the Gulf Coast Chenier Plain (GCCP) has received little study and quantitative data is needed for management of GCCP waterfowl. Radio-telemetry techniques were used to record habitats used by 135 female Mallards during winters 2004-2005 and 2005-2006 in southwestern Louisiana. Habitat use was quantitatively estimated for areas open and closed to hunting, by general habitat types (i.e., marsh, rice, idle, pasture, or other), and for specific marsh types (i.e., freshwater, intermediate, brackish, or salt). Variation in these estimates was subsequently examined in relation to individual female, female age (adult or immature), winter (2004-2005 or 2005-2006), and hunt periods within winter (second hunting season [SHUNT] or post hunting season [POST]). Diurnal use of areas closed to hunting was greater during hunted time periods in winter 2005-2006 than in winter 2004-2005. Nocturnal use of areas closed to hunting was 3.1 times greater during SHUNT than during POST, and immatures used areas closed to hunting more than adults. Diurnal use of marsh was 3.3 times greater than that of any other habitat during both winters. Nocturnal use of marsh, rice, idle, and pasture were similar during both winters. Females used freshwater marsh habitats extensively (64.6-99.8% proportional use), whereas brackish and salt marsh combined was used less frequently (0-35.8% proportional use). These results suggest that freshwater marsh is important to Mallards and a high priority for restoration and management efforts. Received 16 April 2011, accepted 22 July 2011.

Key words.—Anas platyrhynchos, freshwater marsh, Gulf Coast, habitat use, hunting, Louisiana, Mallards, radio-marked, winter.

One quarter of the North American dabbling duck population (Palmisano 1973) and two-thirds of the Mississippi Flyway waterfowl population historically wintered in coastal Louisiana (Bellrose 1989). However, Louisiana coastal marshes are disappearing by as much as 100 km2/yr (Gagliano et al. 1981). Threats to coastal marshes include saltwater intrusion from channel dredging (Fruge 1982), hurricanes, subsidence, sea level rise, and loss of sediment and freshwater inputs from levee construction (Chabreck et al. 1989). Current wetland conservation efforts seek to reduce loss, restore, enhance, and create new marsh habitats within the region (Esslinger and Wilson 2001). In addition to coastal wetlands, agricultural lands (e.g., rice, idle fields, pasture) also provide habitat for wintering waterfowl in southwestern Louisiana (Esslinger and Wilson 2001).

Current habitat objectives for the Gulf Coast Chenier Plain (GCCP) largely are based on diurnal observations of waterfowl (Wilson 2003). Aerial surveys often are used to estimate waterfowl populations and habitat use (Palmisano 1973; Reinecke et al. 1992). However, aerial surveys alone provide biased estimates of numbers of birds using habitats with low visibility rates (Smith et al. 1995) and cannot provide information about nocturnally used habitats. The importance of certain diurnally used habitats may be over-emphasized without information concerning nocturnal habitat use. Other than Northern Pintail (Anas acuta, hereafter Pintail), use of habitats by dabbling ducks has received little study in the GCCP (Cox and Afton 1997).

Proportional use of habitats may be related to factors such as bird age, habitat conditions, and hunting pressure or disturbance (i.e., agricultural activities, bird-watching, etc.). Davis et al. (2009) reported that Mallard nocturnal use of areas closed to hunting varied among female ages and time periods and among female ages and winters. Tamisier (1976) concluded that Green-winged Teal (Anas crecca) and Pintails gathered in large flocks on non-hunted areas as "more
of a fundamental requirement” of wintering ducks rather than a response to hunting pressure or disturbance. However, radio-marked Pintails in California (Fleskes 2002), southwestern Louisiana (Cox and Afton 1997), and Mexico (Migoya et al. 1994) shifted from hunted to non-hunted areas in response to hunting pressure. Accordingly, we hypothesized that habitat use by Mallards in south Louisiana would vary in relation to female ages, hunting season, and habitat conditions.

Quantitative information on habitat use of Mallards in this region is needed for refining habitat objectives of the GCCP, to guide refuge management decision making, and to help conservation planners prioritize areas for acquisition, protection, and management of habitats for wintering waterfowl. Accordingly, we initiated a study to examine proportional use of areas closed and open to hunting, and to quantify habitats used by female Mallards wintering in the GCCP. We radio-marked only females because males outnumber females and hence do not limit production (Johnson and Sargeant 1977; Johnson et al. 1987). Specifically, we quantitatively estimated daily habitat use of females in relation to areas open and closed to hunting, general use of habitats and specific marsh types, and examined variation in proportional use in relation to individual birds, female age, winter, and hunt periods within winter.

**Methods**

**Study Area**

Our study area was located within the GCCP in southwestern Louisiana (Fig. 1) and included all lands within Cameron, Calcasieu, Jefferson Davis, Acadia, and Vermillion Parishes. The Chenier Plain of southwestern Louisiana spans 60 to 110 km inland from the Gulf of Mexico and encompasses more than 2.5 million ha (Chabreck et al. 1989). The two primary waterfowl habitats of the region are coastal marshes and rice agriculture, which is located immediately inland from coastal marshes (Chabreck et al. 1989). We assumed that our study area was representative of the GCCP. We captured and radio-marked female Mallards within 80 km of three capture sites: 1) Cameron Prairie National Wildlife Refuge (29°56’N, 93°02’W), 2) Amoco Pool (29°50’N, 92°34’W), and 3) Lacassine National Wildlife Refuge (29°57’N, 92°55’W). The GCCP and Amoco Pool are described in detail by Chabreck et al. (1989).
Greenwood 1993). Alligator clips were used while adjusting harness tension. We tied double overhand knots on the final harness tension, and used purple primer and all-purpose cement (Oatey®, Cleveland, OH) on attachment points. We released radio-marked females in groups at capture sites 4–14 h after capture (overnight for birds captured at dusk).

Radio-marked females were tracked using four vehicles equipped with four-element, null-peak antenna systems, GPS units (GPS 76, Garmin© Corporation, Olafte, KS), and laptop computers (Cochran 1980:517–518; Cox and Afton 1997, 1998; Cox et al. 2002). Vehicle tracking systems were equipped with electronic compasses (Azimuth® 1000R, KVH Industries, Inc., Middletown, RI) and empirically calibrated to within 0.5 degrees. We used LOAS (Location of a Signal) software to estimate locations on site (LOAS 2003) and used the Universal Transverse Mercator coordinate system for all location estimations. Prior to radio-tracking Mallards, we trained technicians with beacon transmitters placed at locations unknown to them, until each was able to maintain a bearing standard deviation of < 3 degrees. To facilitate tracking near Amoco Pool, an area inaccessible by truck, two, 13-m permanent towers were constructed; each tower supported a single nine-element unidirectional antenna. The towers rotated on a center mast and had a compass rose and pointer to facilitate reading the azimuth to peak record peak signals. Towers were empirically calibrated using beacon transmitters.

We collected a minimum of three azimuths for each female or until error ellipses were restricted to one habitat or marsh type. Aerial telemetry techniques were employed (11% of all locations) when birds could not be located by vehicles or towers (Gilmer et al. 1981). Flights were conducted at altitudes (Range = 300 m to 3000 m) such that all radio-marked birds present on the study area could be located. Also, we monitored for female Mallards that were radio-marked in northeast Louisiana (Davis et al. 2009), and included them in our habitat use analysis immediately upon detection (n = 1 during winter 2004-2005, n = 5 during winter 2005-2006).

All birds present on the core study area were located daily or as often as permitted by weather and pilot availability. We defined diurnal and nocturnal locations as those collected 0.5 hour before sunrise to 0.5 hour after sunset and 0.5 hour after sunset to 0.5 hour before sunrise, respectively. Diurnal and nocturnal habitat use by radio-marked females was quantified separately in relation to individual birds, female age, winter (2004-2005 and 2005-2006), and hunt periods within winter. We tested for effect of individual birds to examine the null hypothesis that the random factor that influences a measurement in a subject has no effect on a subsequent measurement in the same subject. In 2004-2005 (hereafter Winter 1), we classified two hunt periods based on hunting season: (1) second hunting season ([SHUNT]; 24 Dec 2004-23 Jan 2005) and (2) post hunting season ([POST]; post-24 Jan 2005). In 2005-2006 (hereafter Winter 2), we classified 4 hunt periods based on hunting season: (1) first hunting season ([FHUNT]; 12 Nov 2005-4 Dec 2005), (2) time between hunt periods ([SPLIT]; 5 Dec 2005-16 Dec 2005), (3) SHUNT (17 Dec 2005-22 Jan 2006), and (4) POST (post-23 Jan 2006). For analysis, comparisons between winters were limited to SHUNT and POST because birds could not be captured during FHUNT or SPLIT in Winter 1 due to later arrival of Mallards on capture sites (Link 2007).

Each location was classified as either CLOSED or OPEN to hunting. CLOSED included Amoco Pool and non-hunted portions of Cameron Prairie National Wildlife Refuge (NWR) and Lacassine NWR (Fig. 1). OPEN areas included all privately owned lands and hunted portions of Cameron Prairie NWR (units 11A, 14A, and 14B) and Lacassine NWR (units B, H, I, J, F1, F2, and F3) in Winter 1. Cameron Prairie NWR and Lacassine NWR were closed entirely to hunting in Winter 2 because of hurricane impacts.

When possible, habitats used by radio-marked birds were identified on site; otherwise this information was obtained using ground surveys, aerial photography, satellite imagery, Farm Service Agency (FSA) records, or mail out questionnaires to landowners. Habitats were classified as: (1) MARSH, (2) tillable lands planted in rice (RICE), (3) IDLE (including: 1] moist soil, e.g. agricultural land in which water was intentionally retained, either by pumping or runoff and 2] idle cropland, e.g. fallow agricultural land not planted to a commodity crop and not flooded); (4) tillable lands planted to native or tame grasses and maintained dry (PASTURE); and (5) OTHER (forested wetlands, soybeans, and sugarcane). We further classified MARSH locations into FRESH, INTERMEDIATE, BRACKISH, or SALT (Chabreck and Linscombe 2001).

Statistical Analysis

We excluded locations from the first four days post-capture for all females to minimize effects of capture and handling on habitat use (Cox et al. 1998). Based on previous studies (Cox and Afton 1997; Davis et al. 2009), we expected habitat use to differ by time of day; thus, separate models were fitted for diurnal and nocturnal locations in each of the following analyses: (1) use of closed and open lands, (2) use of general habitats, and (3) use of specific marsh types.

Use of CLOSED and OPEN lands.—Proportional use of OPEN and CLOSED lands was compared for each bird within the study area during each hunt period (SHUNT and POST) for diurnal and nocturnal locations separately. We calculated log-ratios by dividing the proportional use of CLOSED by the proportional use of OPEN, and then taking the napierian logarithm (Aebischer et al. 1993a) to normalize the data and remove the unit sum constraint (Aitchison 1986). Zero values were replaced with 0.002 (an order of magnitude smaller than the lowest non-zero habitat recorded for any bird in any hunt period [Aebischer et al. 1993b]).

We then used the transformed proportional use of OPEN and CLOSED data in split-plot ANOVAs (PROC GLM, SAS Institute 2007) to test for differences in use
among the following explanatory variables: individual female, female age (adult or immature), winter (Winter 1 or Winter 2), and hunt period within winter (SHUNT or POST). Variation due to individual females was used as the error term to test for effect of female age, winter, and their interaction, and residual error to test for effect of individual female, hunt period, and all other interactions. We began with full models (including all possible interactions) and used backward, step-wise procedures to eliminate non-significant (P > 0.05) terms, beginning with highest order interactions (Cox and Afton 1997). Once final models were determined, relative use of OPEN and CLOSED was compared among explanatory variables using Fisher’s LSD (SAS Institute 2007) as described by Cox and Afton (1997).

Use of general habitats.—We compared proportional use of various habitats for diurnal and nocturnal locations separately. Proportional habitat use of the five general habitat types (MARSH, RICE, IDLE, PASTURE, and OTHER) were calculated for each female in each hunt period (SHUNT and POST), and we constructed 4 log-ratios by dividing the proportional use of each habitat by proportional use of IDLE, then taking the napierian logarithm. Zero values were replaced with 0.007 (an order of magnitude smaller than the lowest non-zero habitat recorded for any bird in any hunt period [Aebischer et al. 1993b]). We then used the transformed proportional habitat use data in split-plot MANOVAs (PROC GLM, SAS Institute 2007) to test for differences in use of habitat types among individual females, female ages, winters, and hunt periods within winter. Variation due to individual females was used as the error term to test for effects of female age, winter, and their interaction, and residual error to test for effects of individual females, hunt period, and all other interactions. We began with full models (including all possible interactions) and used backward, step-wise procedures to eliminate non-significant (P > 0.05) terms, beginning with highest order interactions. Once final models were determined, we compared use of marsh types relative to INTERMEDIATE by testing whether least-square means of log-ratios differed (P < 0.05) from zero (Aebischer et al. 1993a), as described by Cox and Afton (1997).

RESULTS

We captured and radio-marked 63 (23 and 40 at Amoco Pool and Cameron Prairie National Wildlife Refuge, respectively) female Mallards during winter 2004-2005 and 64 (28 and 36 at Cameron Prairie National Wildlife Refuge and Lacassine National Wildlife Refuge, respectively) female Mallards during winter 2005-2006.

Use of CLOSED and OPEN Lands

Diurnal.—The analysis of diurnal use of areas OPEN or CLOSED to hunting included 6,067 diurnal locations on 133 females (n = 80 adults, n = 53 immatures). Our final fitted model contained individual female (F = 2.36; 131, 102 df; P < 0.0001), winter (F = 14.34; 1, 102 df; P = 0.0003), and hunt periods (F = 71.24; 1, 102 df; P < 0.0001). All other explanatory variables and interactions were not significant (Ps > 0.08). Use of CLOSED lands was greater (P = 0.0003) during Winter 2 (\(\bar{x} = 36.2\% \pm 2.9 \pm SE\)) than during Winter 1 (\(\bar{x} = 26.8\% \pm 2.9 \pm SE\)). Use of CLOSED was greater (P < 0.0001) during SHUNT (\(\bar{x} = 44.4\% \pm 2.8 \pm SE\)) than during POST (\(\bar{x} = 15.1\% \pm 2.3 \pm SE\)).

Nocturnal.—Our analysis of nocturnal use of areas OPEN or CLOSED to hunting included 2,358 nocturnal locations on 130 females (n = 78 adults, n = 52 immatures). The final fitted model contained individual female (F = 2.62; 124, 98 df; P < 0.0001), hunt periods (F = 12.94; 1, 98 df; P = 0.0005), and age (F = 12.38; 1, 98 df; P = 0.0007) as significant explanatory
variables. All other explanatory variables and interactions were not significant (Ps > 0.09). Use of CLOSED lands was greater (P = 0.0005) during SHUNT (\(\bar{x} = 20.9\% \pm 2.9 [\pm SE]\)) than during POST (\(\bar{x} = 6.8\% \pm 1.9 [\pm SE]\); Table 1). Immatures (\(\bar{x} = 20.6\% \pm 3.6 [\pm SE]\)) used CLOSED lands more than adults (\(\bar{x} = 11.1\% \pm 2.0 [\pm SE]\), P < 0.0006).

Use of General Habitats

**Diurnal.**—Our analysis of diurnal use of habitats included 6,067 diurnal locations on 133 females (n = 80 adults, n = 53 immatures). The final fitted model contained individual female (F = 2.09; 395, 524 df; P < 0.0001), winter (F = 5.4; 4, 98 df; P = 0.0006), and hunt period (F = 9.36; 4, 98 df; P < 0.0001) as significant explanatory variables. All other explanatory variables and interactions were not significant (Ps > 0.19). Use of RICE (P = 0.003), MARSH (P = 0.006), and PASTURE (P = 0.01) relative to IDLE was greater during Winter 1 than during Winter 2 (Table 2). Use of MARSH relative to IDLE was greater (P = 0.007) during SHUNT than during POST, whereas use of RICE relative to IDLE was greater (P = 0.02) during POST than during SHUNT (Fig. 2).

**Nocturnal.**—We analyzed 2,358 nocturnal locations on 130 females (n = 78 adults, n = 52 immatures). Our final fitted model contained individual female (F = 1.98; 367, 504 df; P < 0.0001), female age, (F = 2.78; 4, 123 df; P = 0.03), hunt period (F = 3.7; 4, 91 df; P = 0.008), and an age-by-winter interaction (F = 4.41; 4, 91 df; P = 0.003) as significant explanatory variables. All other interactions were not significant (Ps > 0.19). Use of RICE relative to IDLE was greater (P < 0.0001) relative to IDLE more so than immatures, whereas immatures used MARSH (P < 0.03) relative to IDLE more so than adults. Use of MARSH relative to IDLE was greater (P = 0.05) during SHUNT than during POST, whereas use of RICE, PASTURE, and OTHER relative to IDLE did not differ between hunt periods (Ps > 0.1, Fig. 3). Adults used MARSH (P < 0.03) and RICE (P < 0.0001) relative to IDLE more in Winter 1 than in Winter 2 (Table 3).

Use of Specific Marsh Types

**Diurnal.**—Our analysis of diurnal use of marsh included 3,005 diurnal locations on 133 females (n = 80 adults, n = 53 immatures). The final fitted model contained individual female (F = 2.16; 262, 182 df; P < 0.0001) and winter (F = 137.95; 2, 91 df; P < 0.0001) as significant explanatory variables. All other explanatory variables and interactions were not significant (Ps > 0.08). Use of FRESH relative to INTERMEDIATE was greater in Winter 2 than in Winter 1 (P = 0.0001, Table 4).

**Nocturnal.**—The analysis of nocturnal use of marsh included 656 nocturnal locations on 95 females (n = 53 adults, n = 42 immatures). Our final fitted model contained individual female (F = 2.18; 186, 86 df; P < 0.0001) and winter (F = 15.13; 2, 92 df; P < 0.001) as significant explanatory variables. All other explanatory variables and interactions were not significant (Ps > 0.12). Use of FRESH relative to INTERMEDIATE was higher in Winter 2 than in Winter 1 (P = 0.0001, Table 4).

### Table 1. Nocturnal use (percent) of CLOSED and OPEN lands by radio-marked female Mallards by hunt period for winters 2004-2005 and 2005-2006 combined in southwestern Louisiana.

<table>
<thead>
<tr>
<th>Hunt Period</th>
<th>n</th>
<th>(\bar{x})</th>
<th>SE</th>
<th>(\bar{x})</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CLOSED</td>
<td>OPEN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FHUNT</td>
<td>14</td>
<td>37.5</td>
<td>12.5</td>
<td>62.5</td>
<td>12.5</td>
</tr>
<tr>
<td>SPLIT</td>
<td>37</td>
<td>36.5</td>
<td>7.9</td>
<td>63.5</td>
<td>7.9</td>
</tr>
<tr>
<td>SHUNT</td>
<td>129</td>
<td>20.9</td>
<td>2.9</td>
<td>79.1</td>
<td>2.9</td>
</tr>
<tr>
<td>POST</td>
<td>96</td>
<td>6.8</td>
<td>1.9</td>
<td>93.2</td>
<td>1.9</td>
</tr>
</tbody>
</table>

*Computed by calculating the percentage use of CLOSED and OPEN for each female in each hunt period, and then averaging over females. Data were transformed for the ANOVA and statistical comparisons are for SHUNT and POST only.

*No data collected during FHUNT and SPLIT in 2004-2005.

*Sample size represents number of radio-marked females monitored.
Table 2. Diurnal use (percent) of habitats (MARSH = marsh, IDLE = tillable land not planted into a cash crop and moist soil, RICE = rice, PASTURE = cattle pasture, and OTHER = forested wetlands, soybeans, and sugarcane) by female Mallards for winters 2004-2005 and 2005-2006 in southwestern Louisiana.

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>2004-2005</th>
<th>2005-2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARSH</td>
<td>0.594</td>
<td>0.562</td>
</tr>
<tr>
<td>IDLE</td>
<td>0.086</td>
<td>0.140</td>
</tr>
<tr>
<td>RICE</td>
<td>0.199</td>
<td>0.148</td>
</tr>
<tr>
<td>PASTURE</td>
<td>0.092</td>
<td>0.086</td>
</tr>
<tr>
<td>OTHER</td>
<td>0.029</td>
<td>0.065</td>
</tr>
</tbody>
</table>

*Computed by calculating the percentage use of each habitat for each female in each winter, and then averaging over females. Data were transformed for the MANOVA and comparisons are from SHUNT and POST only.

**DISCUSSION**

Diurnal proportional use of CLOSED during SHUNT in Winter 1 was low (0.36). Our estimate could be biased high if birds marked on CLOSED tend to use closed areas more than those marked on open areas (c.f. Blohm et al. 1987). Our radio-marked Mallards did not shift abruptly from OPEN to CLOSED in response to hunting in Winter 2 as reported for Pintails in California (Fleskes 2002), Louisiana (Cox and Afton 1997), and Mexico (Migoya et al. 1994).

Hurricane Rita, the most intense tropical cyclone observed in the Gulf of Mexico (Johnson 2006), came ashore in southwestern Louisiana on 24 September 2005 as early migrating waterfowl were arriving on the GCCP. Lacassine Pool was one of few marsh areas that sustained minimal storm damage (i.e., presence of green emergent and submergent vegetation; P. Link, pers. obs.) and radio-marked females concentrated there in Winter 2. For example, proportional use of Lacassine Pool increased from 0.03 to 0.20 between Winter 1 and 2, respectively. Additionally, 18 of 28 females captured on Cameron Prairie NWR in Winter 2 subsequently were located on Lacassine Pool. Further, numbers of Mallards surveyed on Lacassine Pool during mid-December increased nearly 300% from Winter 1 to Winter 2 (W. Syron, Lacassine NWR, unpubl. data). The few other FRESH areas that didn’t receive damage (i.e., Cherry Ridge, Florence Club, and White Lake Wetlands Conservation Area; P. Link, pers. obs.) similarly attracted large numbers of Mallards despite hunting on these areas (Link 2007). Thus, the higher use of CLOSED in Winter 2 probably was due to effects of Hurricane Rita rather than hunting.

Paulus (1984) suggested that waterfowl could afford to expend greater energy...
avoiding disturbance when using high-quality habitats. The relatively low diurnal use of CLOSED by Mallards during Winter 1 may have occurred because high quality habitat was abundant on OPEN lands during that winter. Cumulative precipitation during 1 October-31 March of Winter 1 and Winter 2 was 70.5 cm and 31.8 cm, respectively; thus, more acres of naturally flooded habitats were observed during Winter 1.

Diurnal use of OPEN increased from SHUNT to POST in Winter 1 and throughout Winter 2. Additionally, mean use of CLOSED was higher during the day than at night during all hunt periods. These results suggest that Mallards may be responding to common diurnal disturbances such as duck hunting, agricultural activities, and bird watching. These results also suggest that Mallards may be depleting food resources on CLOSED (i.e., refuging theory; Hamilton and Watt 1970). Increased use of OPEN throughout winter also may indicate that Mallards were able to find areas of sanctuary within OPEN. Greater nocturnal use of CLOSED during SHUNT than during POST suggests diurnal disturbance may prevent Mallards from using some habitats even at night. Further research is needed to confirm these hypotheses.

Mallards are highly adaptable in their use of habitats (Bellrose 1988) and appear to use some habitats relative to their abundance in the GCCP (Link 2007). Acreages of RICE, IDLE, and PASTURE changed dramatically due to the influence of Hurricane Rita (Table 5) and may have influenced proportional habitat use. RICE acreage and proportional use was greater in Winter 1 than in Winter 2, whereas IDLE acreage and proportional use was greater in Winter 2 than in Winter 1 (Table 2). Mallard use of RICE and IDLE

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>2004-2005</th>
<th>2005-2006</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Adult</td>
<td>Immature</td>
</tr>
<tr>
<td>MARSH</td>
<td>31.7 ± 4.1</td>
<td>36.2 ± 7.0</td>
</tr>
<tr>
<td>IDLE</td>
<td>13.5 ± 2.7</td>
<td>19.7 ± 5.8</td>
</tr>
<tr>
<td>RICE</td>
<td>35.1 ± 4.0</td>
<td>30.6 ± 6.8</td>
</tr>
<tr>
<td>PASTURE</td>
<td>17.6 ± 2.9</td>
<td>10.0 ± 4.2</td>
</tr>
<tr>
<td>OTHER</td>
<td>2.1 ± 0.8</td>
<td>3.5 ± 1.3</td>
</tr>
</tbody>
</table>

*aComputed by calculating the percentage use of each habitat for each female in each hunt period, and then averaging over females. Data were transformed for the MANOVA and comparisons are from SHUNT and POST only.

Table 3. Nocturnal use (percent*) of habitats (MARSH = marsh, IDLE = tillable land not planted into a cash crop and moist soil, RICE = rice, PASTURE = cattle pasture, and OTHER = forested wetlands, soybeans, and sugarcane) by adult and immature female Mallards for winters 2004-2005 and 2005-2006 in southwestern Louisiana.

Table 4. Diurnal and nocturnal use (percent*) of marsh habitats by female Mallards during winters 2004-2005 and 2005-2006 in southwestern Louisiana.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>x ± SE</td>
<td>x ± SE</td>
</tr>
<tr>
<td>Diurnal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRESH</td>
<td>64.6 ± 3.7</td>
<td>99.8 ± 0.1</td>
</tr>
<tr>
<td>INTERMEDIATE</td>
<td>34.5 ± 3.6</td>
<td>0.2 ± 0.1</td>
</tr>
<tr>
<td>BRALT*</td>
<td>0.9 ± 0.5</td>
<td>0.0 ± 0.0</td>
</tr>
<tr>
<td>Nocturnal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRESH</td>
<td>66.1 ± 5.0</td>
<td>99.2 ± 0.8</td>
</tr>
<tr>
<td>INTERMEDIATE</td>
<td>31.9 ± 5.0</td>
<td>0.8 ± 0.8</td>
</tr>
<tr>
<td>BRALT*</td>
<td>1.9 ± 1.4</td>
<td>0.0 ± 0.0</td>
</tr>
</tbody>
</table>

*aComputed by calculating the percentage use of each marsh type for each female in each hunt period, and then averaging over females.
Brackish and Salt marsh types were combined (BRALT). Data were transformed for the ANOVA and comparisons are from SHUNT and POST only.
was lower than that of Pintails (Cox and Ashton 1997). Rice agriculture provides valuable seasonal wetland habitat for Mallards and other wildlife species. However, rice agriculture is disappearing at an alarming rate due to urban expansion, limited freshwater, and conversion to other less wildlife-friendly crops. Waterfowl managers may want to encourage cooperative efforts with rice growers to provide critical seasonal wetland habitat for wintering waterfowl and other wildlife.

Diurnal and nocturnal use of PASTURE was nearly equal to that of IDLE. Despite non-agricultural habitats having lower energy per unit area than agricultural habitats (Fredrickson and Taylor 1982; Miller 1987; Stafford et al. 2006; Kross et al. 2008; Greer et al. 2009; Foster et al. 2010), Mallards may be able to acquire most of their energetic requirements from non-agricultural habitats (e.g., MARSH, PASTURE). We hypothesize Mallards are able to utilize areas with lower energy per unit area due to their less gregarious behavior as compared to Pintails in the study area (P Link, pers. obs.); thus, this reduced food depletion rate may allow Mallards to utilize these habitats without depleting available food resources.

Hurricane Rita directly affected habitat acreages between winters by causing high soil salinities, breached levees, difficulty in access to lands for some farmers, and damaged farm implements. Indirect affects of Hurricane Rita also affected habitat acreages between winters, by preventing freshwater pumping, displacing farm operators, and increasing fuel prices (USDA 2005). The most notable hurricane effect was salt burn and vegetation scouring of freshwater marsh (Neyland 2007). Despite the obvious reduction in quality and quantity of freshwater marsh in Winter 2, MARSH was used during the diurnal period at over twice the frequency of the next highest selected habitat type during both winters, thus, clearly emphasizing the importance of MARSH to wintering Mallards. Of the 3 types of marsh, freshwater marsh had the greatest use by female Mallards (65-99% of our radio-marked birds). Our telemetry results are consistent with observations of Chabreck et al. (1989), suggesting that freshwater marsh is the most important habitat for wintering Mallards in southwestern Louisiana.

We found that nocturnal MARSH use by Mallards was high during both winters and hunt periods and use was relatively greater than that reported for Pintails (Cox and Ashton 1997). Nocturnal use of MARSH may have declined throughout winter due to negative impacts of Hurricane Rita on the quality and quantity of freshwater marshes, reduced or eliminated hunting disturbance, late-winter rains flooding additional habitats, or a combination of these factors.

### Management Implications

Of marsh types, we found that freshwater marsh (0.65-0.99 proportional use) received the highest use by radio-marked female Mallards, despite the fact that freshwater marsh comprises only 27% of northern Gulf Coast marshes (Chabreck et al. 1989). Accordingly, evidence suggests that freshwater marsh is an important habitat of Mallards wintering

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bData provided by FSA offices in each parish.
along the Gulf Coast. Given that Gulf Coast marshes are disappearing at an alarming rate (Gagliano et al. 1981), our results indicate that conservation programs which protect and restore coastal marshes of south Louisiana would be beneficial to wintering Mallards.

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