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PINTAIL DISTRIBUTION AND SELECTION OF MARSH TYPES AT MENDOTA WILDLIFE AREA DURING FALL AND WINTER

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To help guide management of Mendota Wildlife Area (MWA), we determined distribution patterns and use relative to availability (i.e., selection) of lake vs. shallow marsh, and shallow marsh by dominant understory vegetation and percentage of emergent cover during September through March, 1991-94 for 145 female northern pintails, *Anas acuta*. Pintails were radio tagged during August - early October at MWA (n = 116), other San Joaquin Valley areas (n = 27), or Suisun Marsh (n = 2). Before duck hunting season (i.e., Prehunt), pintail distribution at MWA generally tracked marsh flooding although distribution was more concentrated during the day than night. During duck hunting season (i.e., Hunt), pintails that had not left MWA sought sanctuary on units closed to shooting and at night dispersed throughout the area; most returned to sanctuary units on both shoot (Wednesdays and weekends) and nonshoot days. Pintails present during Posthunt (i.e., after Hunt ended) dispersed throughout MWA. Pintails avoided the central lake in favor of the more shallow marsh units throughout MWA. Among the marsh units, pintails selected open and avoided heavily vegetated units at night. Open marsh units were also selected during the day during Posthunt and, except in 1993, during Prehunt. However, closed or hemi marshes were selected during day during Hunt. Marshes where swamp timothy, *Heleochloa schoenoides*, was the dominant or prominent understory plant were always selected and received more use by pintails than any other marsh type. Watergrass, *Echinochloa crusgalli*, marsh was avoided during the day but, along with timothy marsh, selected at night most years. Selection of marsh where alkali bulrush, *Scirpus paludosus*, or other non-timothy or non-watergrass plants were primary understory plants ranked in the middle during the day but were avoided at night. Our finding that foraging pintails selected swamp timothy is consistent with food habits and habitat use reported elsewhere, but the greater use of watergrass marsh at MWA than in the

Grassland Ecological Area indicates regional differences in management or pintail ecology. Exodus of pintails coinciding with start of Hunt indicates that some aspect of the sanctuary or other habitats were lacking at MWA, and will need to be improved to maintain pintail use all winter.

INTRODUCTION

The Mendota Wildlife Area (MWA) wetland complex in California's San Joaquin Valley lies between important waterfowl wintering habitats in the vicinity of Kern National Wildlife Refuge (NWR), 100 km to the southeast, and the Grassland Ecological Area, 50 km to the northwest (Fig. 1). The MWA supports large concentrations of northern pintails, *Anas acuta*, and other waterfowl while providing recreation to thousands of hunters, fishermen, wildlife watchers, and others pursuing an outdoor experience. Surrounded by crop fields that are mostly plowed after harvest and left dry, waterfowl wintering at MWA rely almost entirely upon wetland resources within the MWA. Thus, the need to provide preferred habitats and intensively manage those habitats for maximum productivity is especially crucial. To accomplish their mandate of providing for the needs of wintering waterfowl, managers require information on how important waterfowl species such as northern pintails use the area and select among the variety of marsh types that are available at MWA.

Although pintail distribution, habitat use, and selection have been reported for other San Joaquin Valley areas (Fleskes et al. 2002a, 2003, 2004), the dynamics of pintail distribution at MWA and use and selection from among the mix of marsh types available there have not been studied. MWA is comprised of numerous marsh units of known vegetation composition and flooding regime, all well within the maximum daily flight range of pintails (43 km, Fleskes 1999) roosting in the central sanctuary or elsewhere on the area, and is surrounded by dry agricultural lands. Thus, MWA provides an excellent setting to test habitat use relative to availability (i.e., selection) by pintails.

Roosting and foraging are primary activities of pintails wintering in California (Miller 1985). Pintails feed extensively at night during all seasons, with most roosting occurring during the day. However, time spent roosting during day is reduced due to extensive day feeding before duck hunting season (i.e., Prehunt) to replenish fat reserves depleted by breeding and fall migration and after hunting season (i.e., Posthunt) to prepare for spring migration and nesting (Euliss[1] 1984, Miller 1985, 1986). Thus, habitat use at night throughout the September - March wintering period mainly reflects foraging site selection, daytime use during hunting season (i.e., Hunt) mainly reflects loafing site selection, and daytime use before and after hunting season reflects both foraging and loafing site selection.

To provide information for wetland habitat managers, we studied use of MWA by female northern pintails, during September through March, 1991-94. We studied only females because they are especially important to population dynamics (Flint et al. 1998)

[1]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.

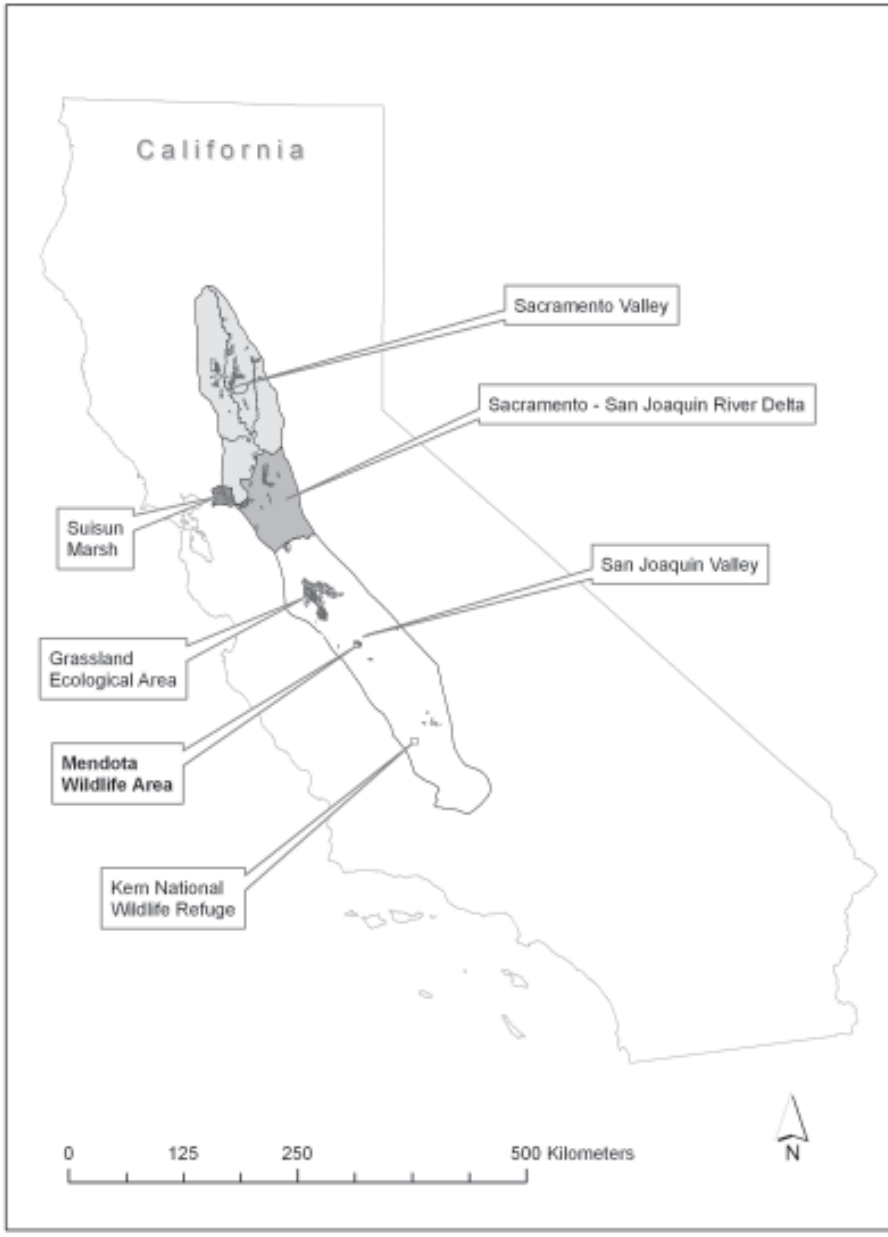

Figure 1. The Mendota Wildlife Area (MWA) in the San Joaquin Valley of California's Central Valley. Habitat use and selection by female northern pintails, *Anas acuta*, in the MWA were studied during September - March, 1991-94 for 145 pintails that were radio tagged in the MWA, Grassland Ecological Area (50 km northwest of the MWA), the Tulare Basin near Kern National Wildlife Refuge (100 km southeast of the MWA), or the Suisun Marsh (230 km northwest of the MWA).

and funding was adequate to study only one sex (sample size had to be sufficient for other study objectives [e.g., survival estimation]). Our goals were to: 1) document distribution patterns and determine day and night habitat use and selection during Prehunt, Hunt, and Posthunt; 2) identify the relative importance of roosting and feeding habitats for pintails in the MWA; and 3) test the null hypothesis that use of each habitat would equal its availability.

STUDY AREA

MWA is comprised of approximately 2,600 ha of wetlands open to waterfowl hunting and a 364-ha sanctuary (Fig. 2) (Fleskes[2] 1999). Most marsh is seasonal and is dry during summer except for periodic irrigations delivered via a series of interconnected ditches 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. Additional water is delivered to flood marshes starting in mid-August, so most are fully flooded by the start of waterfowl hunting season. Periodic water deliveries and late-winter rains maintain water levels in marshes throughout hunting season. After hunting season, water is drained from marshes to allow wetland plants to germinate.

Duck hunting daily bag limits and season lengths remained constant during the study, but the timing of 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[3] 1991, California Department of Fish and Game[4] 1992, California Department of Fish and Game[5] 1993). MWA 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.

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[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]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.

[4]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.

[5]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.

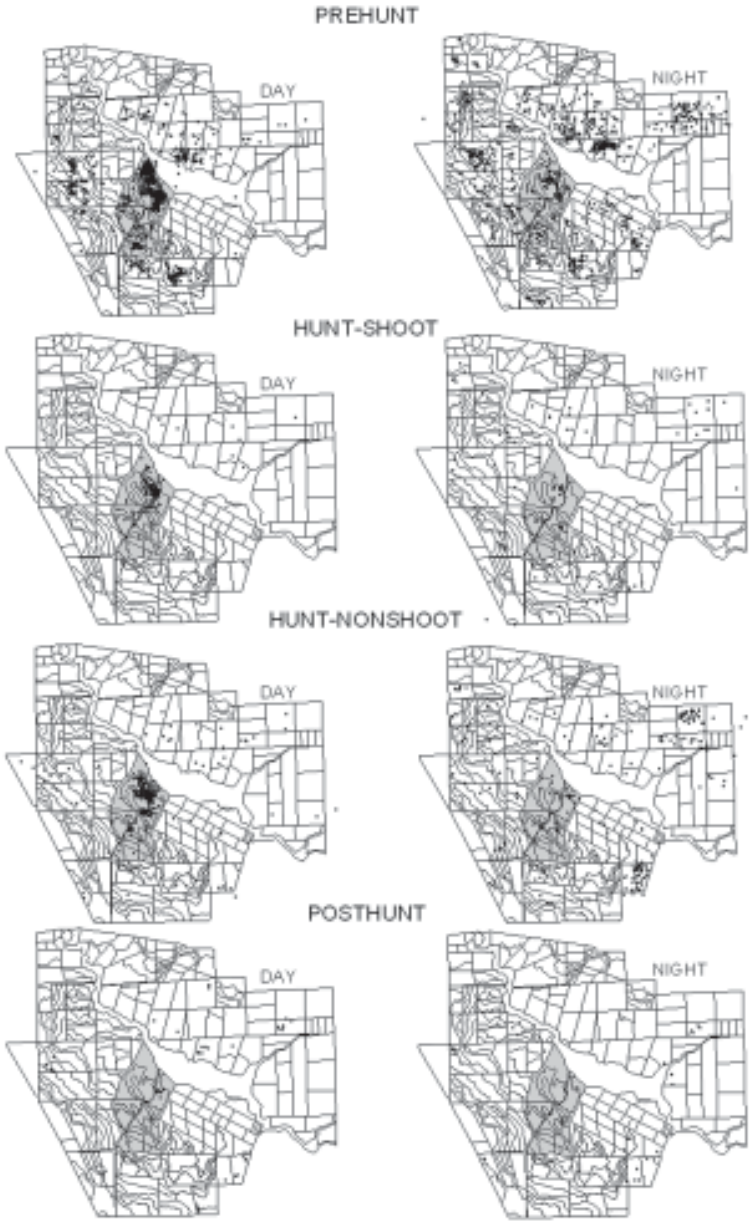

Figure 2. Day and night locations (points) of radio-tagged female northern pintails, *Anas acuta*, in the Mendota Wildlife Area before (prehunt), on shoot (Wednesdays and weekends) and nonshoot days during (hunt), and after (posthunt) the duck hunting season, 1991-94. Duck hunting was not allowed in the shaded marsh units (sanctuary) but was allowed in the lake (large central unit oriented northwest-southeast on the north border of the sanctuary) and all the other units.

METHODS

Classifying Habitat

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

MWA was composed of a mostly open central lake and numerous more shallow marsh units (Fig. 2). Vegetation and weekly flooding data were mapped for each unit by a MWA biologist. Based upon the dominant understory vegetation, we classified the MWA marsh units (excluding the lake) and three privately-held in-holding marsh units as: 1) swamp timothy (includes pricklegrass); 2) watergrass (usually associated with sprangletop, *Leptochloa* spp.); 3) alkali bulrush, *Scirpus paludosus*; 4) upland plants; and 5) other (primarily *Juncus* spp., *Paspalum distichum*, *Polygonum* spp.). We further classified marsh units (excluding the lake) with <25% of surface area with emergent vegetation (i.e. *Typhus* sp., *Juncus* spp., etc.) as "open", 25-75% as "hemi" and ≥76% as "closed".

Measuring Habitat Availability

To represent the average amount of each habitat type that was available to the radio-tagged pintails in the MWA 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 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 MWA during August-March, 1991-94. Finally, because the number of radio-tagged pintails present in the MWA changed each week due to emigration, 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 MWA 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 within intervals were more similar than across intervals. Weighting weekly flooding estimates by the number of pintail locations that week to calculate interval averages avoided potential bias in comparisons of habitat availability and use by our radio-tagged sample of pintails. For instance, suppose timothy units comprised a greater proportion of total flooded habitat during the first few weeks of Prehunt, when few radio-tagged pintails

were present because we had not yet radio tagged our entire sample, than during the later weeks of Prehunt, by which time the entire radio-tagged sample of pintails were at Mendota WA. Then calculating an average availability of timothy during Prehunt without weighting weekly flooding estimates by our weekly sample size would overestimate the true percentage of total habitat comprised by timothy that was available on average during Prehunt to an average radio-tagged pintail. This hypothetical overrepresentation of actual timothy availability would result in a bias against finding selection of timothy by pintails in the comparison of habitat use vs. availability during Prehunt.

Measuring Habitat Use

Pintail Capture and Tracking

We periodically pinpointed locations of 145 radio-tagged female pintails (n = 30 in 1991-92, 30 in 1992-93, and 85 in 1993-94) to track their habitat use in the MWA during September through late March, 1991-94. We studied MWA habitat use of all 46 Hatch-Year (HY) and 70 After-Hatch-Year (AHY) pintails that we radio tagged in MWA, 5 HY and 8 AHY pintails that we radio tagged in the Grassland Ecological Area, 7 HY and 7 AHY pintails that we radio tagged in post-harvest flooded fields near Kern NWR, and 1 AHY and 1 HY pintails that Casazza[6] (1995) radio tagged in Suisun Marsh (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[7] 1992), weighed ($\pm$ 5 g), measured (flat wing, culmen 1, total tarsus [Dzubin and Cooch[8] 1992]), radio tagged (Dwyer 1972, Pietz et al. 1995), and released at the capture site.

We scanned the MWA entirely from trucks and aircraft (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$2 days and nights each week during Prehunt and Posthunt. We obtained two bearings from known locations using a truck-mounted dual-Yagi null-peak telemetry system (Cochran and Lord 1963) to minimize time between bearings and because preliminary tests showed more bearings did not increase accuracy in our flat, open study areas. We obtained >89% of locations <1.6 km from the bird at 50-130 degree angles. Warnock and Takekawa (1995) reported an average azimuth error of 1.5 degrees and an error polygon of 1.1 ha with location distances 0.5-3.0 km using an identical system, which is much smaller than the average size of habitat polygons ($\bar{x}$ = 17.2 ha) in the MWA. We

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

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

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

calculated pintail locations using a modified version of XYLOG and UTMTEL (Dodge et al.[9] 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 MWA available for potential use by each pintail in the MWA because all flooding was well within the daily pintail flight range from major pintail roost sites in the MWA (Fleskes[2] 1999). 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 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 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

Habitat Area

Area of flooded habitat differed among intervals but was similar among study years (Table 1). The average area of flooded marsh was 2-3 times greater during Hunt and Posthunt than during the Prehunt interval. Despite annual variation in precipitation (California Department of Water Resources[10] 1991, National Oceanic and Atmospheric Administration, Asheville, North Carolina, USA, unpublished data), water supplies to flood MWA marshes were consistently available during the study. Thus, unlike in other parts of the San Joaquin Valley (Fleskes[2] 1999), area of waterfowl habitat at MWA was similar among study years. A weekly average of 949-1,256 ha of shallow marsh was flooded during Prehunt and 2,565-2,762 ha of shallow marsh was flooded during Hunt and Posthunt; area of the slighty deeper lake in the center of MWA ranged between 269 ha and 364 ha (Table 1).

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

[10]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.

Table 1. Mean weekly flooded hectares of lake and marsh habitat at Mendota Wildlife Area during Prehunt, Hunt, and Posthunt, 1991-94. Flooded hectares of marsh (i.e., excluding the lake) where swamp timothy (T), watergrass (W), alkali bulrush (A), other wetland (O), or upland (U) plants were the dominant plants and by emergent cover (<25% open, ≥25-75% hemi, >75% closed) are also presented.

	PREHUNT			HUNT			POSTHUNT		
Habitat	1991-92	1992-93	1993-94	1991-92	1992-93	1993-94	1991-92	1992-93	1993-94
Lake	364	364	364	364	364	337	364	364	269
Marsh	1,256	949	1,075	2,568	2,593	2,762	2,565	2,672	2,610
T	857	686	686	1,763	1,726	1,699	1,771	1,735	1,622
W	87	66	154	261	386	539	268	423	573
A	60	15	20	83	22	20	69	15	10
O	224	154	163	401	357	310	412	336	235
U	28	28	52	60	102	194	45	163	170
Open	732	627	815	1,711	1,994	2,244	1,721	2,088	2,150
Hemi	437	250	201	766	501	429	746	486	395
Closed	87	72	59	91	98	89	98	98	65

General Patterns of Use

Distribution and movement patterns of pintails within MWA varied by season. During Prehunt, pintail distribution generally tracked flooding of marsh units although their distribution was more concentrated during the day and more dispersed within and among units at night (Fig. 2). During Hunt, the few pintails that did not leave MWA dispersed throughout the area at night but mostly returned to the sanctuary units on both shoot and nonshoot days. The few pintails present during Posthunt dispersed throughout MWA during both day and night (Fig. 2)

Use and Selection of the Lake vs. Marsh Units

Although the lake in the center of MWA comprised 11-20% of the average weekly flooded area there, female pintails avoided it in favor of the marsh units throughout the rest of the area ($t \geq 21.70$, $P < 0.001$). Except for Posthunt nights, $\leq$1% of pintail locations were ever in the lake (Table 2).

Use and Selection of Marsh by Dominant Understory Plant

Swamp timothy marsh received more pintail use than any other marsh type, comprising 65-71% of the marsh available and receiving 63-91% of the use by pintails (Table 2). Pintail use of watergrass marsh was greater at night than during day and greater during Hunt and Posthunt than during Prehunt (Table 2). Female pintails selected timothy marsh during all intervals; watergrass marsh was avoided during the day, but along with timothy marsh, was selected at night during most years (Table 3). Selection of flooded marsh where upland plants, alkali bulrush, or other "non-timothy or watergrass" plants were primary understory plants ranked in the middle during the day but was avoided at night during most intervals and years. Selection strength differed among years and between shoot and nonshoot dates but rankings were similar (Table 3).

Use and Selection of Open vs. Hemi vs. Closed Marsh

Use and selection of marsh by the percentage of emergent cover varied. Closed marsh comprised $\leq$5% of the available marsh but received 27% of the use during day during Prehunt and 26% during Hunt; use of closed marsh was minimal at night in all seasons and during Posthunt days (Table 2). Pintails selected open and avoided closed marsh at night; selection during the day varied among seasons and years (Table 3). During Prehunt days, open marsh was selected in 1991 and 1992 but closed marsh was selected in 1993. During Hunt days, closed or hemi marsh was selected. During Posthunt days, open marsh was selected.

Selection Relative to Pintail Body Mass and Age

Habitat rankings were nearly identical for HY and AHY pintails. Pintail age appeared

Table 2. Composition (proportions) of wetland types (lake, marsh), marsh by dominant plant (swamp timothy [T], watergrass [W], alkali bulrush [A], other wetland [O], or upland [U] plants), and marsh by emergent cover (<25% open, ≥25-75% hemi, >75% closed) that was available (Avail = $\bar{x}$ of weekly proportions weighted by number of pintail locations) and used during prehunt, hunt, and posthunt days and nights by 145 radio-tagged female northern pintails, *Anas acuta*, at Mendota Wildlife Area, 1991-94.

	PREHUNT			HUNT			POSTHUNT		
Habitat	Avail	Day use	Night use	Avail	Day use	Night use	Avail	Day use	Night use
Lake	0.20	<0.01	<0.01	0.12	<0.01	0.01	0.11	<0.01	0.08
Marsh	0.80	>0.99	>0.99	0.88	>0.99	0.99	0.89	>0.99	0.92
T	0.71	0.91	0.86	0.66	0.90	0.69	0.65	0.87	0.63
W	0.10	0.01	0.05	0.14	0.02	0.24	0.16	0.11	0.32
A	0.02	<0.01	<0.01	0.02	<0.01	<0.01	0.01	<0.01	<0.01
O	0.15	0.08	0.08	0.14	0.06	0.06	0.13	<0.01	0.03
U	0.02	0.01	0.01	0.04	0.01	0.01	0.05	0.03	0.01
Open	0.70	0.51	0.73	0.74	0.42	0.76	0.76	0.93	0.88
Hemi	0.25	0.22	0.20	0.22	0.32	0.22	0.21	0.07	0.12
Closed	0.05	0.27	0.07	0.04	0.26	0.02	0.03	<0.01	<0.01

Table 3. Selection by radio-tagged female northern pintails, *Anas acuta*, of marshes classified by dominant vegetation (swamp timothy [T], watergrass [W], alkali bulrush [A], other wetland [O], upland plants [U]) and emergent cover (<25% open, 25-75% hemi, >75% closed) at Mendota Wildlife Area, California, during prehunt (Pre), hunt (Hnt) and posthunt (Pos) days (D) and nights (N), 1991-94.

Comparison[a]					Ranking[b] by dominant plant					Ranking by % cover		
Interval	n	Year	Age	Shoot Status	T	W	A	O	U	open	hemi	closed
PreD	131	Pooled	Pooled	Nonshoot	1A	5C	2B	3B	4B	3B	2B	1A
	28	1991-92	Pooled	Nonshoot	1A	5D	4D	2B	3C	1A	2A	3A
	27	1992-93	Pooled	Nonshoot	1A	5D	3C	2B	4CD	1A	2B	3B
	76	1993-94	Pooled	Nonshoot	1A	5C	2B	4C	3B	3C	2B	1A
	80	Pooled	HY	Nonshoot						3B	2B	1A
	51	Pooled	AHY	Nonshoot						2A	3A	1A
PreN	131	Pooled	Pooled	Nonshoot	1A	2B	4B	3B	5B	1A	2B	3C
HntD	70	Pooled	Pooled	Pooled	1A	5D	2B	4C	3C	3B	2A	1A
	17	1991-92	Pooled	Pooled	1A	5C	4BC	3BC	2B	2AB	3B	1A
	13	1992-93	Pooled	Pooled	1A	5C	2B	4BC	3B	3A	2A	1A
	40	1993-94	Pooled	Pooled	1A	5C	2B	4C	3C	3B	1A	2AB
HntN	57	Pooled	Pooled	Pooled	1A	2B	4B	3B	5B	1A	2B	3B
	13	1991-92	Pooled	Pooled	1A	2AB	4BC	5C	3B	1A	2AB	3B
	11	1992-93	Pooled	Pooled	1A	4B	2B	3B	5B	1A	2A	3B
	33	1993-94	Pooled	Pooled	1A	2A	3B	4C	5C	1A	3C	2B
	26	Pooled	Pooled	Shoot	1A	3B	2B	5C	4B			
	51	Pooled	Pooled	Nonshoot	1A	2A	3B	4C	5C			
PosD	12	Pooled	Pooled	Nonshoot	1A	3B	2B	5B	4B	1A	2B	3B
PosN	8	Pooled	Pooled	Nonshoot	2A	1A	4B	4B	5B	1A	2AB	3B

[a]Comparisons listed by year, pintail age or shoot status only when rankings for that variable differed (Wilks= Lambda test, $P < 0.05$); rankings for pintails with different body condition did not differ.
[b]Rankings with same letters not different (*t*-test, $P < 0.05$).

as a significant factor in habitat selection models in only one instance when use rankings of Hemi and Open marsh during Prehunt differed by age (Table 3). Habitat selection did not differ among pintails that were lighter or heavier than average at capture.

DISCUSSION

Foraging Habitats Selection

All but a few pintail locations were in marsh units rather than the lake. We speculate this was because the lake produced fewer seeds preferred by pintails and was too deep for pintails to tip-up and forage for seeds in the lake bottom. Our finding that foraging pintails used and selected both swamp timothy and watergrass marsh at MWA is consistent with pintail food habits (Beam and Gruenhagen[11] 1980, Connelly and Chesemore 1980) and habitat use reported for other San Joaquin Valley areas (Euliss and Harris 1987). However, in contrast to the high night use of watergrass marsh by pintails that we observed at MWA and was reported for pintails at Kern NWR (Euliss and Harris 1987), pintails in the Grassland Ecological Area mostly avoided watergrass marsh at night (Fleskes et al. 2004). We speculate that watergrass fields were more attractive to feeding pintails at MWA than in the Grassland Ecological Area because watergrass fields at MWA were drained earlier and allowed to dry before reflooding (G. Gerstenberg, California Department of Fish and Game, Los Banos, California, USA, personal communication), resulting in shorter, less dense stands with seeds that ripen and disperse when reflooded. Alternatively, with fewer mallards, *Anas platyrhynchos*, at MWA than in the Grassland Ecological Area (California Department of Fish and Game, Sacramento, California, unpublished data), pintails may have faced less competition in watergrass marsh at MWA than in the Grassland Ecological Area allowing increased pintail use of watergrass at MWA.

Roosting Habitat Selection

Pintails roosted in or near feeding marshes during all Posthunt periods but selected closed or hemi-marsh on Hunt days and some Prehunt days. The need to avoid disturbance is a major factor in roost selection (Wolder[12] 1993) and we speculate that pintails avoided the mostly open water lake and open marsh units and sought isolation in vegetated marshes to avoid disturbance from hunters, fishermen, water managers, and others that was greatest during Hunt and some Prehunt days.

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[11]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.

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

MANAGEMENT IMPLICATIONS

Major (e.g., 95% of radio-tagged pintails) exodus of pintails from MWA each fall coinciding with the start of hunting season indicates that disturbance associated with hunting made MWA less attractive to pintails than areas to the north where most pintails went (Fleskes et al. 2002b). Cox and Afton (1998) reported low pintail use of 12 Louisiana sanctuaries 137 ha to 2,514 ha in size and cited placement of sanctuaries in areas with few pintails, late flooding, dense vegetation, and small size of sanctuaries as reasons for low use by pintails. The MWA sanctuary was surrounded by >2,500 ha of flooded marsh and both the sanctuary and surrounding wetlands were flooded during Prehunt and used extensively by pintails (Fig. 2), suggesting that its 364-ha size may have been the limiting factor. Although larger than the Merced NWR sanctuary that held large concentrations of pintails during the same years as this study, the MWA sanctuary was only half the total area of the San Luis NWR sanctuary, which was the main pintail roost area in the Grassland Ecological Area (Fleskes et al. 2002a, California Department of Fish and Game, unpublished data). Further, although roads open to the public surrounded and bisected sanctuaries on all three areas, road traffic or some aspect of its management resulted in few pintails using the southern half of the MWA sanctuary during the hunting season (Fig. 2), effectively halving its functional size. Thus, any effort to reduce exodus of pintails from MWA should first focus on why the southern part of the sanctuary received little use by pintails.

Pintails concentrated in sanctuary units not only on shoot days but also on nonshoot days during Hunt and in some instances selected closed marsh even during Prehunt days. This indicates that disturbance impacting pintail use of habitats at MWA was not limited to hunting. Many roads on MWA are open to the public during Prehunt for fishing and dove hunting and some are open to the public on nonshoot days during Hunt. In addition, flooding and maintenance of units require frequent monitoring by managers.

The management and layout of MWA provides an attractive landscape for pintails during Prehunt but habitat requirements of pintails are apparently not being met thereafter. Although it is possible that depleted food supplies contributed to pintails leaving MWA, the fact most departed during the first few days of hunting season indicates disturbance was the main factor. Thus, to increase the percentage of pintails that stay beyond the first week of Hunt, management should not only continue to emphasize shallow (i.e., $\leq$30 cm, Isola et al. 2000) preferred feeding habitats such as watergrass (as managed at MWA) and timothy marsh but also reduce disturbance and increase functional sanctuary.

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