Habitat Use of Female Northern Pintails in the Playa Lakes Region of Texas

Jena A. Moon,[1] *MS 2125, Department of Natural Resources Management, Texas Tech University, Lubbock, TX*

David A. Haukos, *United States Fish and Wildlife Service, MS 2125, Department of Natural Resources Management, Texas Tech University, Lubbock, TX*

Abstract: Playas and other wetlands of the High Plains provide important winter and migration habitats for the continental population of northern pintail (*Anas acuta*). Factors hypothesized to influence habitat use by pintails in the Playa Lakes Region of Texas (PLR) include wetland type, annual rainfall, and natural and anthropogenic disturbance. We assessed patterns of habitat use for 133 and 164 radio-tagged female pintails 23 October 2002–18 February 2003 and 10 October 2003–18 February 2004, respectively, in the PLR. Birds were continuously monitored for a 24-hour period at least three times a week. We used log-linear models to compare habitat use (playa wetlands, reservoirs, feedlot lakes, irrigation tailwater pits) among months (October–February), daily time periods (predawn, morning, mid-day, and evening), surrounding landuse, (e.g., agricultural fields, Conservation Reserve Program [CRP] grasslands, urban areas, and mixed [two or more habitat types in association with one wetland]), and percent emergent vegetation cover within wetlands (0–25, 25–50, 50–75, 75–100%). Playa wetlands were the predominant habitat used by pintails, accounting for over 98% of observations for both years. During 2002–03, female pintails used playas surrounded by mixed watersheds more than other habitats in October and during evening, and playas surrounded by CRP for the remainder of the winter and other time periods. During 2003–04, playas surrounded by CRP watersheds were used in greater proportion during morning and mid-day time periods during November, January, and February. In 2002–03, playas with greater percent vegetative cover were used in greater proportion during December, January, and February than October and November, and during the morning, mid-day, and evening time periods. During 2003–04, female pintails used playa wetlands with greater vegetative cover during December, January, and February, with greater use of more percent cover occurring throughout all daily time periods. Playas with increasing cover of emergent vegetation were increasingly used possibly due to decreasing water levels, increased food availability, protective microhabitats, and disturbance avoidance in heavily vegetated playas.

Key words: Anas acuta, habitat use, northern pintail, playa wetlands

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 62:82–87

Northern pintails (*Anas acuta*) have declined dramatically from the late 1970s to the early 1990s in North America, and populations remain at relatively low levels despite recent periods of improved breeding habitat conditions (Miller and Duncan 1999, U.S. Fish and Wildlife Service 2007). The 2007 breeding population estimate of 3.3 million in the traditional survey area was a slight increase from previous years; however, this estimate remains well below the goal of 5.6 million birds established by the North American Waterfowl Management Plan (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1998, Miller and Duncan 1999).

Smith and Sheeley (1993) recognized the importance of habitats provided by playa wetlands in northwestern Texas for migrating and wintering pintails. They found that during years of above-average rainfall, pair bonds were established earlier, field feeding was initiated later, and pintails had more body fat that in dryer years. The availability and quality of playa habitats also directly influences over-winter survival and body condition of pintails in the Playa Lakes Region (Moon 2004, Moon and Haukos 2006, Moon et al. 2007). Pintails select wetland seeds and aquatic invertebrates in playas until these forage resources are exhausted, and then switch to feeding in agricultural fields while continuing to use playas as resting and loafing habitat until spring migration (Lee 1985, Sheeley and Smith 1989, Moon 2004).

Because the Playa Lakes Region (PLR) of northwestern Texas is an important area for migrating and wintering pintails, understanding the relationship of use among playas and other potential wetland habitats is critical to the management and conservation of pintails. Several habitat types are potentially available to wintering pintails in the PLR, including playa wetlands, man-made reservoirs, feedlot effluent lakes, irrigation tailwater pits, and harvested agricultural fields. Unfortunately, little information on landscape and playa-specific habitat characteristics is available to formulate specific management and conservation recommendations.

Knowledge about wetland characteristics of playas used by pintails, including vegetative cover, water depth, potential forage base, and surrounding land practices are needed to improve manage-

1. Current address: U. S. Fish and Wildlife Service, McFaddin National Wildlife Refuge, P.O. Box 358, Sabine Pass, TX 77655

ment for pintails in the PLR. Habitat use is suspected to be related to wetland type, habitat availability, weather, periods of hunting, periods of field feeding, and anthropogenic disturbances in the region. Our goal was to assess the daily pattern of habitat use for female pintails during the wintering period in the PLR. Our specific objectives were to 1) quantify use among wetland habitat types in the PLR, 2) evaluate the relationship of use based on surrounding landscape practices, and 3) evaluate use based on vegetative cover within wetlands.

Study Area

Our study area was located in the PLR of northwest Texas, which included the High Plains (north of the Canadian River), the Southern High Plains (SHP), and a portion of the eastern adjacent Rolling Plains ecological region (Haukos and Smith 1994, Moon and Haukos 2006). We concentrated the study in the SHP, which contained about 20,000 playa wetlands (Haukos and Smith 1994). The SHP had a dry steppe climate with mild winters (Blackstock 1979), an average growing season of 180–220 days, and an average annual precipitation of 33–45 cm (Gould 1975). Most precipitation occurred in the form of rainfall with 54%–72% occurring during intense, localized thunderstorms from May–September (Bolen et al. 1989). Elevations in the SHP ranged from 1,000–1,200 m (Haukos and Smith 1994), with nearly level to gently undulating topography interrupted by numerous enclosed depressions lined by an impermeable vertisol clay, holding playa wetlands (Blackstock 1979).

In 2002, we captured pintails in Lubbock County, Texas, on two privately-owned wetlands; in Randall County (southwest of Canyon, Texas), centered around Buffalo Lake National Wildlife Refuge. We also trapped pintails on four privately-owned playas in Oldham County during 2002 (near Vega, Texas; Moon and Haukos 2006). During 2003, we used six separate capture areas and all were located on private lands; three were located in Randall County, Texas, and three in Lamb County, Texas (Moon and Haukos 2006).

Methods

We captured pintails using baited swim-in traps and rocket nets during fall 2002 and 2003 (Moon 2004, Moon and Haukos 2006). To ensure that a representative population of pintails inhabiting the PLR were sampled, we captured birds during different time periods and relative to their distribution among different subregions of the PLR (Moon and Haukos 2006). We established two capture periods during each year, we captured pintails 10–31 October and 14–28 November in 2002, and 10–31 October and 1 November–2 December in 2003. These periods correspond to autumn and early winter periods established by Whyte et al. (1986) for the region.

We aged captured female pintails (hatch-year [HY] and after-hatch-year [AHY]) based on plumage characteristics (Duncan 1985, Carney 1992), and attached a U. S. Geological Survey numbered aluminum leg band to each pintail. We also attached a backpack harness-style, 21.5-g, VHF radio-transmitter (Dwyer 1972) tuned for a life expectancy of 185 days to each female pintail. In 2002, we held pintails for <12 hours in a temperature-regulated facility, provided them with water as needed, and released them after sunset to reduce potential predation by diurnal predators (M.R. Miller, U.S. Geological Survey, personal communication). During 2003, we processed captured birds at trapping sites and released them within three hours of capture. During both years, we held all captured males and released them with radio-tagged females in an effort to maintain pair bonds.

We randomly selected a minimum of four radio-tagged females prior to commencement of tracking to intensively track each week 15 October – 28 February. We relocated randomly selected radio-tagged females at least once during each daily time period using vehicles outfitted with a four-element Yagi antenna on a 4.5–m retractable mast. We also conducted aerial tracking flights every two–four weeks to locate missing birds and assess pintail dispersal across the region using methods outlined by Gilmer et al. (1981). Once located, we documented habitat use patterns of each selected individual for a complete 24-hour period. Monitoring of habitat use was separated into four encounter periods for the complete 24-hour cycle; predawn = 2400 to sunrise, morning = sunrise to 1200, mid-day = 1200 to sunset, and evening = sunset to 2400. Each selected bird was located at least once during each time period and positions recorded using a Global Positioning System (GPS). Triangulation for pintail locations was not necessary due to the solitary nature of habitats and excellent access throughout most of the region. Playa wetlands are singular wetlands less than 15 ha in size, and very few are connected to other wetlands or playas (Bolen et al. 1989).

To ensure that we accurately assessed habitat use within the region, we would constantly monitor randomly selected radio-tagged females during the predawn and evening periods when the majority of movement is known to occur in the PLR (Baldassarre and Bolen 1984, Moon 2004). During movement, we would follow the signal until the bird stopped or returned to the original location. Should the bird travel to a new location, a new GPS coordinate was taken and habitat information was collected. If sufficient light was not available to assess the new habitat, we would return during daylight hours to classify habitats. When birds were feeding in agricultural fields, we stayed with the signal until the bird

returned to a roost. At least once weekly, females were located between 2400 and 0400 to ensure that birds were not field feeding or changing habitats during the predawn period.

Habitat type was assessed for selected individuals. Habitats available in the PLR consisted of playa wetlands—natural small ephemeral wetlands; reservoirs—large open bodies of water, generally larger than 80 ha; feedlot lakes—small man-made lakes associated with a feedlot cattle operation; tail-water pits—man-made depressions often in association with a playa wetland to aid gathering water for irrigation use; agricultural fields—generally harvested grain fields where waste grains were available to water-fowl. Surrounding landuse was then assessed for each wetland where radioed pintails were documented. Common surrounding landscapes included: Conservation Reserve Program Grasslands (CRP)—fields planted with grasses (native and non-native) and left out of agricultural production; cotton—row cropped planted cotton or harvested cotton; feedlot—feedlot cattle operation; grassland—native short grass prairie; sorghum—row crop planted sorghum or harvested sorghum; urban—completely surrounded by city or houses, and mixed—a combination of any two or more surrounding landuses. Surrounding landuse was generally assessed for the area directly adjacent to the wetland and included the complete circumference of the wetland. Exceptions were made only for observations in reservoirs. If pintails were observed in reservoirs, the immediate banks of the cove used by the marked individual were assessed for surrounding landuse. Also, an ocular estimation of percent vegetation cover was conducted (0–25, 25–50, 50–75, 75–100%) for the entire wetland used by the marked female. Similar to surrounding landuse data, exceptions were made for observations in reservoirs. Only the cove or general area used by the female was assessed, rather than the entire reservoir.

Habitat use data were analyzed using a multi-way log-linear model to assess independence of frequency of occurrence in surrounding landuse categories for year, time of day, and month (October-February) in SAS (SAS 1997; PROC FREQ and CATMOD). A similar log-linear model was used to assess independence of year, percent emergent cover, time of day, and month. A *G*-test statistic was used to assess all variable independence ($\alpha = 0.05$).

Results

Habitat conditions differed during the two winters of our study. The percentage of wetlands containing water during the winter of 2002–03 exceeded that of the previous three winters by a factor of two with about 22% of playas containing enough water to support duck use during the Midwinter Waterfowl Inventory (1–5 January, W. Johnson, Texas Parks and Wildlife Department, personal communication). However, total rainfall for 2003 was the lowest on record since 1911 (http://www.srh.noaa.gov), and in 2003–04, <1% of playa wetlands contained water during the Midwinter Waterfowl Inventory (W. Johnson, Texas Parks and Wildlife Department, personal communication). From 2001–2008, an average of 16.8% of playa wetlands were available to wintering waterfowl (range 0.0–54%; Haukos 2008).

Although disturbance within the region was difficult to quantify, we theorized that disturbance would be increased during periods of waterfowl hunting. The pintail hunting season was restricted to the last 39 days of the general duck season in our study area (107 days for other waterfowl), with a bag limit of one pintail (either-sex) per day during both years. Specific pintail hunting seasons were 12 December 2002 to 19 January 2003 and 18 December 2003 to 25 January 2004.

We tracked habitat use for 133 and 164 radio transmittered female northern pintails during 2002–03 and 2003–04, respectively. The predominant habitat type used by pintails in the PLR was playa wetlands with 99% (2002–03) and 98% (2003–04) of observations for female pintails occurring in playas. The remaining observations (1% and 2%) occurred in feedlot effluent ponds or in upland habitats during field feeding activities, thus habitat analyses focused solely on playa wetlands.

Surrounding Landuse

We recorded 1,259 and 3,028 habitat-use observations during 2002–03 and 2003–04, respectively. Landuse surrounding used playa wetlands was dependent on year, landuse, and time period ($X^2_{14} = 107.02$, $P < 0.001$). During 2002–03, the majority of observations occurred on playas surrounded by CRP (78.32%) or mixed watersheds (19.98%). Because only 1.70% of observations occurred among all other habitat types considered (i.e., cotton, feedlot, grassland, sorghum, or urban), only CRP and mixed watershed habitats were included in further analyses for 2002–03.

The proportion of observations between landuse types was dependent on month ($X^2_{14} = 42.95$, $P < 0.001$) and time period ($X^2_{15} = 188.48$, $P < 0.001$) for 2002–03. In October, pintails only used playas surrounded by mixed landuses, but switched to predominately using playas surrounded by CRP for the remainder of the winter 2002–03 (Figure 1). Pintails used playas surrounded by CRP more during the predawn, morning, and mid-day time periods, but switched to playas surrounded by mixed landuses during the evening time period 2002–03 (Figure 2).

In 2003–04, the majority of playas used by female pintails were surrounded by CRP (5.09%) and mixed watersheds (93.63%), but dominate use was reversed. Surrounding landuse of used playas was dependent on month ($X^2_{16} = 214.89$, $P < 0.001$) and time period ($X^2_{15} = 107.18$, $P < 0.001$). Early in winter, female pintails

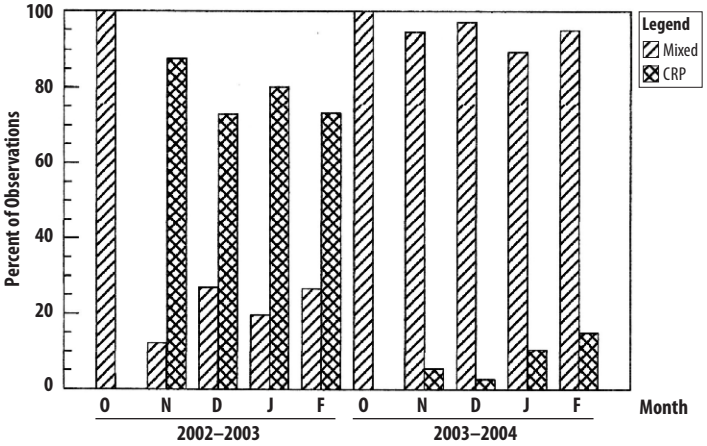

Figure 1. Total proportion of observations for transmittered female northern pintails by month (October–February) in playa wetlands surrounded by Conservation Reserve Program (CRP) and mixed (multiple landuses in one watershed) watersheds during the winter of 2002–03 and 2003–04 in the Playa Lakes Region of northwest Texas.

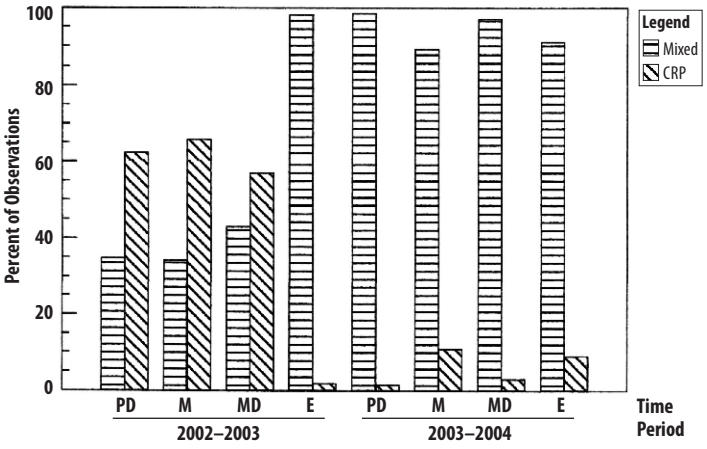

Figure 2. Total proportion of observations for transmittered female northern pintails by time period (predawn, morning, mid-day, and evening) in playa wetlands surrounded by Conservation Reserve Program (CRP) and mixed (multiple landuses in one watershed) watersheds during the winter of 2002–03 and 2003–04 in the Playa Lakes Region of northwest Texas.

Table 1. Total proportion of observations for transmittered female northern pintails by month for percent emergent cover in playa wetlands during 2002–03 and 2003–04 in the Playa Lakes Region of northwest Texas.

Year	% Cover	October	November	December	January	February
2002–03	0–25	100	96.6	66.4	64.2	73.1
	25–50	0	2.7	28.4	8.7	14.6
	50–75	0	0.5	1.2	14.3	7.3
	75–100	0	0.2	4.0	12.8	5.0
2003–04	0–25	74.4	59.9	43.3	72.3	58.6
	25–50	12.5	26.9	0.1	0.1	0
	50–75	0	2.2	3.4	3.1	1.2
	75–100	13.1	11.0	53.2	24.5	40.2

Table 2. Total proportion of observations for transmittered female northern pintails by time period for percent emergent cover in playa wetlands during 2002–03 and 2003–04 in the Playa Lakes Region of northwest Texas.

Year	% Cover	Predawn	Morning	Mid-day	Evening
2002–03	0–25	87.3	78.2	78.5	77.4
	25–50	6.0	12.1	12.5	9.5
	50–75	2.9	4.3	6.9	6.7
	75–100	3.8	5.4	2.9	6.4
2003–04	0–25	61.7	60.7	58.3	61.5
	25–50	7.6	3.7	7.8	1.7
	50–75	1.9	5.0	3.5	1.1
	75–100	28.8	30.6	30.4	35.7

predominately used playas surrounded by mixed landuses, but increased use of those surrounded by CRP in late winter months (Figure 1). During 2003–04, the proportion of surrounding landuse habitat observations by female pintails was principally dominated by mixed landuses for all time periods (Figure 2). Playas surrounded by CRP grasslands were used in largest proportions during the morning and evening time periods.

Percent Emergent Vegetation

There were a total of 1,286 and 3,031 percent emergent vegetation observations collected in 2002–03 and 2003–04, respectively. Because frequency of use for percent emergent vegetation was dependent on year, time period, and month ($X^2_6 = 18.28$, $P = 0.01$), further analyses were conducted by year comparing proportions of use among cover categories for month and time period. Percent emergent vegetation was dependent on month ($X^2_{11} = 25.49$, $P = 0.008$) and time period ($X^2_{19} = 196.17$, $P < 0.001$) for 2002–03. Proportions of percent cover observations were similar between October and November, but starting in December and continuing throughout the winter, use of wetlands with greater percent cover increased (Table 1). The proportion of observations for categories of emergent vegetation among used playas was similar among time periods (Table 2).

During 2003–04, the proportion of use among emergent vegetation categories also was dependent on month ($X^2_{16} = 89.79$, $P < 0.001$) and time period ($X^2_{26} = 691.85$, $P < 0.001$). Trends were similar to 2002–03. Female pintails used playa wetlands with greater vegetative cover during December, January, and February (Table 1), and use was similar among time periods for both years (Table 2). However, compared to 2002–03, there was greater use of wetlands with 75–100% vegetative cover in 2003–04 (Table 2).

Discussion

Use of playa wetlands in over 98% of observations emphasizes their importance of these wetlands to wintering pintails. Our

findings confirm conclusions by Smith and Sheeley (1993) on the importance of playa wetlands to wintering pintails using the PLR during winter and migration periods. Similar to our results, they also concluded that playas comprised the majority of wintering pintail habitats used during their 1984–1986 study. Use of playas by female pintails wintering in the PLR during 2002–2004 was affected by surrounding landuse and percent emergent vegetation.

Pintail movements and habitat use correspond with the frequent changes in playa availability (Moon 2004). Pintails primarily used playa wetlands with watersheds surrounded by CRP and mixed landuses, as evident by 97% and 98% of observations in 2002–03 and 2003–04, respectively. These findings are directly related to different regions of the PLR that received sufficient rainfall to flood playas, and respective land practices within those regions (i.e., mostly CRP north of Tulia,Texas; and mostly row cropping south of Tulia, Texas). Female pintails were only documented in playas surrounded by mixed watersheds during October of 2002. However, a large storm event (~15 cm) filled additional playa wetlands that were previously dry. Following the event, we observed a shift in pintail habitat use from playas surrounded by mixed landuses to those surrounded by CRP for the remainder of the 2002–03 wintering period. After this shift in habitat use, playas surrounded by mixed watersheds were still used but in much smaller proportions. The newly flooded playas (i.e., playas that were dry prior to the storm) likely provided new food resources not previously available. Also, playas surrounded by CRP should have fewer disturbances associated with wetlands (e.g., no agricultural activities, less accessible to hunters) likely making these playas more appealing to pintails.

During 2003–04, no major habitat use shifts were observed among months for surrounding landuse practices, likely because of the lack of environmental changes to playa hydrology. Playas surrounded by mixed landuses made up the majority of wetlands available to wintering waterfowl during this nearly unprecedented drought period. During November, December, and January, we observed pintails using playa wetlands surrounded by CRP in greater proportions than in October and February. We think this change may be a response to increased disturbance during those months. The peak harvest and post-harvest field preparation periods for most agricultural crops in the PLR is November and December. During these periods, many wetlands, especially those in mixed watersheds, can experience a large increase in human activity. The pintail hunting season in 2003–04 began during mid-December and lasted nearly the whole month of January. While hunting pressure remains low within the PLR, our primary period of mortality occurred during the hunting season during 2002–03, indicating that birds were more stressed during hunting season (Moon and Haukos 2006). Because few wetlands were available, all hunting activities were concentrated on the wetlands that did receive rainfall, which also increased disturbance during the months of November, December, and January.

Landuse practices surrounding playa wetlands should be more thoroughly evaluated to assess how potential landscape changes (e.g., loss of CRP) would affect pintail populations in the Region. Playas in CRP may provide more protection from disturbance, and playas in mixed watersheds may be closer to food resources, which likely accounted for the change in playa use during the evening time period during 2002–2003 (i.e., periods of field feeding; J. A. Moon, Texas Tech University, unpublished data). Additionally, management actions should be taken in the region so that time spent feeding in playa wetlands is maximized. Such actions may include moist-soil management, staggered flooding, and wetland enhancement within the region. For average and wet growing-season years, we recommend playa wetlands with food resources (i.e., wetland plants) are artificially flooded at the beginning of the hunting season and just prior to spring migration to aid in reducing disturbance and increasing body condition during these periods.

Female pintails exhibited a change in habitat use related to percent emergent vegetation across the wintering period. During both years of our study, female pintails used mainly open water playas upon arrival in the PLR, and during December began using playas with greater vegetative cover. This habitat use change may have been due to either a change in availability of playa wetlands with open water or increased security in playas with greater coverage of vegetation. The PLR receives the majority of precipitation during the late spring and summer months, making sizable precipitation events rare during the wintering period (Bolen et al. 1989). As water levels recede (due to aquifer recharge and evapotranspiration) with the progression of the wintering period, more emergent vegetation will become exposed, possibly increasing the percent cover visible in wetlands. Habitats with thicker emergent vegetation may have been appealing to female pintails due to increased cover from predators, relief from disturbance, thermal insulation, or due to greater availability of food resources (Anderson 1996).

Because playa wetlands provide the majority of habitat for wintering waterfowl in the PLR, management efforts that increase acquisition (i.e., form a wetland management district) and improved conservation of playas are needed within the PLR (Haukos and Smith 2003). The general lack of habitat management programs in the PLR may be affecting the daily movements, body condition, survival, and habitat use patterns of northern pintails in the PLR (Moon 2004, Moon and Haukos 2006, Moon et al. 2007). Management efforts to date have been insufficient, and past manage-

ment recommendations have not been implemented to improve habitat quality for wintering waterfowl. There is an urgent need for playa conservation, especially in the SHP where row cropping is common. Preserving functional playa wetlands will improve habitat for wintering waterfowl and ensure future use of the PLR by wintering pintails. The conservation and management of playa habitats will assist managers in minimizing energy expenditure by pintails and other waterfowl to acquire resources during winter, and may improve spring migration condition and subsequent recruitment.

Acknowledgments

We thank Texas Tech University, U.S. Fish and Wildlife Service Region 2 Migratory Bird Office, Northern Prairie Wildlife Research Center, and the Playa Lakes Joint Venture for providing funding for this project. L. Smith, R. Cox, B. Johnson, B. Davis, L. Gustafson, D. Casida, J. Smith, J. Bredy, P. Thorpe, and F. Roetker provided field assistance during this study. L. Nymeyer provided field technicians, vehicles, and access to trapping sites. G. Filnor, J. Heath, J. Jones, B. Jones, M. Been, M. Montene, C. Sargent, A. McNeil, and J. Stevens provided access to private lands for trapping efforts. We also thank R. Cox, L. Smith, and anonymous referees for thorough reviews of previous drafts of this manuscript. This is paper T-9-1161 of the College of Agricultural Resources and Natural Resources, Texas Tech University.

Literature Cited

Anderson, J.T. 1996. Invertebrate communities in vegetated playa wetlands. Doctoral Dissertation. Texas Tech University, Lubbock.

Baldassarre, G.A. and E.G. Bolen. 1984. Field feeding ecology of waterfowl wintering on the Southern High Plains of Texas. Journal of Wildlife Management 48:63–71.

Blackstock, D.A. 1979. Lubbock county soil survey. U.S. Department of Agriculture, Soil Conservation Service and Texas Agricultural Experiment Station. College Station, Texas.

Bolen, E.G., L.M. Smith, and H.L. Schramm. 1989. Playa lakes: prairie wetlands of the Southern High Plains. BioScience 39:615–623.

Carney, S.M. 1992. Species, age, and sex identification of ducks using wing plumage. U.S. Department of the Interior, Washington, D.C.

Duncan, D.C. 1985. Differentiating yearling from adult northern pintails by wing-feather characteristics. Journal of Wildlife Management 49:576–579.

Dwyer, T. J. 1972. An adjustable radio-package for ducks. Bird-Banding 43:282–284.

Gilmer, D. S., L.M. Cowardin, R.L. Duval, L.M. Mechlin, J.W. Shaiffer, and V.B. Kuechle. 1981. Procedures for the use of aircraft in wildlife biotelemetry studies. U.S. Fish and Wildlife Service, Washington, D.C.

Gould, F.W. 1975. Texas plants-A checklist and ecological summary. Misc. Publ. 585 Texas Agricultural Experiment Station, College Station, Texas.

Haukos, D.A. 2008. Analyses of selected midwinter waterfowl survey data (1955–2008). Regional Migratory Bird Office, U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

——— and L.M. Smith. 1994. The importance of playa wetlands to biodiversity of the Southern High Plains. Landscape and Urban Planning 28:83–98.

——— and ———. 2003. Past and future impacts of wetland regulations on playa ecology in the Southern Great Plains. Wetlands 23:577–589.

Lee, S.D. 1985. A time budget study of mallards on the Texas High Plains. Masters Thesis, Texas Tech University, Lubbock, Texas.

Miller, M. R. and D.C. Duncan. 1999. The northern pintail in America: status and conservation needs of a struggling population. Wildlife Society Bulletin 27:788–800.

Moon, J.A. 2004. Survival, movements, and habitat use of female northern pintails wintering in the Playa Lakes Region. Masters Thesis. Texas Tech University, Lubbock.

——— and D.A. Haukos. 2006. Survival of female northern pintails wintering in the Playa Lakes Region. Journal of Wildlife Management 70:777–783.

———, ———, and L.M. Smith. 2007. Declining body condition of northern pintails wintering in the Playa Lakes Region. Journal of Wildlife Management 71:218–221.

SAS Institute. 1997. SAS/STAT software: changes and enhancements. Release 6.12. SAS Institute, Cary, North Carolina.

Sheeley, D.G. and L.M. Smith. 1989. Tests of diet and condition bias in hunter-killed northern pintails. Journal of Wildlife Management 53:765–769.

Smith, L.M. and D.G. Sheeley. 1993. Factors affecting condition of northern pintails wintering in the Southern High Plains. Journal of Wildlife Management 57: 62–71.

Whyte, R.J., G.A. Baldassarre, and E.G. Bolen. 1986. Winter condition of mallards on the southern high plains of Texas. Journal of Wildlife Management 50:52–57.

U.S. Fish and Wildlife Service. 2007 Trends in duck breeding populations, 1955–2003. U.S. Department of the Interior, Office of Migratory Bird Management, Laurel, Maryland.

——— and Canadian Wildlife Service. 1988. North American waterfowl management plan—a strategy for cooperation. U.S. Department of the Interior, Washington, D.C.