CALIFORNIA

FISH and GAME

"CONSERVATION THROUGH EDUCATION"

VOLUME 90 WINTER 2004 NUMBER 1

REPRINT FROM *CALIFORNIA FISH AND GAME* 90(1)

California Fish and Game 90(1):13-28 2004

HABITAT SELECTION BY FEMALE NORTHERN PINTAILS WINTERING IN THE GRASSLAND ECOLOGICAL AREA, CALIFORNIA

JOSEPH P. FLESKES and DAVID S. GILMER
U.S. Geological Survey
Western Ecological Research Center
6924 Tremont Road
Dixon, CA 95620
joe_fleskes@usgs.gov

ROBERT L. JARVIS
Oregon State University
Department of Fish and Wildlife
104 Nash Hall
Corvallis, OR 97331

To determine relative importance of habitats available in the Grassland Ecological Area (GEA) to wintering female northern pintails, *Anas acuta*, we studied habitat use relative to availability (i.e., habitat selection) in the GEA during September through March, 1991-94 for 196 Hatch-Year (HY) and 221 After-Hatch-Year (AHY) female pintails that were radio tagged during August - early October in the GEA (n = 239), other San Joaquin Valley areas (n = 132), or other Central Valley areas (n = 46). Habitat availability and use varied among seasons and years, but pintails always selected shallow and, except on hunting days, open habitats. Swamp timothy, *Heleochloa schoenoides*, marsh was the most available, used, and selected habitat. Watergrass, *Echinochloa crusgalli*, marsh in the GEA was used less than available at night in contrast to previous studies in other SJV areas. Preferred late-winter habitats were apparently lacking in the GEA, at least relative to in the Sacramento Valley and Delta where most pintails moved to in December each year. Impacts on pintails of the increasing practice of managing marshes for increased emergent vegetation to attract other species should be monitored. Shallow, open habitats that produce seeds and invertebrates available to pintails in late winter would help maintain pintail abundance in the GEA.

INTRODUCTION

Current abundance of breeding northern pintails, *Anas acuta*, in North America is near the historic lows of the early 1990s (U.S. Fish and Wildlife Service and Canadian Wildlife Service[1] 2002) and pintail abundance in California during winter is only about 25% of that during the 1970s (U.S. Fish and Wildlife Service, Portland, Oregon, USA,

[1]U. S. Fish and Wildlife Service and Canadian Wildlife Service. 2002. Waterfowl population status, 2002. U.S. Fish and Wildlife Service, Washington, D.C., USA.

unpublished data). Because wintering habitats may affect survival (Fleskes[2] 1999) and productivity of pintails (Raveling and Heitmeyer 1989), effective pintail management requires a thorough understanding of their winter habitat selection. This is especially important in the Central Valley, where over 90% of natural wetland habitat has been lost, yet about half of pintails in North America still winter (Gilmer et al. 1982, Austin and Miller 1995).

The need to intensively manage waterfowl habitats is especially crucial in the Grassland Ecological Area (GEA) in the northern part of the San Joaquin Valley (SJV). Although the GEA is the largest contiguous block of wetland habitat remaining in the Central Valley (Heitmeyer et al. 1989), in contrast to Central Valley areas to the north, where winter-flooded rice and grain fields maintain many of the same functions as wetlands they replaced (Elphick 2000), most crop fields in the northern SJV are plowed after harvest and left dry. Thus, waterfowl wintering in the northern SJV must rely almost entirely upon wetland resources within the GEA (Fleskes et al. 2002*a*).

Pintails wintering in California spend most of their time resting and feeding (Miller 1985). Pintails loaf during the daytime throughout the wintering period (i.e., August - March), but before hunting season they feed extensively during both daytime and night to replenish fat reserves depleted by breeding and fall migration (Miller 1985, 1986). During hunting season, most feeding is done at night and loafing is the main daytime activity (Euliss[3] 1984, Miller 1985). Daytime feeding increases again after the hunting season as pintails prepare for spring migration and nesting. Thus, habitat use at night mainly reflects feeding site selection, daytime use during hunting season mainly reflects loafing site selection, and daytime use before and after hunting season reflects both feeding and loafing site selection.

Information on habitat use and selection by pintails in the GEA is lacking. Surveys (Isola et al. 2000, California Department of Fish and Game, Los Banos, California, USA, unpublished data) provide some information on general habitat use, but no areas were surveyed at night. Food habits of pintails collected at Los Banos Wildlife Area (WA) (Beam and Gruenhagen[4] 1980, Connelly and Chesemore 1980) provide some insight into habitat use on that area, but most pintails fly to private duck clubs at night (Fleskes et al. 2002*a*) and data on habitat selection throughout the GEA are lacking. To provide information for wetland habitat managers, we studied habitat use by female northern pintails relative to availability (i.e., selection) in the GEA during September through March, 1991-94. Our goals were to determine day and night habitat use and selection before, during, and after hunting season, to identify the relative importance of roosting

[2]Fleskes, J. P. 1999. Ecology of female northern pintails during winter in the San Joaquin Valley, California. Dissertation, Oregon State University, Corvallis, Oregon, USA.

[3]Euliss, N. H., Jr. 1984. The feeding ecology of pintail and green-winged teal wintering on Kern National Wildlife Refuge. Thesis, Humboldt State University, Arcata, California, USA.

[4]Beam, J., and N. Gruenhagen. 1980. Feeding ecology of pintails (*Anas acuta*) wintering on the Los Banos Wildlife Area, Merced County, California. California Department of Fish and Game, Federal Aid Wildlife Restoration Progress Report, Project W-40-D-1.

and feeding habitats for pintails in the GEA and test the null hypothesis that use of each habitat would equal its availability.

STUDY AREA

Habitat in the GEA was composed mainly of seasonal (≤23,313 ha) and semipermanent-permanent marsh (≤1,160 ha) with other flooded areas including San Luis Reservoir and forebay (6,300 ha), sewer (≤245 ha) and evaporation ponds (≤39 ha), and flooded agricultural lands (≤1,572 ha) (Fleskes[2] 1999). Excluding the San Luis Reservoir and forebay, 75% of the habitat flooded before hunting season and 82% thereafter was privately-owned (Fleskes et al. 2002a). Some public areas were completely open to hunting (Volta, Salt Slough, and China Island WAs) and others included units closed to hunting (Los Banos WA and San Luis, Kesterson, Merced, and Arena Plains National Wildlife Refuges [NWRs], Fig. 1).

Habitat conditions differed before (Prehunt), during (Hunt), and after (Posthunt) waterfowl hunting season. Most marsh was seasonal and was dry during summer except for periodic irrigations to promote seed production of watergrass, *Echinochloa crusgalli*, swamp timothy, *Heleochloa schoenoides*, pricklegrass, *Crypsis niliaca*, (a species similar to swamp timothy), and other wetland plants. These marshes were usually filled with water during Prehunt to be fully flooded by the start of Hunt. Thus, the average amount of flooded marsh was 2-4 times greater during Hunt and Posthunt than during Prehunt. Most flooding of agricultural lands and other uplands within the GEA occurred during late-winter as a result of rain events and stream overflows.

Annual variation in precipitation, water supplies and management affected habitats differently in the GEA (Fleskes[2] 1999). Conditions in the GEA were the driest on record during 1991-92 because continuing drought and resulting low reservoir levels (California Department of Water Resources[5] 1991, National Oceanic and Atmospheric Administration, Asheville, North Carolina, USA, unpublished data) prevented summer irrigation, delayed fall flood-up and greatly reduced water deliveries to private wetlands; water deliveries to public areas were less reduced and allowed nearly normal management and flood-up (Grassland Water District, Los Banos, California, USA, unpublished data). Conditions improved during 1992-93 with above-average precipitation and normal water deliveries to all GEA areas. During 1993-94, conditions improved further when implementation of the Central Valley Project Improvement Act (Davis 1992) nearly doubled the water delivered to the Grassland Water District (Grassland Water District, Los Banos, California, USA, unpublished data) and wetlands on Kesterson NWR and Salt Slough WA were restored. Annual changes in the GEA were most evident for seasonal marsh with the average amount of flooded seasonal marsh present each week increasing during Prehunt from 5,385 to 6,698 to 9,603 ha; during Hunt from 19,358 to 19,915 to 22,713 ha; and during Posthunt from 20,011 to 21,206 to 23,313 ha, in 1991-92,

---

[5]California Department of Water Resources. 1991. California's continuing drought, 1987-1991: A summary of impacts and conditions as of December 1, 1991. Sacramento, California, USA.

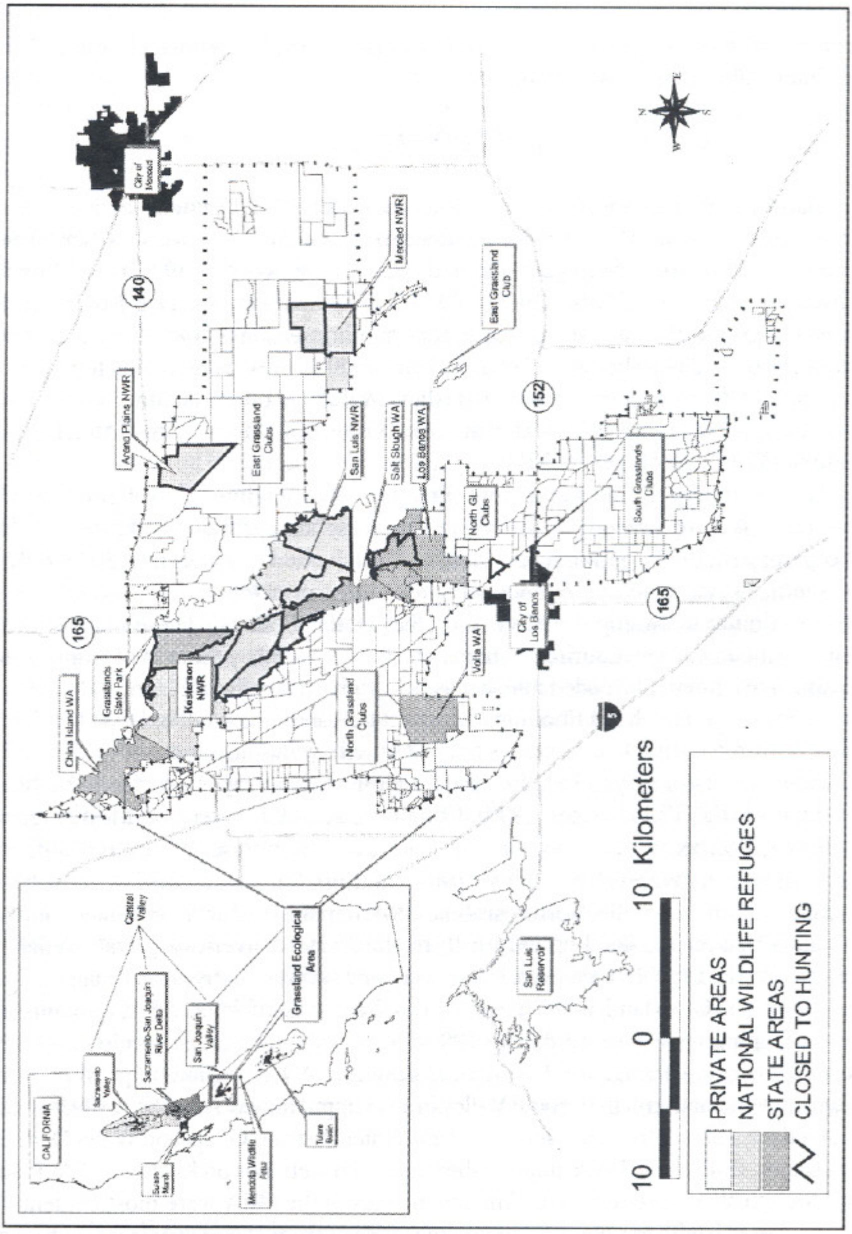

Figure 1. The Grassland Ecological Area (GEA) in the San Joaquin Valley of California's Central Valley. The GEA includes California Department of Fish and Game Wildlife Areas (WAs), U.S. Fish and Wildlife Service National Wildlife Refuges (NWRs), private waterfowl hunting clubs, and San Luis Reservoir. Habitat use and selection by female northern pintails, *Anas acuta*, in the GEA were studied during September - March, 1991-94 for pintails that were radio tagged in the GEA, Mendota WA (50 km southeast of the GEA), the Tulare Basin (150 km southeast of the GEA), and the Suisun Marsh (180 km northwest of the GEA).

1992-93 and 1993-94, respectively (Fleskes[2] 1999). Flooded area of evaporation ponds, sewer ponds, and reservoirs was fairly constant among intervals and years. Study area habitats are described by U.S. Fish and Wildlife Service[6] (1978) and Heitmeyer et al. (1989).

Duck hunting daily bag limits and season lengths remained constant during the study, but the timing of the hunting season (Hunt) varied among years. For 1991, 1992, and 1993, respectively, Hunt was composed of a 22-day first season starting 26, 24, or 23 October, a 12-, 19-, or 27-day closure that split the duck hunting season, and a 37-day second season ending 5, 10, or 16 January (California Department of Fish and Game[7] 1991, California Department of Fish and Game[8] 1992, California Department of Fish and Game[9] 1993). WAs, NWRs, and nearly all duck clubs in the GEA allowed hunting only on Wednesdays, Saturdays, and Sundays during Hunt (hereafter shoot days). We define Posthunt as the interval from end of Hunt to 1 April 1992 and 1993 or 17 March 1994.

METHODS

Classifying Habitat

We observed no pintails using dry lands (except levees, shorelines, islands) in the SJV and considered only flooded areas as habitat. We classified habitats three ways based upon: 1) hydrology and physical characteristics, 2) vegetation composition, and 3) percent emergent cover.

We used U. S. Geological Survey Quadrangles, the San Joaquin Valley Drainage Program Study Team[10] (1990) report, aerial photographs, site visits, and data provided by managers to identify hydrology and physical characteristics and classify eight general habitats: 1) agricultural drainwater evaporation ponds; 2) sewage treatment ponds; 3) deepwater reservoirs and lakes (e.g., San Luis Reservoir, fish-rearing ponds), 4) seasonal marsh, which included vernal pools; 5) semipermanent and permanent

---

[6]U. S. Fish and Wildlife Service. 1978. Concept plan for waterfowl wintering habitat preservation, Central Valley, California. U.S. Fish and Wildlife Service, Portland, Oregon, USA.

[7]California Department of Fish and Game. 1991. 1991 California hunting regulations: Parts II and III. Resident and migratory game birds. California Department of Fish and Game, Sacramento, California, USA.

[8]California Department of Fish and Game. 1992. 1992 California hunting regulations: Parts II and III. Resident and migratory game birds. California Department of Fish and Game, Sacramento, California, USA.

[9]California Department of Fish and Game. 1993. 1993 California hunting regulations: Parts II and III. Resident and migratory game birds. California Department of Fish and Game, Sacramento, California, USA.

[10]San Joaquin Valley Drainage Program Study Team. 1990. Fish and wildlife resources and agricultural drainage in the San Joaquin Valley, California. Volume I and II. San Joaquin Valley Drainage Program, Sacramento, California, USA.

marshes, which included marshes, sloughs, shallow lakes, and oxbows that remained at least partially flooded throughout most years; 6) uplands, which included idle grasslands and irrigated pasture; 7) rice (harvested), and 8) other tilled agricultural lands. Each year, we used data provided by wetland managers, interpretation of Natural Resources Conservation Service and our aerial photography, and site visits to further classify marsh based on dominant understory vegetation as: 1) swamp timothy (includes pricklegrass); 2) watergrass (usually associated with sprangletop, *Leptochloa* spp.); and 3) other (e.g., jointgrass, *Paspalum distichum*, spikerush, *Eleocharis macrostachya*, alkali bulrush, *Scirpus robustus*, smartweed, *Polygonum lapthifolium*, etc.,). In addition, we used aerial photographs to classify marsh as "open" (<25% emergent vegetation), or "hemi-closed"(≥25% emergent vegetation). We define emergent vegetation as cattail, *Typha* sp., bulrush, *Scirpus* sp., watergrass and any other erect plant that was above water after the area was fully flooded.

Measuring Habitat Availability

To represent the average amount of each habitat type that was available to radio-tagged pintails in the GEA during the multi-week Prehunt, Hunt, and Posthunt intervals (i.e., habitat availability), we weighted weekly estimates of the amount of flooded area of each habitat by the number of pintail locations we obtained that week and then calculated each interval average. First, we entered vegetation and weekly flooding data obtained from managers, aerial photographs, and site visits into a Geographic Information System (GIS) and ARC/INFO (ESRI) computer program. Next, we used the data in the GIS to determine flooded area of each habitat each week in the GEA during August-March, 1991-94. Finally, because the number of radio-tagged pintails present in the GEA changed each week due to emmigration, immigration, and mortality, rather than simply averaging weekly flooding estimates to calculate average flooded area of each habitat for the multi-week Prehunt, Hunt and Posthunt intervals, we instead weighted weekly flooding estimates by the number of pintail locations obtained in the GEA that week and then calculated interval averages. We estimated availability and use for the three multi-week intervals rather than individual weeks because the number of locations we obtained per week for each pintail was inadequate for weekly comparisons of use and availability. Also, although flooding did change somewhat among weeks within intervals (especially as marshes were flooded during Prehunt), flooding and pintail movement patterns (Fleskes et al. 2002a) within intervals were more similar than across intervals.

Measuring Habitat Use

Pintail Capture and Tracking

We periodically pinpointed locations of 417 radio-tagged female pintails to track their habitat use in the GEA during September through late March, 1991-94. We studied GEA habitat use of all 124 HY and 115 AHY pintails that we radio tagged throughout the GEA (Volta and Los Banos WAs, San Luis and Kesterson NWRs, duck clubs in the south part of the GEA), 36 HY and 53 AHY pintails that we radio tagged in Mendota WA (50 km southeast of the GEA), 13 HY and 30 AHY pintail that we radio tagged in the Tulare Basin (150 km southeast of the GEA), and 24 AHY and 22 HY pintails that Casazza[11] (1995) radio tagged in Suisun Marsh (180 km northwest of the GEA, Fig. 1). Pintails were captured with rocket-nets (Schemnitz 1994) during 29 August - 6 October 1991, 31 August - 5 October 1992, and 28 August - 25 September 1993. Captured pintails were aged (Carney[12] 1992), weighed ($\pm$5 g), measured (flat wing, culmen 1, total tarsus [Dzubin and Cooch[13] 1992]), radio tagged (Dwyer 1972, Pietz et al. 1995), and released at the capture site. All pintails radio tagged in GEA were included in this study but 29 pintails radio tagged at Mendota WA, 19 at Tulare Basin, and 148 at Suisun Marsh did not visit the GEA and were not included in our study.

We scanned the GEA entirely (Gilmer et al. 1981) and determined each pintail's location on $\geq$2 shoot days and following nights and $\geq$2 nonshoot days and following nights each week during Hunt and $\geq$2 days and nights each week during Prehunt and Posthunt. We obtained two bearings from known locations using a vehicle-mounted dual-Yagi null-peak telemetry system (Cochran and Lord 1963) to minimize time between bearings and because preliminary tests showed more bearings did not increase accuracy in our flat, open study areas. We obtained >89% of locations <1.6 km from the bird at 50-130 degree angles. Warnock and Takekawa (1995) reported an average azimuth error of 1.5 degrees and an error polygon of 1.1 ha with location distances 0.5 - 3.0 km using an identical system, which is much smaller than the average size of habitat polygons ($\bar{x}$ = 20.3 ha) in the GEA. We calculated pintail locations using a modified version of XYLOG and UTMTEL (Dodge et al.[14] 1986, Dodge and Steiner 1986). We intersected pintail locations in the GIS with digitized habitat maps to determine habitat for each location.

Habitat Selection Analysis

We used compositional analysis (Aitchison 1986, Aebischer et al. 1993) to examine day and night habitat selection by pintails. We considered all flooded areas in the GEA available for potential use by each pintail in the GEA because all flooding was within the daily pintail flight range from major pintail roost sites in the GEA (Fleskes et al. 2002*a*). We used multivariate analysis of variance (Johnson and Wichern 1982, SAS Institute 1989) to test whether a composition of use-to-availability log ratios differed

---

[11]Casazza, M L. 1995. Habitat use and movements of northern pintails wintering in the Suisun Marsh, California. Thesis, California State University, Sacramento, California, USA.

[12]Carney, S. M. 1992. Species, age and sex identification of ducks using wing plumage. U.S. Fish and Wildlife Service, Washington, D. C., USA.

[13]Dzubin, A., and E. G. Cooch. 1992. Measurement of geese: general field methods. California Waterfowl Association. Sacramento, California, USA.

[14]Dodge, W. E., D. S. Wilkie, and A. J. Steiner. 1986. UTMTEL: A laptop computer program for location of telemetry Afinds@ using Loran-C. Massachusetts Cooperative Research Unit. Report, U.S. Fish and Wildlife Service.

significantly from zero ($P \leq 0.05$), indicating selection by pintails. When selection was detected, ranks were assigned to each habitat type, means and standard errors for each log-ratio were calculated, and *t*-tests were used to identify significant ($P \leq 0.05$) differences among rankings of habitats (Aebischer et al. 1993). We combined drainwater evaporation and sewage treatment ponds because habitat was similar and use was minimal for both. We compared habitat selection among years (1991-92, 1992-93, 1993-94), shoot and nonshoot days during hunting season, bird age class (HY, AHY), and bird capture mass (above vs. below age-class mean).

RESULTS

General Habitat Use and Selection

During all intervals, seasonal marsh received highest pintail use (Table 1) and was most highly selected (Table 2); deepwater reservoirs and sewage treatment and evaporation ponds received lowest pintail use (Table 1) and were least selected (Table 2). Flooded rice and other agriculture lands were not always available but when available they were selected above all other habitats except seasonal marsh. Permanent-semipermanent marsh ranked higher during the day than at night and was used more than available only on shoot days.

Marsh Types Used and Selected

Swamp timothy marsh received more use by pintails than marshes dominated by watergrass or other plants (Table 1). Pintails selected swamp timothy and avoided watergrass marsh at night and during Prehunt, Posthunt, and nonshoot days during Hunt; marsh without much timothy or watergrass (i.e., other) ranked in the middle (Table 2). Watergrass was selected only on shoot days, when most pintails in GEA roosted in the sanctuary of San Luis NWR (Fleskes et al. 2002a) which included several watergrass fields. In the evening, pintails that had day-roosted on San Luis NWR flew past Salt Slough WA watergrass units on their way to night-feed in timothy marsh on duck clubs (Fleskes et al. 2002a). Pintails selected open over hemi-closed marsh ($t \geq 4.74$, $P < 0.001$), except on shoot days ($t = 7.13$, $P < 0.001$).

Selection Relative to Pintail Body Mass and Age

Habitat rankings were nearly identical for HY and AHY pintails. Pintail age appeared as a significant factor in habitat selection models in only two instances when significance levels of the rankings differed by age (Table 2). Habitat selection did not differ among pintails that were lighter or heavier than average at capture.

Table 1. Composition (proportions) of habitat types (evaporation pond [EP], sewer pond [SP], reservoir [RS], upland [UP], rice [RI] , other tilled agriculture [AG], permanent-semipermanent marsh [PM], seasonal marsh [SM]), marshes by dominant plant (swamp timothy [T], watergrass [W], other [O]) and habitats (except EP, SP, RS) by emergent cover (<25% open, ≥25% hemi-closed [Hemic]) available (Avail = $\bar{x}$ of weekly proportions weighted by locations) and used by 417 radio-tagged female pintails in Grassland Ecological Area, 1991-94.

	PREHUNT			HUNT			POSTHUNT		
Habitat	Avail	Day Use	Night Use	Avail	Day Use	Night Use	Avail	Day Use	Night Use
EP	0.002	<0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001
SP	0.011	<0.001	<0.001	0.008	0.005	<0.001	0.008	<0.001	<0.001
RS	0.346	<0.001	<0.001	0.226	0.004	0.001	0.210	0.044	0.048
UP	0.005	0.013	0.006	0.005	0.006	0.014	0.032	0.069	0.089
RI	0	-	-	0.001	<0.001	0.001	0.001	0.004	0.002
AG	0.002	0.002	0.004	0.001	0.005	0.002	0.004	0.034	0.044
PM	0.042	0.020	0.015	0.032	0.078	0.007	0.034	0.013	0.030
SM	0.591	0.966	0.975	0.726	0.900	0.976	0.709	0.834	0.786
T	0.543	0.585	0.639	0.549	0.477	0.632	0.545	0.614	0.534
W	0.116	0.161	0.082	0.099	0.352	0.087	0.102	0.140	0.093
O	0.341	0.253	0.279	0.351	0.170	0.281	0.354	0.246	0.373
Open	0.66	0.71	0.81	0.70	0.63	0.86	0.70	0.78	0.76
Hemic	0.33	0.29	0.19	0.30	0.37	0.14	0.30	0.22	0.24

Table 2. Selection by radio-tagged female northern pintails of flooded habitats (seasonal marsh [SM], rice fields [RI], other tilled agriculture [AG], idle or grazed uplands [UP], semipermanent-permanent marsh [PM], evaporation and sewer ponds [ES], reservoirs [RS]), and marshes (i.e., SM and PM) classified by dominant plant (swamp timothy [T], watergrass [W], other [O]) during prehunt (Pre), hunt (Hnt) and posthunt (Pos) days (D) and nights (N) in Grassland Ecological Area, California, 1991-94.

		Comparison[a]			Rankings[b] of general habitats and marsh type									
Interval	n[c]	Year	Age	Shoot status	SM	RI	AG	UP	PM	ES	RS	T	W	O
PreD	275	Pooled	Pooled	Nonshoot	1A		2B	3C	4D	5DE	6E	1A	3B	2B
	85	91-92	Pooled	Nonshoot	1A		2B	3C	4D	5DE	6E	1A	2B	3B
	89	92-93	Pooled	Nonshoot	1A		2B	3C	4CD	5D	6E	1A	3C	2B
	101	93-94	Pooled	Nonshoot	1A		2B	3B	4B	5B	6B	1A	2B	3B
	137	Pooled	HY	Nonshoot	1A		2B	3C	5D	4D	6E			
	138	Pooled	AHY	Nonshoot	1A		2B	3C	4D	5D	6E			
PreN	274	Pooled	Pooled	Nonshoot	1A		2B	3C	5D	4D	6E	1A	3C	2B
	85	91-92	Pooled	Nonshoot	1A		2B	3C	5D	4D	6E	1A	3B	2A
	88	92-93	Pooled	Nonshoot	1A		2B	3C	4D	5DE	6E	1A	3C	2B
	101	93-94	Pooled	Nonshoot	1A		2B	3B	4B	5B	6C	1A	3C	2B
HntD	365	Pooled	Pooled	Pooled	1A	2B	3C	4D	5E	6F	7G	2B	1A	3C
	100	91-92	Pooled	Pooled	1A	2B	3B	5C	4B	6D	7E	2B	1A	3C
	108	92-93	Pooled	Pooled	1A	2B	4C	5D	3BC	6E	7F	2B	1A	3C
	157	93-94	Pooled	Pooled	1A	3B	2B	5C	4C	6D	7E	2B	1A	3C
	347	Pooled	Pooled	Shoot	1A	2B	4C	5D	3B	6E	7F	2B	1A	3C
	337	Pooled	Pooled	Nonshoot	1A	2B	3B	5C	4C	6E	7F	2B	1A	3C
HntN	348	Pooled	Pooled	Pooled	1A	2B	3C	4D	6F	5E	7G	1A	3C	2B
	96	91-92	Pooled	Pooled	1A	2B	3B	4C	6D	5D	7F	1A	3C	2B
	102	92-93	Pooled	Pooled	1A	2B	3C	4D	6F	5E	7G	1A	3C	2B
	150	93-94	Pooled	Pooled	1A	3B	2B	4C	6E	5D	7F	1A	3C	2B
PosD	75	Pooled	Pooled	Nonshoot	1A	2B	3BC	4C	6E	5E	7F	1A	3C	2B
	16	91-92	Pooled	Nonshoot	1A	4BC	2A	3AB	5CD	6D	7D			
	36	92-93	Pooled	Nonshoot	1A	2B	4B	3B	6C	5C	7D			
	23	93-94	Pooled	Nonshoot	1A	3B	2B	4C	5C	6D	7D			
PosN	71	Pooled	Pooled	Nonshoot	1A	2B	3B	4B	6C	5C	7D	1A	3C	2B
	15	91-92	Pooled	Nonshoot	3AB	4B	2A	1A	5BC	6C	7C			
	32	92-93	Pooled	Nonshoot	1A	2B	4CD	3BC	6E	5DE	7F			
	24	93-94	Pooled	Nonshoot	1A	3B	2B	4C	6C	5C	7C			
	31	Pooled	HY	Nonshoot								1A	3B	2AB
	40	Pooled	AHY	Nonshoot								1A	3C	2B

[a]Comparisons by year, pintail age, or shoot status are listed only when rankings for that variable differed (Wilks= Lambda test, $P < 0.05$); rankings for birds with different body condition did not differ.

[b]Rankings with same letters not different (t-test, $P < 0.05$). Rice not ranked during prehunt because none was flooded.

[c]Number of radio-tagged pintails.

DISCUSSION

Foraging Habitats Selection

Pintails throughout the Central Valley feed primarily on seeds during Prehunt to replenish fat reserves lost during migration but invertebrates comprise a major portion of the diet in spring to provide protein for rapid growth of reproductive organs (Miller 1987). Invertebrates do not comprise a major portion of the pintail diet in the Sacramento Valley until February (Miller 1987) but in the SJV invertebrates make up a major portion of the pintail diet as early as November (Beam and Gruenhagen[4] 1980, Connelly and Chesemore 1980, Euliss[3] 1984). The reason invertebrates were prominent in the pintail diet earlier in the SJV is unknown. However, based upon habitat selection we observed, we speculate that without abundant flooded agriculture like in the Sacramento Valley, pintails (and probably other waterfowl) almost completely relied upon managed marsh habitats and depleted wetland seeds in SJV marshes earlier.

Swamp timothy marsh produces greater biomass of invertebrates than other SJV marsh types (Severson[15] 1987), which may explain why pintails continued their high use of timothy marsh throughout winter. However, pintails immediately selected the only flooded rice fields in the GEA when they became available in November, even though these habitats were farther from sanctuary than all others (Fleskes et al. 2002*a*). In addition, most pintails left the SJV and flew to Sacramento Valley rice fields during early December (Fleskes et al. 2002b). Thus, availability of preferred seeds is apparently a key factor when pintails select feeding habitats but invertebrate availability may become more important as seeds decline or physiological needs change.

In contrast to the low night use of GEA watergrass marsh by pintails that we observed, pintails at Mendota WA (Fleskes[2] 1999) and Kern NWR (Euliss and Harris 1987) used watergrass extensively at night. We speculate two possible reasons for why pintail use of watergrass varies among areas. First, management or structure of watergrass marsh may differ among areas in ways that makes watergrass attractive to foraging pintails in Mendota WA and Kern NWR but not in the GEA. For instance, watergrass fields at Mendota WA were drained earlier than those at Salt Slough WA in the GEA and allowed to dry before reflooding (G. Gerstenberg, California Department of Fish and Game, Los Banos, California, USA, personal communication), resulting in a shorter, less dense stand with seeds that ripen and disperse when reflooded. Alternatively, the level of competition with mallards, *Anas platyrhynchos*, in watergrass marsh may vary among areas and impact use of watergrass marsh by pintails. Pintails are well adapted to feed in timothy marsh, the habitat they normally selected in the GEA. The pintail bill is structured for efficient collection of small seeds (Krapu 1974) and may provide an advantage over larger-billed species, such as mallards for feeding on swamp timothy seeds. However, this advantage for pintails may be lost

---

[15]Severson, D. J. 1987. Macroinvertebrate populations in seasonally flooded marshes in the northern San Joaquin Valley of California. Thesis, Humboldt State University, Arcata, California, USA.

when competing with mallards for the larger watergrass seeds. Thus, with mallards more abundant in the GEA than in the Tulare Basin and Mendota WA (California Department of Fish and Game, Sacramento, California, unpublished data), pintails in the GEA may have selected timothy rather than watergrass marsh for feeding because they have the competitive advantage over mallards when feeding on timothy seeds but not on the larger watergrass seeds. Pintails do feed extensively on the relatively large rice seeds in the Sacramento Valley (Miller 1987), where mallards are even more abundant than in the GEA (California Department of Fish and Game, Sacramento, California, unpublished data). However, other factors such as seed abundance or the lack of emergent vegetation may make harvested rice fields attractive to pintails even when mallards are abundant.

Our finding that foraging pintails selected swamp timothy is consistent with food habit studies at Los Banos WA (Beam and Gruenhagen[4] 1980, Connelly and Chesemore 1980) where seeds of swamp timothy were the most common vegetative food found in collected birds. However, watergrass seeds were also very common in pintails collected on Los Banos WA, suggesting that either habitat use on Los Banos WA was not representative of habitats used throughout the GEA, or use of watergrass during our study was lower than during those studies. Beam and Gruenhagen[4] (1980) did conclude that swamp timothy was the most sought after food by pintails because although swamp timothy decreased in importance during winter as watergrass (and associated sprangletop, *Leptochloa* spp.) increased, pintails did not use watergrass in greater proportion than its availability. Miller (1983) observed pintails diving for swamp timothy seeds in the Sacramento Valley.

Pintails selected open and shallow seasonal marsh and flooded fields during most days and all nights and avoided deep habitats (i.e., evaporation and sewer ponds, reservoirs). Isola et al. (2000) also reported that water depth, percent open water, and percent emergent vegetation were the most highly correlated factors with pintail diurnal foraging sites in GEA marshes; they did not measure night use. Euliss[3] (1984) reported highest pintail day use in open marsh at Kern NWR but that densely vegetated marsh (especially watergrass) received nearly all night use by pintails. It is unclear why our night use findings disagreed with Euliss[3] (1984), but open habitats, especially timothy marsh and rice fields, were selected by pintails we located at night and in contrast to the conclusion made by Euliss[3] (1984) that pintails avoid open habitats at night.

Roosting Habitat Selection

Numerous factors determine where pintails roost. During this study, most pintails in GEA roosted near foraging sites (Fleskes et al. 2002a), but before San Luis NWR and other sanctuaries were established in the 1960s, most flew to San Luis Reservoir on shoot days (California Department of Fish and Game, Sacramento, California, USA, unpublished data), a situation similar to that described by Cox and Afton (1997). Thus, disturbance avoidance was probably more important in roost selection than other site characteristics (Wolder[16] 1993). During nonhunting intervals and nonshoot days, most pintails day-roosted in the same areas used at night, indicating that if undisturbed, pintails prefer to roost near foraging sites in shallow, open habitats. High shoot day ranking of watergrass may have been coincidental because most watergrass in the GEA was in San Luis and Merced NWR sanctuaries.

Pintail Age and Condition

Habitat selection by HY and AHY female pintails was similar, although ranking significance differed. Immature birds have been reported to be less selective (Draulans and Vessem 1985, Warnock and Takekawa 1995), but the less significant rankings that we observed in some instances for HY could also be due to their smaller sample sizes. We observed no relationship between pintail body condition in fall and habitat use during winter.

MANAGEMENT IMPLICATIONS

Preferred late-winter habitats were apparently lacking in the GEA during 1991-94, at least relative to in the Sacramento Valley and Delta, where most pintails moved to in December each year. Abundance of pintails in the GEA declined greatly during December as most went to the Sacramento Valley or Delta (Fleskes et al. 2002b). Some radio-tagged pintails revisited the GEA but only briefly before again going back to the Sacramento Valley or Delta (Fleskes et al. 2002b).

Although numerous factors, including the amount of sanctuary, impacts how attractive landscapes are to pintails, the earlier decline of seeds in the pintail diet in the GEA than in the Sacramento Valley (Beam and Gruenhagen[4] 1980, Connelly and Chesemore 1980, Miller 1987) and the long flights that pintails made to rice fields in the GEA immediately upon their flooding (Fleskes 2002a), indicates that food supplies, especially seeds, were probably depleted or at least less abundant in the GEA than in the Sacramento Valley and Delta by late-winter. Most SJV wetlands are intensively managed to maximize seed production and are flooded fully by early November to allow waterfowl hunting or provide sanctuary. This system apparently provides good early-winter habitat most years but has only partially mitigated the loss of late-winter habitat. Future management should increase preferred late-winter habitats and amounts of foods available to pintails during late-winter. Incentives could be used to encourage flooding of harvested rice or other preferred crops during late winter and delay flooding of some new or existing wetlands.

Restoration efforts for pintails should emphasize shallow habitats (i.e., $\leq$30 cm, Isola et al. 2000). Pintails that we studied clearly preferred shallow over deep-water habitats and given adequate quantities of high quality shallow-water habitats, pintails would

[16]Wolder, M. A. 1993. Disturbance of wintering northern pintails at Sacramento National Wildlife Refuge, California. Thesis, Humboldt State University, Arcata, California, USA.

be diverted away from evaporation and sewer ponds, thus reducing the contaminant and disease risk sometimes associated with those areas (Moulton et al. 1976, Custer et al. 1996, Lemly and Ohlendorf 2002). Female pintails selected timothy marsh whenever available and management plans emphasizing this habitat would benefit pintails. Information on seasonal availability and depletion rates of seeds and invertebrates are needed for habitats throughout the Central Valley.

In contrast to concern of the past trend towards open marshes (Euliss and Harris 1987), we caution that monitoring is needed to determine what impact a shift in the SJV towards more closed marsh will have on pintails, shorebirds, and other fauna that are associated with open wetland habitats. An increased discrepancy in the daily bag limit for mallards and pintails (0 difference before 1988, 2-3 more mallards permitted during 1988-94, 4-6 more mallards during 1995-99, California Department of Fish and Game, Sacramento, CA, USA, unpublished data) may lead to increased conversion of open marsh to hemi-closed permanent or semi-permanent marsh, that managers perceive as being more favorable for mallard harvest or production. Increased water availability due to the 1992 Central Valley Project Improvement Act (Davis 1992) has provided managers with the opportunity to provide a more diverse array of habitats and may increase conversion of timothy wetlands to watergrass wetlands, that require more water but can produce greater seed crops. As seen in Kern NWR (Euliss and Harris 1987) and Mendota WA (Fleskes[2] 1999), watergrass marsh can be attractive to pintails and has potential to provide late winter seeds that pintails are apparently seeking when they move to Sacramento Valley rice fields. However, additional research is needed to determine why pintails selected watergrass for feeding in some SJV areas but not in GEA during this study.

ACKNOWLEDGMENTS

Numerous individuals and organizations contributed to the success of this study. C. Meslow, J. Moore, C. Pereira, and W. B. Shephard provided guidance that improved all aspects of this project. The staffs of Grassland Water District, Natural Resources Conservation Services, San Luis and Kern NWRs, and Mendota and Los Banos WAs provided housing, habitat information, or logistical support. Nearly all landowners we contacted permitted trapping or tracking access and nearly all hunters reported and provided information about pintails they recovered. M. Carriere of Busch Agriculture donated rice for trapping. L. Belt, D. Breneman, D. Buford, M. Chouinard, Jr., C. Davis, R. Dunston, M. Humpert, P. Johnston, J. Laffitte, K. Mazacco, C. Stemler, and K. Young trapped and tracked pintails. California Department of Fish and Game donated aerial search costs. C. Fleskes, K. Lee, and G. Martinelli entered habitat data and W. Perry and J. Daugherty provided GIS support. J. L. Lee provided extensive statistical support. M. Wolder, P. Hofmann, D. Gifford, and K. Hashagen provided comments that improved the manuscript.

LITERATURE CITED

Aebischer, N. J., P. A. Robertson, and R. E. Kenward. 1993. Compositional analysis of habitat use from radio-tracking data. Ecology 74:1313-1325.

Aitchison, J. 1986. The statistical analysis of compositional data. Chapman and Hall, New York, New York, USA.

Austin, J. E., and M. R. Miller. 1995. Northern pintail, *Anas acuta*,. Number 163 *in* A. Poole and F. Gill, editors. The Birds of North America. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C., USA.

Cochran, W. W., and R. D. Lord, Jr. 1963. A radio-tracking system for wild animals. Journal of Wildlife Management 27:9-24.

Connelly, D. P., and D. L. Chesemore. 1980. Food habits of pintails, *Anas acuta*, wintering on seasonally flooded wetlands in the northern San Joaquin Valley, California. California Fish and Game 66:233-237.

Cox, R. R., Jr., and A. D. Afton. 1997. Use of habitats by female northern pintails wintering in southwestern Louisiana. Journal of Wildlife Management 61:435-443.

Custer, T. W., D.W. Sparks, S. A. Sobiech, R. K. Hines, and M. J. Melancon. 1996. Organochlorine accumulation by sentinel mallards at the Winston-Thomas sewage treatment plant, Bloomington, Indiana. Archives of Environmental Contamination and Toxicology 30:163-169.

Davis, P. A. 1992. Omnibus western water law. Congressional Quarterly. November 21, 3687-3690.

Dodge, W. E., and A. J. Steiner. 1986. XYLOG:A computer program for field processing locations of radio-tagged wildlife. U.S. Fish and Wildlife Service Technical Report 4.

Draulans, D., and J. V. Vessem. 1985. Age-related differences in the use of time and space by radio-tagged grey herons (*Ardea cinerea*) in winter. Journal of Animal Ecology 54:771-780.

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

Elphick, C. S. 2000. Functional equivalency between rice fields and seminatural wetland habitats. Conservation Biology 14:181-191.

Euliss, N. H., Jr., and S. W. Harris. 1987. Feeding ecology of northern pintails and green-winged teal wintering in California. Journal of Wildlife Management 51:724-732.

Fleskes, J. P., D. S. Gilmer and R. L. Jarvis. 2002a. Distribution of female northern pintails in relation to hunting and location of hunted and non-hunted habitats in the Grassland Ecological Area, California. California Fish and Game 88:75-94.

Fleskes, J. P., R. L. Jarvis, and D. S. Gilmer. 2002b. Distribution and movements of female northern pintails radio tagged in the San Joaquin Valley, California. Journal of Wildlife Management 66:138-152.

Gilmer, D. S., L. M. Cowardin, R. L. Duval, L. M. Mechlin, C. W. Shaiffer, and V. B. Kuechle. 1981. Procedures for the use of aircraft in wildlife bio-telemetry studies. U.S. Fish and Wildlife Service Resource Publication 140.

Gilmer, D. S., M. R. Miller, R. D. Bauer, and J. R. LeDonne. 1982. California's Central Valley wintering waterfowl: concerns and challenges. Transactions of the North American Wildlife and Natural Resources Conference 47:441-452.

Heitmeyer, M. E., D. P. Connelly, and R. L. Pederson. 1989. The Central, Imperial, and Coachella valleys of California. Pages 475-505 *in:* L. M. Smith, R.L. Pedersen, and R.M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech Press, Lubbock, Texas, USA.

Isola, C. R., M. A. Colwell, O. W. Taft, and R. J. Safran. 2000. Interspecific differences in habitat use of shorebirds and waterfowl foraging in managed wetlands of California's San Joaquin Valley. Waterbirds 23:196-203.

Johnson, R. A., and D. W. Wichern. 1982. Applied multivariate statistical analysis. Second edition. Prentice Hall, Englewood Cliffs, New Jersey, USA.

Krapu, G. L. 1974. Feeding ecology of pintail hens during reproduction. Auk 91:278-290.

Lemly, A. D., and H. M. Ohlendorf. 2002. Regulatory implications of using constructed wetlands to treat selenium-laden wastewater. Ecotoxicology and Environmental Safety 52:46-56.

Miller, M. R. 1983. Foraging dives by post-breeding northern pintails. Wilson Bulletin 95:294-296.

Miller, M. R. 1985. Time budgets of northern pintails wintering in the Sacramento Valley, California. Wildfowl 36:53-64.

Miller, M. R. 1986. Northern pintail body condition during wet and dry winters in the Sacramento Valley, California. Journal of Wildlife Management 50:189-198.

Miller, M. R. 1987. Fall and winter foods of northern pintails in Sacramento Valley, California. Journal of Wildlife Management 51:405-414.

Moulton, D. W., W. I. Jensen, and J. B. Low. 1976. Avian botulism epizootiology on sewage oxidation ponds in Utah. Journal of Wildlife Management 40:735-742.

Pietz, P. J., D. A. Brandt, G. L. Krapu, and D. A. Buhl. 1995. Modified transmitter attachment method for adult ducks. Journal of Field Ornithology 66:408-417.

Raveling, D. G., and M. E. Heitmeyer. 1989. Relationships of population size and recruitment of pintails to habitat conditions and harvest. Journal of Wildlife Management 53:1088-1103.

SAS Institute. 1989. SAS/IML software: usage and reference. Version 6. SAS Institute, Cary, North Carolina, USA.

Schemnitz, S. D. 1994. Capturing and handling wild animals. Pages 106-124 *in:* T. A. Bookhout, editor. Research and management techniques for wildlife habitats. Fifth edition. The Wildlife Society, Bethesda, Maryland, USA.

Warnock, S. E., and J. Y. Takekawa. 1995. Habitat preferences of wintering shorebirds in a temporally changing environment: western sandpipers in the San Francisco Bay Estuary. Auk 112:920-930.

Received: 18 July 2002
Accepted: 6 October 2003