Selection of flooded agricultural fields and other landscapes by female northern pintails wintering in Tulare Basin, California

Joseph P. Fleskes, Robert L. Jarvis, and David S. Gilmer

Abstract Habitat selection and use are measures of relative importance of habitats to wildlife and necessary information for effective wildlife conservation. To measure the relative importance of flooded agricultural fields and other landscapes to northern pintails (*Anas acuta*) wintering in Tulare Basin (TB), California, we radiotagged female pintails during late August–early October, 1991–1993 in TB and other San Joaquin Valley areas and determined use and selection of these TB landscapes through March each year. Availability of landscape and field types in TB changed within and among years. Pintail use and selection (based upon use-to-availability log ratios) of landscape and field types differed among seasons, years, and diel periods. Fields flooded after harvest and before planting (i.e., pre-irrigated) were the most available, used, and selected landscape type before the hunting season (Prehunt). Safflower was the most available, used, and—except in 1993, when pre-irrigated fallow was available—selected pre-irrigated field type during Prehunt. Pre-irrigated barley–wheat received 19–22% of use before hunting season, but selection varied greatly among years and diel periods. During and after hunting season, managed marsh was the most available, used, and, along with floodwater areas, selected landscape type; pre-irrigated cotton and alfalfa were the least selected field types and accounted for ≤13% of pintail use. Agricultural drainwater evaporation ponds, sewage treatment ponds, and reservoirs accounted for 42–48% of flooded landscape available but were little used and least selected. Exodus of pintails from TB coincided with drying of pre-irrigated fallow, safflower, and barley–wheat fields early in winter, indicating that preferred habitats were lacking in TB during late winter. Agriculture conservation programs could improve TB for pintails by increasing flooding of fallow and harvested safflower and grain fields. Conservation of remaining wetlands should concentrate on increasing the amount and productivity of marsh that is shallow-flooded as pre-irrigated grain fields dry. If pintails were provided with adequate preferred field and marsh habitats, including hunt-day sanctuaries, contaminant risks associated with exposure to drainwater evaporation ponds probably should remain low for these waterfowl even if their abundance in TB increased.

Key words *Anas acuta*, California, habitat selection, northern pintail, San Joaquin Valley, Tulare Basin

Northern pintail (*Anas acuta*) breeding populations in North America are at historic low levels last seen in the early 1990s (United States Fish and Wildlife Service 2002), and numbers are less than half of the North American Waterfowl Management Plan goal (United States Fish and Wildlife Service

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and Canadian Wildlife Service 1986). Because pintail survival (Fleskes et al. 2002*a*) and productivity (Raveling and Heitmeyer 1989) vary with winter habitat conditions, effective pintail management requires a thorough understanding of their winter habitat selection. Knowledge of pintail habitat selection is especially important in the Central Valley of California, where about half of the pintails in North America winter but over 90% of wetlands have been lost (Gilmer et al. 1982, Heitmeyer et al. 1989).

Information required to intensively manage waterfowl habitats is especially crucial in Tulare Basin (TB), which is the southern and most arid part of the Central Valley (United States Fish and Wildlife Service 1978). Unlike other Central Valley basins, where winter-flooded rice fields maintain many of the same functions as wetlands (Elphick 2000), rice is not an important crop in TB. The relative value to pintails of cotton, safflower, and other crops that replaced most TB wetlands is unknown. This information is needed to update the current Central Valley Habitat Joint Venture implementation plan, which assumes that only wetlands, rice fields, and corn fields provide energy for waterfowl in the Central Valley (Central Valley Habitat Joint Venture Implementation Board 1990). Efforts to conserve water have reduced the amount and duration of flooding of agricultural lands during fall and winter in TB (Barnum and Euliss 1991) and contributed to decline of pintails throughout the region (Fleskes et al. 2002*b*). The expected rapid expansion of human populations in the region (State of California 2001), with the resulting increased competition for land and water resources, could further reduce the capacity of TB to provide habitat for pintails.

Information on relative diurnal and nocturnal value of specific crop types and general landscape types available in TB to pintails is needed to guide wetland restoration and agricultural enhancement efforts in the region (Central Valley Habitat Joint Venture Implementation Board 1990). Past surveys (Coe 1990, Barnum and Euliss 1991) provided information on diurnal use of TB wetlands and other landscapes, but none except managed marsh on Kern National Wildlife Refuge (NWR) were surveyed at night (Euliss and Harris 1987). Loafing is a common diurnal activity of pintails throughout the August–March wintering interval; before the hunting season, pintails not only feed nocturnally but also feed extensively during the diurnal period to replenish fat reserves depleted by breeding and fall migration (Miller 1985, 1986). During hunting season, most feeding is done nocturnally and loafing is the main diurnal activity (Euliss 1984, Miller 1985). Diurnal feeding increases again after hunting season as pintails pair and prepare for spring migration and nesting (Miller 1985). Thus, nocturnal habitat selection during all seasons mainly reflects feeding-site preferences, diurnal habitat selection during the hunting season mainly reflects loafing-site preferences, and diurnal habitat selection before and after the hunting season reflects both feeding- and loafing-site preferences.

To determine availability and relative value of agricultural fields and other landscapes to wintering pintails in TB, help update the Central Valley Habitat Joint Venture implementation plan (R. Shaffer, United States Fish and Wildlife Service, personal communication), and improve waterfowl habitat management in TB and other wintering areas, we studied diurnal and nocturnal habitat use and selection by female northern pintails in TB from September through March, 1991–1994. Our objectives were to determine landscape types and specific types of agriculture fields in TB that were available, used, and selected by pintails for loafing and feeding before, during, and after hunting season.

Study area

The study area included all flooded areas in TB (United States Fish and Wildlife Service 1978) that were within the maximum daily flight range of pintails (43 km, Fleskes 1999) from their major diurnal loafing sites in the Tulare Lake Bed and Kern NWR vicinity (Figure 1). Most flooded areas in TB were considered available to pintails. Only a few areas south and west of Bakersfield, which were not used by our radiotagged pintails (Fleskes 1999), and the Mendota Wildlife Area on the northern border of TB (United States Fish and Wildlife Service 1978), which was used only by pintails roosting there (Fleskes 1999), were excluded from consideration in this study.

Duck-hunting daily bag limits and season lengths were identical during the study, but timing of the 59-day hunting season varied among years, starting on 9 (1991), 14 (1992), or 20 November (1993) (California Department of Fish and Game, unpublished data). Kern NWR and many TB waterfowl hunting clubs allowed hunting only on Wednesdays and Saturdays during hunting season (i.e., shoot days).

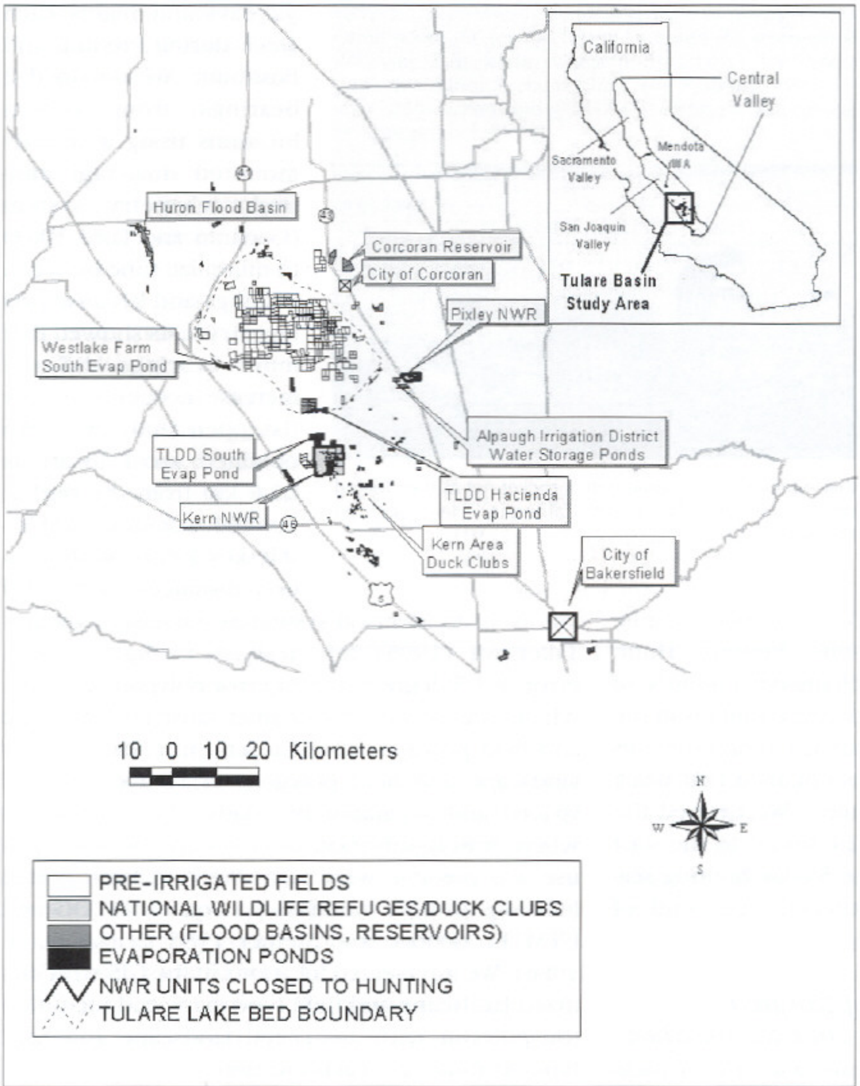


Figure 1. Potential waterfowl habitats in the Tulare Basin study area, California during August–March, 1991–1994.

Methods

Classifying habitats

We observed no pintails using dry lands except levees, shorelines, and islands in the San Joaquin Valley and considered only flooded areas as potential habitat available to pintails. Flooded areas were classified 3 ways. First, we used United States Geological Survey Quadrangles, the San Joaquin Valley Drainage Program Study Team (1990) report, aerial photographs, site visits, and data provided by managers to identify hydrology and physical characteristics, and classified 6 landscape types: 1) managed marsh (mostly seasonal but also some temporary and semi-permanent) on waterfowl hunting clubs and Kern-Pixley NWRs that were flooded by delivered water; 2) floodwater retention basins and other areas inundated by natural flood waters; 3) pre-irrigated fields (fallow and harvested-then-disced crop fields that were flooded for ≥1 week during September–March); 4) agricultural drainwater evaporation ponds; 5) sewage wastewater treatment ponds; and 6) deep-water reservoirs (including fish-rearing ponds). Next, we used preharvest site visits (1991) and crop maps (1991–1994) provided by local offices of the Natural Resources Conservation Service, United States Department of Agriculture to classify pre-irrigated fields into 5 types: 1) fallow, 2) barley-wheat, 3) safflower, 4) cotton, and 5) alfalfa. Finally, we used aerial reconnaissance each year to classify all landscape types except floodwater areas (which we did not survey) with <25% emergent cover as open-water landscapes and all landscapes types except floodwater areas with ≥25% (most 25–75%) emergent cover as vegetated landscapes.

Measuring availability of agricultural fields and other landscapes

We mapped flooding in TB each week during August–March, 1991–1994, using aerial photographs, site visits, and data provided by managers. We digitized flooded areas using a Geographic Information System (GIS) and ARC/INFO (Environmental Systems Research Institute, Inc., Redlands, Calif.) computer program and calculated flooded area of each landscape and field type each week. To represent average availability of flooded

Northern pintails (*Anas acuta*) and other ducks were captured with a rocket-net as they loafed on a bare levee of a pre-irrigated safflower field in Tulare Basin, California. Here captured birds are being removed. Photo by Joe Fleskes.

fields and other landscapes to the radiotagged pintails during each of 3 seasons (Prehunt, Hunt, Posthunt) and account for changing amounts of flooding and numbers of radiotagged pintails in the study area, we weighted weekly flooding estimates by number of pintail locations obtained that week and calculated seasonal averages. We defined the Prehunt as the interval from 28 August to the start of hunting season, Hunt as the 59-day hunting season, and Posthunt as the interval from end of Hunt-20 March.

Measuring pintail use of flooded agricultural fields and other landscapes

We captured northern pintails with 11-14 rocket-net (Schemnitz 1994) shots each year at rice-baited and unbaited sites on flooded agricultural fields in TB and in wetlands at Mendota Wildlife Area and other areas in the northern San Joaquin Valley (Fleskes 1999). We radiotagged (Dwyer 1972, Pietz et al. 1995) 191 Hatch-Year (HY) (Carney 1992) and 228 After-Hatch-Year (AHY) female pintails during 29 August-6 October 1991, 31 August-5 October 1992, and 28 August-25 September 1993 from these captures and tracked use of landscape and field types in TB through late March of all pintails (n =70) that used TB. We scanned the entire TB from aircraft (Gilmer et al. 1981) to determine which pintails were present in TB and determined each pintail's location using a vehicle-mounted dual-Yagi null-peak telemetry system (Cochran and Lord 1963) on $\geq$2 shoot days and nights and $\geq$2 non-shoot days and nights each week during Hunt and $\geq$2 days and nights each week during Prehunt and Posthunt. We obtained 2 bearings from known locations using a vehicle-mounted dual-Yagi null-peak telemetry system (Cochran and Lord 1963) to minimize time between bearings and because preliminary tests showed that more bearings did not increase accuracy in our flat, open study area. We obtained most locations <1.6 km from the bird at 50-130 degree angles (Fleskes 1999). With location distances of 0.5-3.0 km using an identical system as ours, Warnock and Takekawa (1995) reported an average azimuth error of 1.5 degrees and an error polygon of 1.1 ha, which was much smaller than most TB landscape and field polygons ($\bar{x}$=34.6 ha). In addition, most landscape and field polygons in TB were widely spaced and separated by roads. Thus, instances where misclassification of landscape or field type use was possible were rare. We calculated pintail locations using a modified version of XYLOG and UTMTEL (Dodge and Steiner 1986, Dodge et al. 1986). We intersected locations in the GIS with digitized landscape and field type maps and identified the polygon with associated landscape and field type attributes for each location.

Habitat selection analysis

We used compositional analysis (Aitchison 1986, Aebischer et al. 1993) to examine diurnal and nocturnal selection of landscape and field types by pintails. We used multivariate analysis of variance (Johnson and Wichern 1982, SAS Institute 1999) to test whether a composition of use-to-availability log ratios differed from zero ($P \leq 0.05$), indicating selection by pintails. We considered all flooding in the study area as potential habitat available to each pintail because the entire study area was within their maximum daily flight range (Fleskes 1999). We used maximum daily flight distance, rather than restricting availability estimates for each pintail to include only flooded areas within a home range as measured by ground locations because, while following individual pintails, we frequently observed

Table 1. Mean weekly flooded hectares of managed marsh (M), floodwater areas (W), evaporation ponds (E), sewage treatment ponds (T), reservoirs (R), and pre-irrigated (P), fallow (P-F), safflower (P-S), barley–wheat (P-B), alfalfa (P-A), and cotton (P-C) fields in Tulare Basin, California during Prehunt, Hunt, and Posthunt, 1991–1994. Flooded hectares of landscapes with <25% (Open) and ≥25% (Veg) emergent cover (except W whose cover was not surveyed), also are presented.

Landscape type	Prehunt			Hunt			Posthunt		
	Year1[a]	Year2	Year3	Year1	Year2	Year3	Year1	Year2	Year3
M	491	490	1,005	1,625	1,675	2,394	2,168	2,579	2,946
W	36	0	69	42	20	266	387	955	1,374
E	1,246	1,545	1,458	1,441	1,593	1,428	1,817	1,951	1,468
T	82	82	114	82	82	82	82	82	82
R	404	448	730	390	470	738	415	552	742
P (all)	2,398	1,802	1,592	566	288	30	426	61	0
P-F	0	0	135	0	0	0	0	0	0
P-S	1,008	1,510	1,102	54	3	0	5	0	0
P-B	540	91	222	21	0	0	10	0	0
P-A	761	201	91	371	27	0	21	0	0
P-C	89	0	42	120	258	30	390	61	0
Open	4,493	4,261	4,502	3,538	3,542	3,701	4,224	4,545	4,267
Veg	128	103	395	546	541	946	660	656	946

[a] Year1 = 1991–1992, Year2 = 1992–1993, and Year3 = 1993–1994.

and tracked pintails flying throughout the study area before selecting a wetland or field in which to land (where it could then be pinpointed). Thus, rather than using a standard home-range estimate based on ground observations that would underestimate the true availability of flooded landscapes to pintails, we followed Morton et al. (1989), who suggested that distance moved between foraging and roosting sites was biologically more valid than traditional home-range measurements. When selection was detected, we assigned ranks to each landscape and field type, calculated means and standard errors for each log-ratio, and used t-tests to identify differences ($P \leq 0.05$) among rankings (Aebischer et al. 1993). We combined agricultural drainwater evaporation ponds and sewage treatment ponds (flooded landscape types rarely used by pintails) when conducting compositional analysis to avoid problems associated with lack of use of one or the other landscape type. We compared selection among years (1991-1992, 1992-1993, 1993-1994), and between shoot and nonshoot days during hunting season, bird age class (HY, AHY), and bird body mass at capture (above vs. below age-class mean).

Results

Availability of agricultural fields and other landscapes

Flooding in TB varied among seasons and years (Table 1). Flooding of pre-irrigated fields declined during the study, whereas managed marsh increased; flooded area of agricultural drainwater evaporation ponds, sewage treatment ponds, and reservoirs was fairly constant among seasons and years (Table 1). Pre-irrigated fields were the most abundant landscape type flooded during Prehunt, but managed wetlands were most abundant thereafter. The amount and type of pre-irrigated fields that were flooded changed during winter, with 1,595-2,399 ha of mostly safflower and other noncotton field types flooded during Prehunt and ≤567 ha of mostly cotton fields flooded thereafter. Pre-irrigated fallow fields were available only during Prehunt in 1993-1994. Most marshes were unflooded during summer, filled with water during Prehunt, and fully flooded by mid-Hunt; rains maintained or increased marsh flooding during Posthunt. Thus, mean weekly flooded area of marsh was 2-4 times greater during Hunt and Posthunt than during Prehunt. Little precipitation occurred before late winter, and except for carryover from previous winters, floodwater areas were dry until late Hunt. Nearly all flooded landscapes in TB (>81%) had <25% of their area covered by emergent vegetation (Table 1).

Use and selection of flooded agricultural fields and other landscapes

Landscape types. The landscape type that female pintails used (Table 2) and selected (Table 3) varied somewhat between diurnal and nocturnal periods and among seasons and years. During Prehunt, pre-irrigated fields were the most used and selected landscape type (Tables 2 and 3). Managed marsh was the second most used landscape type during Prehunt; selection of managed marsh ranked third during some diurnal and all nocturnal periods after

Table 2. Composition (%) of landscape types (managed marsh [M], floodwater areas [W], evaporation ponds [E], sewage treatment ponds [T], reservoirs [R], pre-irrigated fields [P]), pre-irrigated fields (fallow [F], safflower [S], barley–wheat [B], alfalfa [A], cotton [C]), and landscapes with <25% (Open) and ≥25% (Veg) emergent cover (excludes W) available[a] and used diurnally (Duse) and nocturnally (Nuse) by radiotagged female northern pintails during each season in Tulare Basin, California 1991–1994.

Land-scape type	Prehunt			Hunt			Posthunt		
	Avail[a]	Duse	Nuse	Avail[a]	Duse	Nuse	Avail[a]	Duse	Nuse
M	11	11	9	44	66	57	42	49	33
W	1	<1	6	2	17	26	11	13	50
E	31	2	4	34	<1	<1	31	20	<1
T	2	<1	<1	2	3	<1	2	<1	<1
R	11	3	4	12	<1	<1	9	7	<1
P (all)	44	84	77	6	13	17	5	11	17
P-F	1	17	7	0			0		
P-S	63	56	68	2	3	37	1	<1	<1
P-B	18	19	22	1	<1	<1	1	50	50
P-A	16	8	3	31	<1	50	1	50	50
P-C	2	<1	<1	66	97	13	97	<1	<1
Open	97	89	93	84	65	69	97	98	99
Veg	3	11	7	16	35	31	3	2	1

[a] Avail = $\bar{x}$ of weekly flooded proportions weighted by number of bird locations obtained.

that of carryover floodwater areas (Tables 2 and 3). After Prehunt, use and selection of managed marsh and floodwater areas increased above that of pre-irrigated fields (Tables 2 and 3). Use of reservoirs and wastewater ponds was minimal except during diurnal Posthunt periods, and selection of these landscape types ranked lowest during all seasons (Tables 2 and 3). Selection differed slightly by pintail age during diurnal ($F_{4,63}=3.53$, $P=0.01$) and nocturnal ($F_{4,52}=3.04$, $P=0.02$) Prehunt periods, and diurnal Hunt periods ($F_{4,54}=3.25$, $P=0.02$), and rankings differed ($P<0.05$) less often for HY than for AHY pintails (Table 3). Selection did not differ among pintails lighter or heavier than average at capture ($P>0.05$).

Pre-irrigated field types. Safflower was the most commonly used pre-irrigated field type during Prehunt (Table 2). Thereafter, pre-irrigated fields received ≤17% of pintail use, with the few pintails that used pre-irrigation mostly in cotton fields diurnally and alfalfa fields nocturnally during Hunt and in barley–wheat and alfalfa fields during Posthunt (Table 2). Pintails selected pre-irrigated fallow fields when available and safflower fields except during Hunt diurnal periods (Table 3). Rankings of other pre-irrigated fields, especially barley–wheat, varied greatly among years, but alfalfa and cotton were consistently used much less than available, especially nocturnally. Ranking of pre-irrigated field types after Prehunt was not possible all years because most pintails left TB and nearly all pre-irrigation was of cotton fields.

Open-water vs. vegetated landscapes. Most pintail use occurred in open-water landscapes (Table 2). Use of vegetated landscapes tended to be greater during diurnal than nocturnal periods and was greatest during the hunting season (Table 2). Pintails selected open-water landscapes during all Prehunt ($t_{69}\geq 5.11$, $P\leq 0.001$) and Posthunt ($t_6\geq 5.66$, $P=0.001$) periods, with ≥85% of use during both diurnal and nocturnal periods occurring in open landscape types. During Hunt, pintails selected open-water landscapes during 1992–1993 diurnal periods (79% of use, $t_{33}=2.28$, $P=0.03$) but vegetated landscapes during 1993–1994 diurnal periods (61% of use, $t_{17}=2.51$, $P=0.02$); diurnal use during 1991–1992 Hunt was split evenly between open-water and vegetated landscapes. Selection during Hunt diurnal periods differed on shoot and nonshoot days ($F_{1,51}=4.51$, $P=0.04$), with the trend toward pintails selecting vegetated landscapes on shoot days (71% of use, $t_{23}=1.42$, $P=0.17$) and open-water landscapes on nonshoot days (57% of use, $t_{32}=1.00$, $P=0.33$).

Discussion

Availability of agricultural fields and other landscapes

Annual variation in flooded area of managed marsh and agricultural fields in TB differed. We speculate that changing environmental, political, and economic factors impacted flooding of marsh and agricultural fields in TB differently. During 1991 continuing drought and resulting low reservoir levels (California Department of Water Resources 1991, National Oceanic and Atmospheric Administration, unpublished data) prevented summer irrigation, delayed fall flood-up, and reduced water deliveries to managed marsh throughout the San Joaquin Valley (Fleskes 1999). Flooded area of managed marsh throughout the San Joaquin Valley increased after 1991 (Fleskes 1999), probably as a result of return of normal precipitation and a new law that increased water supplies for wetland management (Davis 1992). In contrast, postharvest flooding of agricultural fields was greater during the drought year of 1991 than

Table 3. Selection of landscape types (pre-irrigated fields [P], floodwater areas [W], managed marsh [M], reservoirs [R], agricultural drainwater evaporation and sewage treatment ponds combined [V]), and pre-irrigated field types (fallow [F], safflower [S], barley–wheat [B], alfalfa [A], cotton [C]) by radiotagged female northern pintails in Tulare Basin, California, diurnally and nocturnally before (Pre), during (Hunt), and after (Post) hunting season, 1991–1994.

Comparison[a]				Ranking[b] Landscape type					Pre-irrigated field				
Interval	*n*	Year	Age	1	2	3	4	5	1	2	3	4	5
Pre Diurnal	70	Pooled	Pooled	P_a	W_b	M_c	R_d	V_d	F_a	S_b	B_c	C_{cd}	A_d
	13	1991–1992	Pooled	P_a	W_b	M_c	V_d	R_d	S_a	A_a	B_a	C_b	
	26	1992–1993	Pooled	P_a	M_b	R_{bc}	V_c		B_a	S_b	A_c		
	31	1993–1994	Pooled	P_a	M_b	W_b	R_c	V_c	F_a	S_b	A_c	C_c	B_d
	22	Pooled	HY	P_a	W_b	M_c	R_c	V_c	F_a	S_b	A_c	C_c	B_d
	48	Pooled	AHY	P_a	W_b	M_c	R_d	V_d	F_a	S_b	A_c	C_c	B_d
Pre Nocturnal	59	Pooled	Pooled	P_a	W_b	M_c	R_d	V_d	S_a	F_a	C_b	B_b	A_c
	11	1991–1992	Pooled	P_a	W_b	M_c	R_d	V_d	B_a	S_a	C_b	A_b	
	23	1992–1993	Pooled	P_a	W_b	M_c	R_d	V_d	S_a	B_b	A_c		
	20	1993–1994	Pooled	P_a	W_b	M_c	R_d	V_d	S_a	F_a	B_b	C_b	A_b
	17	Pooled	HY	P_a	W_a	R_b	M_b	V_b	S_a	F_a	C_b	B_b	A_c
	42	Pooled	AHY	P_a	W_b	M_c	V_d	R_d	S_a	F_a	C_b	B_b	A_c
Hunt Diurnal	41	Pooled	Pooled	M_a	W_{ab}	P_b	R_c	V_c					
	34	1992–1993	Pooled	M_a	P_a	R_b	V_b		F_a	B_{ab}	C_b	S_c	A_c
	22	1993–1994	Pooled	M_a	W_{ab}	P_{bc}	R_{cd}	V_d					
	23	Pooled	HY	W_a	P_a	M_a	R_b	V_b	F_a	B_{ab}	C_b	S_c	A_c
	39	Pooled	AHY	M_a	W_b	P_c	R_d	V_d	F_a	B_{ab}	C_b	S_c	A_c
Hunt Nocturnal	37	Pooled	Pooled	W_a	M_{ab}	P_c	R_d	V_d	F_a	S_a	B_{ab}	A_{bc}	C_c
Post Diurnal	9	Pooled	Pooled	M_a	P_a	W_a	R_a	V_a					
Post Nocturnal	6	Pooled	Pooled	W_b	P_{ab}	M_{ab}	R_b	V_c					

[a] Comparisons listed by year and pintail age only when rankings for those variables differed (Wilks' lambda test, $P < 0.05$); rankings did not differ by shoot status or for pintails with different body condition at time of capture.

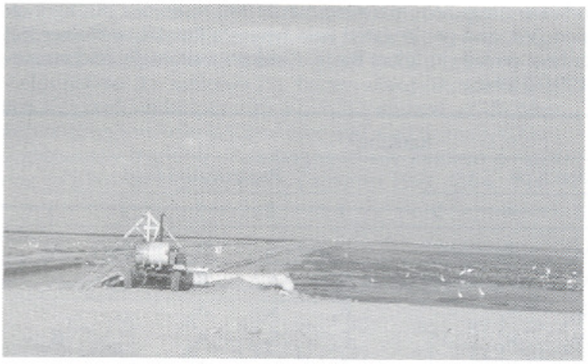
[b] Rankings with same subscript letters were not different (*t*-test, $P < 0.05$). Incomplete or no rankings due to lack of ≥1 landscape or field type and small sample size after Prehunt.

during later years with near-average precipitation. Thus, factors such as crop rotation, field management, and water costs probably were more important than environmental conditions at controlling flooding of agricultural lands. Additional information on the impact of agricultural practices and other factors on annual flooding of marsh and agricultural fields in TB is needed for effective habitat conservation planning.

Use and selection of flooded agricultural fields and other landscapes

High use of flooded agricultural fields by pintails has been reported previously (Barnum and Euliss 1991, Austin and Miller 1995, Cox and Afton 1997), but selection of flooded fallow and safflower fields and avoidance of cotton and alfalfa fields have not been previously documented. Pintails feed heavily during diurnal and nocturnal periods in Prehunt and nocturnally during Hunt periods (Euliss 1984, Miller 1985). Therefore, availability of preferred foods probably was a key factor in pintail selection of pre-irrigated safflower and fallow fields during those periods.

Pintail food habits in pre-irrigated fields in TB have not been reported, and the observed selection of fields could reflect differences in availability of seeds, invertebrates, or both. Although pintails generally are reported to feed primarily on seeds during fall and winter, they are opportunistic and select feeding habitats that provide abundant food (Austin and Miller 1995). In the Sacramento Valley, rice fields are abundant and rice and other seeds comprise the greatest portion of the winter diet of pintails (Miller 1987). In the San Joaquin Valley, flooded agriculture is less abundant and invertebrates are more important earlier in winter (Beam and Gruenhagen 1980, Connelly and Chesemore 1980, Euliss and Harris 1987). On TB evaporation ponds, invertebrates comprised the majority of pintail diet during September (Euliss et al. 1991). We speculate that fallow fields were especially



Water is pumped into a harvested and disced barley–wheat field in Tulare Basin, California. Selection of pre-irrigated barley–wheat fields by wintering northern pintails varied greatly. Photo by Joe Fleskes.

attractive to pintails because the vegetation present provided abundant seeds and substrate for development of invertebrates. However, other pre-irrigated fields were disced intensively before flooding. We observed some safflower seeds windrowed near the water's edge and speculate that pintails may have selected pre-irrigated safflower over barley–wheat fields because the oily safflower seeds were more buoyant and remained more available to pintails after discing than barley and wheat seeds. The wide variation in selection of barley–wheat fields by pintails may reflect differences in discing intensity. Alternatively, safflower fields were the earliest flooded, possibly allowing aquatic invertebrates to become established and more abundant than in other field types (D. Barnum, United States Geological Survey, personal communication). The low use of flooded cotton fields during periods when pintails feed extensively suggests that neither seeds nor invertebrates consumed by pintails were abundant in that field type.

Our findings indicate that pintails responded to changing availability of landscape types they preferred but not to changing availability of other landscape types. Pintail use after Prehunt shifted from pre-irrigated fields to managed marsh as the availability of pre-irrigated fields that pintails preferred (i.e., fallow, safflower, and barley–wheat) declined and availability of preferred managed marsh increased. Pintails shifted use from pre-irrigated fields to marsh even in years when availability of pre-irrigated cotton fields increased after Prehunt because pre-irrigated cotton fields were not preferred by pintails. Barnum and Euliss (1991) also observed the shift in pintail use to managed marsh after Prehunt but attributed it to an overall decline in pre-irrigation availability rather than a decline in availability of preferred field types. We agree with Barnum and Euliss (1991) that the onset of hunting also contributed to increased pintail use of managed marsh after Prehunt as pintails concentrated on the managed marsh available in the no-hunting zone on Kern National Wildlife Refuge.

Similar to other regions (Howard and Kantrud 1986, Austin and Miller 1995), pintails in TB selected flooded landscapes that were shallow and, except on hunting days, mostly devoid of emergent vegetation. Pintails selected vegetated landscapes only on shooting days during our study, probably because most vegetated marsh occurred in no-hunting zones in Kern NWR (Fleskes 1999) and pintails used emergent vegetation to avoid disturbance (Wolder 1993). Euliss (1984) and Isola et al. (2000) also reported that shallow, open-water marshes were preferred pintail diurnal foraging sites. However, during nocturnal surveys of Kern NWR marsh units, Euliss (1984) observed that nearly all pintails were in densely vegetated marsh units and few were in open-water marsh. It is unclear why our nocturnal-use findings disagreed with Euliss (1984), but open-water landscapes, especially pre-irrigated fields, were highly selected by pintails we located during nocturnal periods.

Management implications

Exodus of pintails from TB (Fleskes et al. 2002*b*) coincided with drying of pre-irrigated fallow, safflower, and barley–wheat fields, indicating that resources available in marsh and other winter habitats present in TB after Prehunt were lacking. Agriculture and other conservation programs such as the Central Valley Habitat Joint Venture (Central Valley Habitat Joint Venture Implementation Board 1990) could improve TB for pintails by increasing flooding of fallow and harvested safflower and grain fields. Conservation of remaining wetlands should concentrate on increasing the amount and productivity of marsh that is shallow flooded as pre-irrigated grain fields dry. Because most TB pintails move north during winter (Fleskes et al. 2002*b*), increased habitats in TB during early fall probably would not only increase fall abundance of pintails in TB but also increase late-winter abundance of pintails in the northern San Joaquin Valley. If flooding of some TB areas was delayed, pintail abundance probably would not be as high as if all areas were flooded early, but their duration of stay in TB would increase. Pintails selected pre-irrigated cotton fields less than available. Thus, any increase in this crop that reduces water supplies or area for preferred habitats in TB will negatively impact pintails.

Food habits of waterfowl in pre-irrigated fields available in TB (e.g., safflower, intensively disced wheat-barley) are unknown and need to be determined before management practices to enhance those habitats for waterfowl can be developed and promoted. Recommended treatments to improve production of invertebrates in wetlands (Euliss and Grodhaus 1987, Fredrickson and Reid 1988) and availability of seeds in corn, rice, and soybean fields (Ringelman 1990) might not be appropriate for TB habitats. For example, if seeds are found to be the food resource pintails use in pre-irrigated wheat fields, reduced discing may be appropriate. However, discing might actually increase availability of safflower seeds. Impacts of discing on invertebrate production may vary among field types.

Abundance of pintails in TB likely will increase if flooding of marsh and preferred agricultural lands is increased and maintained throughout the winter. If pintails are provided with adequate good-quality water to provide preferred field and marsh habitats for feeding and sanctuary from hunting, their risk from contaminants associated with use of drainwater evaporation ponds (Barnum and Gilmer 1988) would probably remain low even if pintail abundance in the region increased. Past losses of pintails and other waterfowl to avian botulism in TB sometimes have been high (Parrish and Hunter 1969). Thus, the ability to control habitat water levels to minimize losses should be included in management plans (Rocke and Friend 1999).

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