AN ABSTRACT OF THE DISSERTATION OF

Joseph. P. Fleskes for the degree of Doctor of Philosophy in Wildlife Science presented on November 19, 1999. Title: Ecology of Female Northern Pintails During Winter in the San Joaquin Valley, California.

Redacted for Privacy

Abstract approved: ____________________ ____________
Robert L. Jarvis

I radio-tagged 191 Hatch-Year (HY) and 228 After-Hatch-Year (AHY) female northern pintails (Anas acuta) in the San Joaquin Valley (SJV), California and studied their movements, habitat use and survival during August - March, 1991-94.

Overall, 94.3% wintered in central California; the highest percentage left during the 1991 drought. Tulare Basin and Mendota Wildlife Area (WA) pintails moved to the Grassland Ecological Area (EA) vicinity when hunting began. Of those wintering in central California, 83% went to the Sacramento Valley, most during December. AHY pintails tended to leave earliest but the effect of age varied with body condition. Loss of Tulare Basin habitat has contributed to the late-winter decline of pintails throughout the SJV.

Local distribution and movements differed most among seasons, day and night periods and shoot and nonshoot days. Overall, 64% of the day and 85% of the night locations in the Grassland EA vicinity were on private wetlands.

Habitat availability and use varied greatly among SJV areas and during the winter. Pintails selected shallow and avoided deepwater habitats. Swamp timothy wetlands were the most abundant and most highly selected habitat in Grassland EA and Mendota WA. In Tulare Basin, preirrigated fields were the most abundant and selected habitat during PREHUNT, but managed wetlands were most abundant and selected thereafter. Selection of watergrass wetlands during night was low in the Grassland EA vicinity but high in Mendota WA. In Tulare Basin, pintails selected preirrigated fallow and safflower fields; selection of barley-wheat fields varied greatly. The exodus of most pintails from the SJV during December implies that preferred late-winter habitats were lacking.

Winter survival was lower for HY (0.67) than AHY (0.76) pintails. Survival was similar to Louisiana and Suisun Marsh but lower than in the Sacramento Valley. Hunting caused 83%, avian predators 7.6%, collisions 1%, and disease or other non-hunting factors 8.7% of the mortalities. Hunting mortality was related to fall body condition for HY but not AHY pintails. The retrieval rate for shot radio-tagged pintails was 80.3%.

This study indicates that inter-related factors influenced female pintail ecology during winter in California but availability of productive habitat was especially important.

ECOLOGY OF FEMALE NORTHERN PINTAILS DURING WINTER IN THE SAN JOAQUIN VALLEY, CALIFORNIA

by

Joseph P. Fleskes

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APPROVED:

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Major Professor, representing Wildlife Science

Redacted for Privacy

Head of Department of Fisheries and Wildlife

Redacted for Privacy

Dean of Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

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Joseph P. Fleskes, Author

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Numerous individuals and organizations contributed to the success of this study. Robert L. Jarvis, my major professor, and other members of my graduate committee, David S. Gilmer, Charles Meslow, James Moore, Clifford Pereira and W. Bruce Shephard provided guidance and advice that improved all aspects of this project.

I thank the staffs of San Luis National Wildlife Refuge (NWR) complex, Kern NWR, Gray Lodge Wildlife Area (WA), Mendota WA and Los Banos WA for providing housing, habitat information and logistical support. Steve Bergerman mapped vegetation and weekly flooding at Mendota WA. Dale Garrison (San Luis NWR) mapped vegetation in most duck clubs in the Grassland Ecological Area (EA). Grassland Water District staff mapped controlled flooding of habitats during August-October and helped gain landowner cooperation in the Grassland EA. The Natural Resources Conservation Service (NRCS) provided crop information in the Tulare Basin. Cindy Kohorst, Kim Lee and Greg Martinelli entered habitat information into computer files. Bill Perry and Joan Daugherty provided GIS support.

I thank Clear Lake and Stillbow duck clubs and Tulare Basin landowners for permitting access to trap pintails, and all landowners for permitting access to track and recover radio-tagged pintails on their lands. I thank the hunters who reported and provided information about pintails they recovered. Doctors of veterinarian medicine, J. Christian Franson and Louis N. Locke of the National Wildlife Health Research Center conducted bird necropsies. Reed Dunston, Dennis Orthmeyer and Kevin Mazacco helped trap pintails. Mike Carriere of Busch Agriculture donated rice for trapping.

Laura Belt, Dan Breneman, Dan Buford, Mike Chouinard, Jr., Craig Davis, Mark Humpert, Peter Johnston, John Laffitte, Casey Stemler and Kendel Young were dedicated technicians that worked day and night during one or more of the 8-month field seasons to trap and track radio-tagged pintails. California Department of Fish and Game donated pilot and airplane costs for aerial searches and Dennis Orthmeyer, Dan Yparraguirre, Sam Blankenship, Mike Miller, Mike Casazza, Barry Parkin, Bruce Conant, Jeff McKay, Dave Mauser, Sean Boyd, Bill Radke, Bill Henry, Roy Lowe, Gary Ivey and Rodrigo Migoya searched for radio-tagged pintails throughout the Pacific Flyway. Wes Newton and Julie Yee provided statistical advice.

Finally, I thank my friends and family who encouraged me to keep going when the end seemed far away and who provided those pleasant distractions that we all need in life.

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PREFACE

I wrote this dissertation as a series of 3 manuscripts. I chose this format to facilitate publication. However, because of this format, it was necessary to present similar information in more than one chapter. Most redundancy is restricted to the introduction and methods sections but the result is a longer report than if the standard format was used.

I organized the chapters in a way that I hope helps the reader better understand the information. I present regional and local movements first because knowledge of these aspects of pintail ecology is important to understand habitat use and survival, which I present in Chapters II and III, respectively.

ECOLOGY OF FEMALE NORTHERN PINTAILS DURING WINTER IN THE SAN JOAQUIN VALLEY, CALIFORNIA

INTRODUCTION

The Central Valley of California is a critical wintering habitat for many species of waterfowl in the Pacific Flyway. Once estimated at 1.6 - 2 million hectares, Central Valley wetlands have been reduced by over 90% (U.S. Fish and Wildlife Service [USFWS] 1978, Gilmer et al. 1982). Wetland conversion to agriculture fields has been especially prevalent in the San Joaquin Valley (SJV) and recent declines of preirrigated cropfields in the Tulare Basin in the southern SJV have further reduced the value of these agricultural lands to waterfowl (Houghten et al. 1985, Barnum and Euliss 1991). Also, subsurface drainwater from some irrigated agricultural lands in the region carry high levels of salinity, trace elements, and heavy metals (e.g. selenium) that have contaminated wetland habitats in the SJV receiving this drainwater (Ohlendorf et al. 1986, Barnum and Gilmer 1988). Constrained by water discharge requirements, many farming operations have developed on-farm or regional evaporation pond systems for disposal of the highly saline subsurface drainwater. Approximately 2,800 ha of evaporation ponds exist in the SJV. Wintering waterfowl use of some of these contaminated ponds is high (Euliss et al. 1984, 1985). Although use by breeding waterfowl is low (Barnum, pers. comm.) rates of embryonic deformities at some ponds exceed those observed at Kesterson Reservoir (Skorupa and Roster 1990). A hazing program has been developed by the California Department of Fish and Game (CDFG) in an attempt to discourage waterfowl use of certain evaporation ponds.

Although Central Valley waterfowl habitat continues to be lost to agricultural and urban development, efforts to reverse this trend have increased. The largest such effort, the Central Valley Habitat Joint Venture (CVHJV), will affect activities on 385,000 hectares of wetlands and agricultural lands in the Central Valley at a capital cost of more than $528 million and an annual cost of about $38 million (CVHJV Implementation Plan 1990). Information on waterfowl ecology before these habitat changes occur is needed so that the response by waterfowl to habitat conservation programs can be measured and the programs can be managed to provide maximum benefit for the resource and its users.

The northern pintail (Anas acuta) is the most abundant duck in the Pacific Flyway (USFWS 1978, USFWS unpubl. data) and one of the most important ducks to California hunters (Gilmer et al. 1989). Half of the pintails in North America migrate to California and winter in the Central Valley (Bellrose 1980, USFWS 1978). Pintails arrive in the Central Valley in early-August; most depart by mid-March. Early-arriving pintails in the Central Valley are primarily adult (after-hatch-year [AHY]) males. Females make up about 6% of the pintail population in August, but the proportion doubles during each of the next two months and sex ratios approach parity by January (Miller 1985). Only 2% of the females captured in late August during 1987-89 were juveniles (hatch-year [HY]) (M. Miller, U. S. Geological Survey, Dixon, Calif., pers. comm.) but nearly equal numbers of AHY and HY pintails were captured during 1948-79 when trapping continued through September (Rienecker 1987a).

North American pintail populations have varied greatly since coordinated surveys began in the mid-1950s (Wilkins and Cooch 1999). Breeding populations were estimated at 6 - 10 million during the 1950s, 3 - 6 million in the 1960s and 4 - 7 million in the 1970s. Pintail populations declined during the 1980s and reached a historic low of 1.8 million in 1991. Populations have improved slightly since but the 1999 estimate of 3 million is still about 30% below the 1955-99 average. Midwinter pintail populations in California are about 25% of those recorded in the 1970s (Pacific Flyway waterfowl reports and USFWS unpubl. data).

Increasingly restrictive pintail harvest regulations were enacted during the 1980s and mallards are now more commonly harvested than pintails on most California public hunting areas (Gilmer et al. 1989). Faced with low pintail bag limits and hunter success, some wetland managers are increasingly tailoring their habitat management towards species other than pintails (e.g. mallards), possibly to the detriment of pintails.

The decline of pintails has been especially prevalent in the SJV. During the 1970s, 50% of all pintails counted in the Central Valley in mid-September and 24% of the pintails counted in early January in the Central Valley occurred in the SJV. However, during the 1980s, only 24% of all pintails counted in mid-September in the Central Valley and 7% of all pintails counted in early January in the Central Valley occurred in the SJV (CDFG, USFWS unpubl. data).

Low recruitment because of persistent drought on the breeding grounds and poor nest success is undoubtedly one reason for decline of pintail populations. However, pintails rely heavily on nutrient reserves during nesting (Krapu 1974), and conditions on the wintering grounds may affect pintail recruitment (Heitmeyer and Fredrickson 1981, Anderson and Batt 1983, Raveling and Heitmeyer 1989) by influencing the amount of these reserves. For instance, pintails gained weight and lipids in late winter and early spring during wet winters in California but lost weight during the same period during dry winters (Miller 1986). Raveling and Heitmeyer (1989) found that winter habitat conditions and recruitment the following spring were correlated.

Pintail populations are directly influenced by winter conditions because of deaths occurring during this period. Female pintails exhibit high fidelity to wintering grounds (Rienecker 1987a, Hestbeck 1993b) and high mortality during winter could limit local populations. Data on the magnitude, timing, and causes of mortality during winter are needed (USFWS and Canadian Wildlife Service 1986).

Winter survival, habitat use, and movements of AHY female pintails have been studied in the Sacramento Valley using radio-telemetry; over-winter survival of adult females averaged 87% (Miller et al. 1995). However, HY females were not studied. Furthermore, habitat conditions in the SJV are different than in the Sacramento Valley, where rice fields are common and used heavily by pintails.

Few Sacramento Valley pintails visited the SJV, indicating that pintails wintering in the Sacramento Valley may be a separate population with different population dynamics (Miller 1990). Rienecker (1987b) identified pintails wintering in the Salton Sea area in southern California as a population distinct from other California pintails. Rienecker's (1987b) data also indicate that annual survival of female pintails banded in the SJV was lower than for those banded in the Sacramento Valley. These data do not provide information on the timing or causes of mortality other than legal harvest. To aid pintail population recovery efforts we need current information on the relative importance of legal and illegal harvest, crippling, and non-hunting mortality (i.e. disease, predation, contamination, starvation, etc.) of SJV pintails during winter.

Daytime habitat use by pintails has been surveyed on specific SJV waterfowl areas (Beam and Gruenhagen 1980, Connelly and Chesemore 1980) but overall pintail use of SJV habitats relative to their availability has not been measured. Additionally, pintails feed mainly at night in the Central Valley (M. Miller, unpubl. data.) and elsewhere (Tamisier 1976), and nocturnal habitat use was notably different than daytime use on the one SJV refuge where surveys at night were attempted (Euliss 1984, Euliss and Harris 1987). Animal materials increased in the diet of pintails late in winter (Beam and Gruenhagen 1980, Connelly and Chesemore 1980, Euliss and Harris 1987, Miller 1987) but, because of the difficulty of determining nocturnal habitat use, it was not known if shifts in feeding habitats also occurred. Data on the use of habitats by pintails during the daytime and at night throughout the winter are needed to improve management of SJV waterfowl habitats for pintails.

Movements of pintails within and out of the SJV are poorly understood. For instance, banding data from the 1940's indicate that pintails move north from the Tulare Basin during the winter (McLean 1950). However, 1987-89 surveys showed that pintail abundance in the Tulare Basin remained constant between September and November even though abundance in the north SJV tripled (USFWS, CDFG unpubl. data). Movement patterns must be understood to better manage pintails (Rienecker 1987ab).

In this investigation, I radio-tagged HY and AHY female pintails in the SJV to study their movements, habitat use and survival during winter.

CHAPTER I. DISTRIBUTION AND MOVEMENTS OF FEMALE NORTHERN PINTAILS RADIO-TAGGED IN THE SAN JOAQUIN VALLEY, CALIFORNIA

INTRODUCTION

Understanding waterfowl distribution and movements during winter is crucial to managing waterfowl populations and their habitats. Habitat program planning and management requires knowledge of waterfowl use patterns and how these patterns change, both on a regional and local scale, as habitat conditions change (Williams et al. 1999).

Despite loss of over 90% of its wetlands since the turn of the century, the Central Valley of California (Figure I.1) remains one of the most important wintering areas in North America for migratory waterfowl (U.S. Fish and Wildlife Service [USFWS] 1978, Gilmer et al. 1982). The Central Valley is especially important to northern pintails (Anas acuta). About half of the pintails in North America migrate to and winter in the Central Valley (Bellrose 1980, USFWS 1978), arriving as early as the first week of August and remaining through March. Pintail breeding populations in North America plunged to all time lows in the early 1990s (USFWS and CWS 1995) and although recent recovery is promising, midwinter pintail populations in California are still only about 25% of those recorded in the 1970s (Pacific Flyway waterfowl reports and USFWS, Portland, OR, unpubl. data).

Abundance of pintails wintering in the San Joaquin Valley (SJV), the southern portion of the Central Valley, has declined more severely than in the more northern

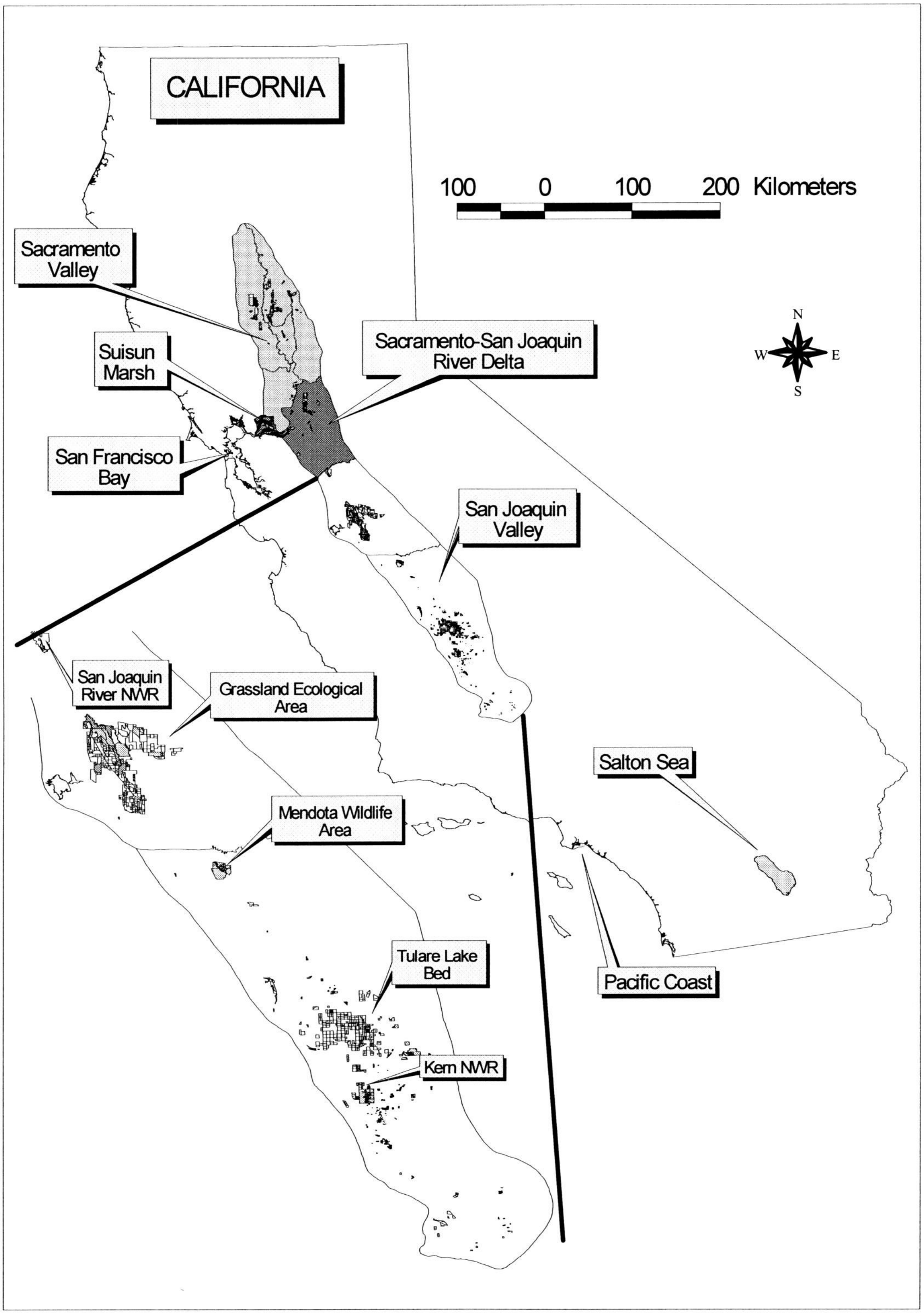


Figure I.1. Regions of California and areas within the San Joaquin Valley used by wintering northern pintails (Anas acuta) during 1991-94.

Sacramento Valley (SACV). For instance, the portion of Central Valley pintails that were counted in the SJV in early January declined from 24% in the 1970s to 8% in the 1980s (Table I.1, Calif. Dept. Fish and Game [CDFG], Sacramento, and USFWS, Portland, OR, unpubl. data). The role of habitat changes in and outside of the SJV on this disparate decline is not understood. Information is needed on the impact of reduced preirrigation of grain fields in the Tulare Basin (Barnum and Euliss 1991), increases in irrigated fields and freshwater marshes along the west coast of mainland Mexico (Kramer and Migoya 1989), and increases in winter flooding of Sacramento Valley (SACV) rice fields (Central Valley Habitat Joint Venture [CVHJV] Tech. Comm. 1996, Elphick and Orrick 1998) on abundance of pintails in the SJV.

Information is also needed on the impact of habitat changes on local movement patterns. Most wetland habitat in the SJV is privately owned and funds to flood and manage these habitats are largely derived from hunters (Gilmer et al. 1982). Changes in local waterfowl distribution and movement patterns that reduce hunter success could reduce funding and incentive to manage private wetlands (Heitmeyer et al. 1989, Baldassarre and Bolen 1994). Because of their critical importance to North American waterfowl and other wetland wildlife, wetland habitat in the Grassland Ecological Area (EA), Tulare Basin and other Central Valley areas is a focal point for habitat conservation efforts. One of the most encompassing ongoing efforts, the CVHJV will affect activities on 950,000 acres of wetlands and agricultural lands in the Central Valley at a capital cost of more than $528 million and an annual cost of about $38 million (CVHJV Implementation Board 1990). Knowledge of pintail movement patterns in the Grassland

Table I.1. Percentage of central California northern pintails surveyed and harvested in the San Joaquin Valley (SJV). Central California includes the SJV, Sacramento Valley (SACV), San Joaquin-Sacramento River Delta (Delta), Suisun Marsh and San Francisco Bay (SFB).

	Percent of pintails surveyed in central California that occurred in the San Joaquin Valley[a]			Percent of central CA pintail harvest
Period	Mid-Sept.[b]	Late Oct.-Early Nov.[c]	Late Dec.-Early Jan.	occurring in SJV[d]
1960s	<39	<<20	13	33
1970s	<50	<30	24	32
1980s	<24	<<24	8	40
1991-94	<<31	<<32	8	36

[a]Pacific Flyway waterfowl reports and U. S. Fish and Wildl. Serv., Portland, OR, Unpubl. data.
[b]Mid-September surveys overestimates actual percentage of central California pintails occurring in the SJV at that time because SFB was not surveyed, Delta was not surveyed 5 years during the 1980s and in 1991, and no private lands in the SACV were surveyed in 1993.
[c]Late Oct. - Early Nov. surveys overestimate actual percentage of central California pintails occurring in the SJV at that time because SFB was not surveyed, Delta was not surveyed during the 1960s, and no or few private lands in the SACV were surveyed during the 1980s and 1991-94.
[b]Carney et al. (1975, 1983) and U. S. Fish and Wildl. Serv., Portland, OR, Unpubl. data..

Ecological Area (EA), Mendota Wildlife Area (WA) and Tulare Basin before habitat changes have occurred is crucial for measuring the response of pintails to the CVHJV and other habitat programs so these efforts provide the maximum sustained benefit for our waterfowl resources.

The range of waterfowl populations need to be delineated to manage harvest and measure exposure to contaminants and disease. The California Department of Health Services has issued a health warning advising limited consumption of waterfowl harvested in the Grassland EA because of elevated selenium levels (CDFG, unpubl. data). Similar warnings are absent for other Central Valley regions. Movements of waterfowl within and out of the Grassland EA are not known and must be understood to better manage pintails (Rienecker 1987a).

Aerial surveys provide some information on regional waterfowl distribution but most surveys are conducted on days when hunting occurs and provide no information on daily, nocturnal or individual movement patterns (CDFG, unpubl. data). Banding data are inadequate to measure changes in pintail distribution relative to recent habitat changes. Little banding data exist for pintails in Mexico wintering areas and few pintails have been banded since the 1970s (Hestbeck 1993b). Also, differences in recovery rates among areas and changes in rates over time complicate interpretation of banding data.

To obtain information important for management of pintails, I radio-tagged Hatch-Year (HY) and After-Hatch-Year (AHY) female pintails throughout the SJV, after their late summer arrival, and monitored their regional and local movements during late-August to mid-April, 1991-94. I radio-tagged only females because females are especially important to population dynamics (Flint et. al. 1998) and funding was adequate to study only one sex (sample sizes had to be adequate for precise survival estimation). I compared distribution and movements of pintails among years, intervals, diurnal periods and shoot and nonshoot days, and tested the effect of age and condition of pintails at capture, and their capture location and date.

STUDY AREA

The study area was composed of 3 areas: a) the SJV, composed of the San Joaquin River National Wildlife Refuge (NWR), Grassland EA, Mendota WA, and Tulare Basin, b) other central California (OCC) regions, composed of the Sacramento Valley (SACV), the Sacramento-San Joaquin River Delta (DELTA), Suisun Marsh (SUISUN) and San Francisco Bay (SFBAY) (Figure I.1) and, c) areas north (NORTH) or south (SOUTH) of central California (combined is NS).

SJV waterfowl habitat consisted primarily of shallow, seasonal wetlands in three distinct blocks (up to 23,313 ha in the Grassland EA, 2762 ha in Mendota WA and 2946 ha in the Tulare Basin) that were separated by agricultural lands (e.g., orchards, cotton fields) that were rarely flooded and were of little value to waterfowl (Fleskes, unpubl. data). In contrast, the 20,000-27,000 ha of wetlands in the SACV were interspersed among 24,000 - 60,000 ha of rice fields flooded after harvest (Central Valley Habitat Joint Venture Technical Committee 1996) which provided a relatively contiguous block of important waterfowl habitat. In the DELTA, approximately 12,000 ha of grain fields that were flooded after harvest, (Central Valley Habitat Joint Venture Technical

Committee 1996) and 7,000 ha of wetlands (Heitmeyer et al.1989) provided waterfowl habitat. SUISUN provided 22,000 ha of brackish wetland habitat (Heitmeyer et al.1989). Salt ponds, tidal and diked marsh and open bay were available in the heavily industrialized and urbanized SFBAY.

The Grassland EA vicinity (Figure I.2) was composed of the Grassland EA and nearby habitats, including the 6300 ha San Luis Reservoir (includes the O'Neill Forebay). Up to 23,313 ha of seasonal marsh, 1160 ha of semipermanent and permanent marsh, 1258 ha of flooded uplands, 245 ha of sewer ponds, 39 ha of evaporation ponds and 314 ha of flooded agricultural fields were available in the Grassland EA vicinity (Fleskes, unpubl. data). The Grassland EA was divided into north, south and east parts. The north grasslands was composed of public lands with some wetlands closed to hunting (San Luis NWR, Kesterson NWR, Los Banos WA), public areas without closed zones (Volta, Salt Slough and China Island WAs) and privately owned waterfowl hunting clubs. (North Clubs). The Grassland State Park in the north grasslands was closed to hunting but had no waterfowl habitat. The south grasslands were composed entirely of private waterfowl hunting clubs (South Clubs). The east grasslands was composed of Merced and Arena Plains NWRs and private waterfowl hunting clubs (East Clubs).

Mendota WA was composed of up to 2459 ha of shallow marsh open to waterfowl hunting, 303 ha of shallow marsh closed to waterfowl hunting and a 364 ha central deep-water pool open to hunting (Figure I.3).

The Tulare Basin (Figure I.4) was composed of up to 2399 ha of preirrigated fields (i.e., barley-wheat, safflower, alfalfa and cotton fields that were harvested and then

Figure I.2. Grassland Ecological Area vicinity in the San Joaquin Valley, including California Department of Fish and Game Wildlife Areas (WA), U.S. Fish and Wildlife Service National Wildlife Refuges (NWR), private waterfowl hunting clubs and San Luis Reservoir, during 1991-94.

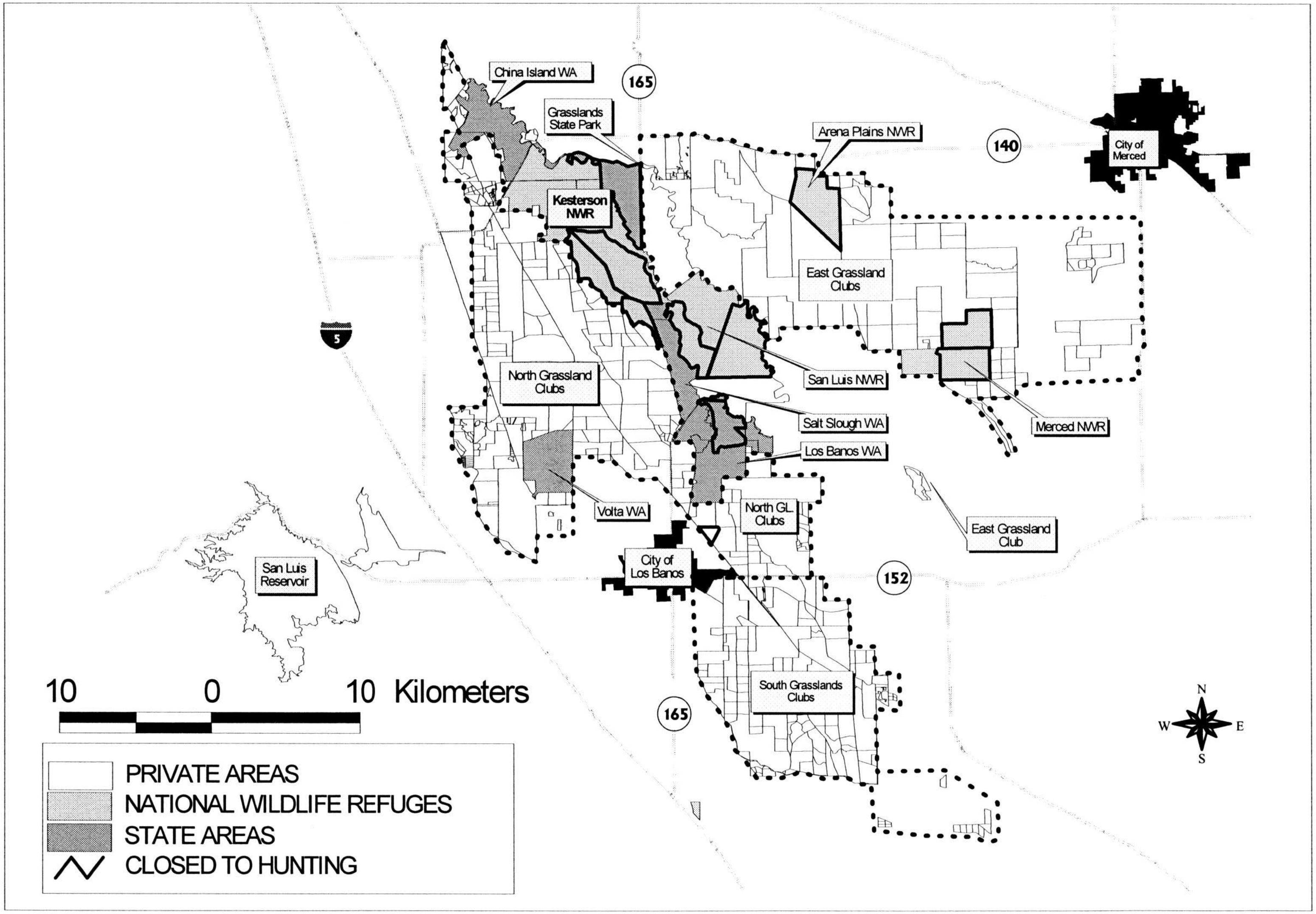

China Island WA
165
Grasslands State Park
Arena Plains NWR
140
City of Merced
Kesterson NWR
East Grassland Clubs
5
North Grassland Clubs
San Luis NWR
Salt Slough WA
Merced NWR
Los Banos WA
Volta WA
North GL Clubs
East Grassland Club
San Luis Reservoir
City of Los Banos
152
10 0 10 Kilometers
165
South Grasslands Clubs
N
W
E
S
PRIVATE AREAS
NATIONAL WILDLIFE REFUGES
STATE AREAS
CLOSED TO HUNTING

Figure I.2.

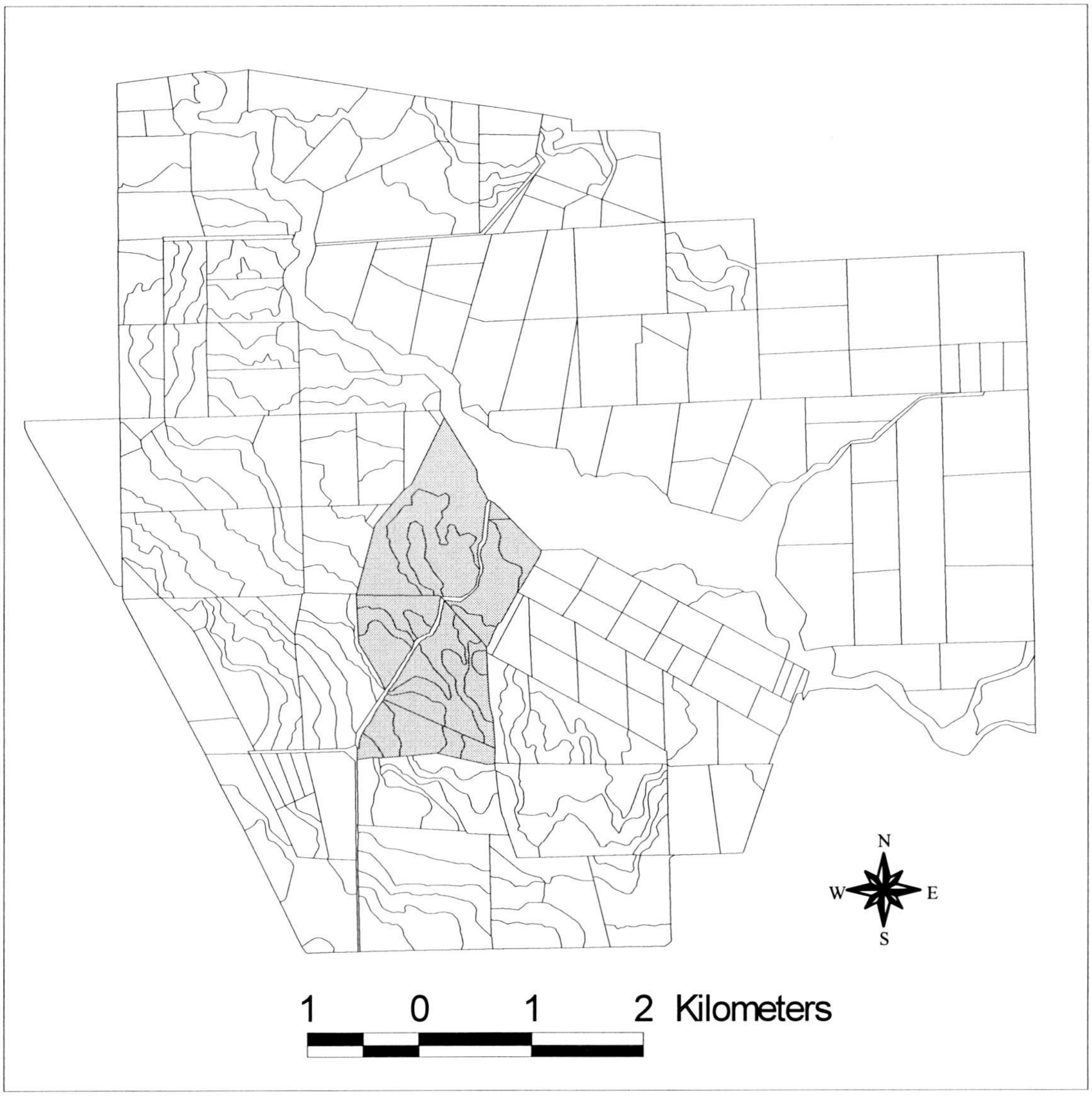


Figure I.3. Mendota Wildlife Area including the 364 ha central deepwater pool, the 303 ha shallow marsh area closed to waterfowl hunting (shaded area) and other shallow marsh units open to waterfowl hunting (up to 2459 ha flooded during 1991-94).

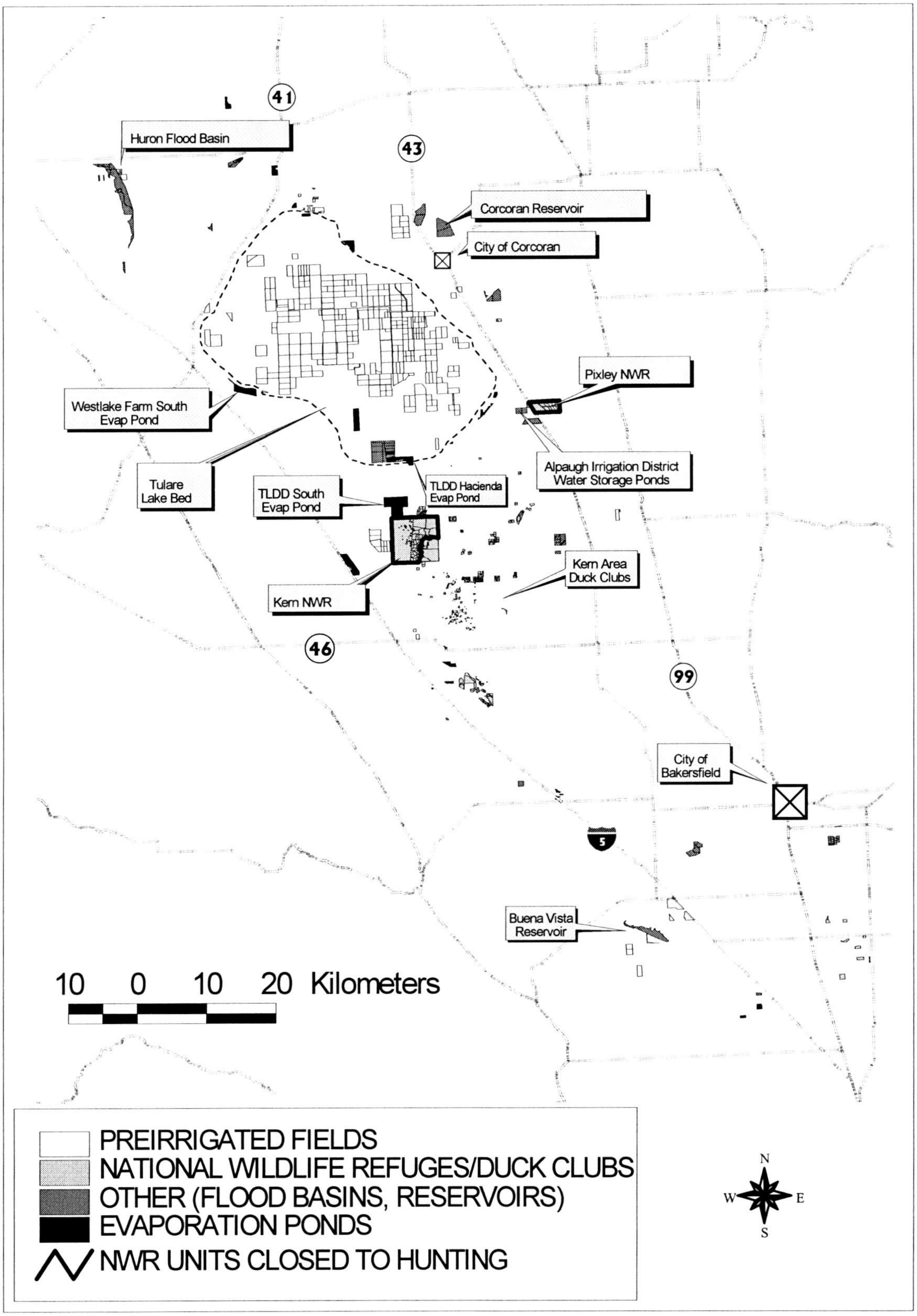


Figure I.4. Wetland habitats in the Tulare Basin during August-April, 1991-94.

disced and flooded before the next planting), up to 2946 ha of public and private wetlands, 1951 ha of agricultural-drainwater evaporation ponds, and miscellaneous habitats (0-1374 ha of flood basins, 82 ha of sewage treatment ponds, and 390-742 ha of reservoirs) in or near the Tulare Lake Bed and Kern NWR (Fleskes, unpubl. data).

Most wetlands in the Central Valley were dry during summer, irrigated periodically during the summer to promote seed production, and flooded during winter. Most initial flooding of wetlands and harvested croplands occurred during mid-August to late-October. Water for irrigation, fall flood-up and water-level maintenance was delivered from reservoirs that stored Sierra snow-melt. Thus, the timing and amount of early-winter habitat varied with the previous winter's snowfall. Late-winter rains flooded additional habitat each year. Study area habitats are described by USFWS (1978, 1979), Heitmeyer et al. (1989), Herbold and Moyle (1989), Kadlec and Smith (1989), Kramer and Migoya (1989), Kempka and Kollasch (1990), Baldassarre and Bolen (1994) and Ducks Unlimited (1994).

Precipitation and the quality and quantity of flooded habitat varied during the study. Reservoir levels were critically low in 1991 due to 4 years of below-normal precipitation; drought conditions in the San Joaquin River drainage were the worst on record (California Department of Water Resources 1991, National Oceanic and Atmospheric Administration, Asheville, NC, unpubl. data). In 1991, no water was delivered to the Grassland Water District for wetland plant irrigation during May-July, fall flood-up was delayed about 2 weeks, and August through mid-November and total water deliveries to the Grassland Water District were the lowest on record (Grassland

Water District, Los Banos, CA, unpubl. data). Drought conditions prevailed through January 1992 but habitat conditions improved during 1992-93 because of near-normal precipitation and higher water level in reservoirs. Conditions during 1993-94 were good because above-average precipitation and enactment of the Central Valley Project Improvement Act (Davis 1992) nearly doubled the amount of water that was delivered to the Grassland Water District (Grassland Water District, Los Banos, CA, unpubl. data).

Wetland restoration also increased available habitats in 1993-94. Salt Slough WA was mostly dry until wetlands were restored and flooded in September, 1993. Also, the Gadwall ponds in the sanctuary part of Kesterson NWR were restored and flooded in 1993.

Duck hunting daily bag limits (4 ducks with 1 either-sex pintail) and season lengths (59 days) were identical throughout California during all years of the study (CDFG, Sacramento, unpubl. data). However, the timing of the hunting seasons differed among years and regions. The hunting season was a consecutive 59 days, starting in early-mid November in the southern SJV zone (includes the Tulare Basin but not the Mendota WA), and starting the second Saturday in October in the northeastern California zone. Elsewhere the season was split, with most areas (including the "remainder of the state zone", where almost all of my radio-tagged pintails wintered), having a 22-day late-October to mid-November first season (HUNT1) and a 37-day second season (HUNT2) starting after a 12 (in 1991), 19 (in 1992) or 27 (in 1993) day closure (i.e., SPLIT) of duck hunting after the end of the first season. In addition, nearly all duck clubs in the Grassland EA and WAs and NWRs in central California allowed hunting only on

Wednesdays, Saturdays, and Sundays (i.e., Shoot dates). Kern NWR was hunted only on Wednesdays and Saturdays and many clubs in the Tulare Basin adopted Wednesday and Saturday (and not Sunday) as shoot dates. Many duck clubs outside the SJV, especially those that hunted rice fields in the SACV, also hunted on windy and rainy days or allowed hunting all 59 days of the season.

METHODS

Field procedures

I captured and radio-tagged female pintails 29 August - 6 October 1991, 31 August - 5 October 1992 and 28 August - 25 September 1993 in the Tulare Basin, Mendota WA, and Grassland EA (Table I.2) and tracked their movements throughout the wintering period (i.e., late August through late March). I radio-tagged female pintails roughly in proportion to pintail abundance in the SJV as determined by September aerial surveys (G. Gerstenberg, CDFG, Los Banos, unpubl. data). I captured 4 - 275 ($\bar{x}$ = 76) northern pintails with each of 11 - 14 rocket-net (Schemnitz 1994) shots each year at rice-baited and unbaited wetland sites on Volta, Mendota and Los Banos WAs; Merced, San Luis, and Kesterson NWRs; Clear Lake and Stillbow duck clubs in the south grasslands; and flooded agricultural lands in the Tulare Basin. Age ratios were skewed heavily toward adults in the captures, especially before late September. Thus, in order to radio-tag pintails of both age classes during a similar period, I radio-tagged all HY females that I captured until the annual goal was reached but released randomly selected AHY females without radios. Even so, mean radio-tagging dates in 1991 and 1992 were about 2 weeks

Table I.2. Number of After-Hatch-Year (AHY) and Hatch-Year (HY) female northern pintails radio-tagged in the Grassland Ecological Area (EA), Mendota Wildlife Area (WA) and Tulare Basin of the San Joaquin Valley, California, 1991-93.

	Year and Age Class											
	1991			1992			1993			All Years		
AREA	AHY	HY	Both	AHY	HY	Both	AHY	HY	Both	AHY	HY	Both
Grassland EA	41	37	78	30	48	78	44(20)[a]	39(18)	83	115	124	239
Mendota WA	21	4	25	17	4	21	33(14)	39(19)	72	71	47	118
Tulare Basin	10	2	12	18	6	24	14(6)	12(5)	26	42	20	62
Total	72	43	115	65	58	123	91(40)	90(42)	181	228	191	419

[a]Number of spear-suture type radio-tags (in parenthesis), included in cell totals. All other radio-tags were harness backpack type.

earlier for AHY (42 days before hunting season opened) than HY (27-28 days before hunting season opened) females because few or no HY pintails were captured until late September in those years due to poor or late production (USFWS and CWS 1991, 1992). In 1993, pintail production improved (USFWS 1993), HY pintails were more common in early captures and mean radio-tagging dates were similar for AHY (35 days before hunting season opened) and HY (32 days before hunting season opened) females. I weighed ($\pm$ 5 g), measured (flat wing, culmen 1, total tarsus [Dzubin and Cooch 1992] $\pm$ 0.01 mm), aged (HY or AHY, Larson and Taber 1980, Duncun 1985, Carney 1992) and legbanded some male and all female pintails that I captured in the SJV. Pintails were released at the capture location from <1 to 19 ($\bar{x}$ = 7.7) hours after capture. During the first two years I exclusively attached 20-21-g (2.0-3.2% of body mass) radio transmitters with back-mounted harnesses (Dwyer 1972). In 1993, I radio-tagged pintails with either harness (n = 98) or spear-suture transmitters (n = 83). The spear-suture transmitters were similar in design to that described by Pietz et al. (1995), except for a circular (20 mm diameter x 12 mm high) rather then rectangular body and weighing 8-9 g rather than 4 g. All transmitters had a unique signal, a mortality sensor, life expectancy $\geq$ 210 days and an initial minimum range of 3.2 km ground-to-ground using 150-db receivers and dual 4-element Yagi antennas mounted on the roof of pick-up trucks. All transmitters were imprinted with a contact address, phone number and identification number. Project descriptions, that requested hunters to report radio-tagged ducks they shot or found and informed them that they were welcome to keep the radio-tags and would receive information about the bird's movements, were posted at public hunting check stations and published in state-wide media.

I recorded status (location, alive or dead) of each pintail 1-2 times a day during the hunting season and at least every other day during non-hunting intervals in SJV, and at least weekly in OCC from the date of the first pintail capture until 20 March each year (202 - 205 days). I conducted aerial searches (Gilmer et al. 1981), including overflights of waterfowl habitat and urban areas, for missing pintails weekly throughout the SJV and other central California regions. I and cooperators searched other areas, including northeastern and coastal California, Salton Sea, Malheur NWR area, Wilamette and Klamath basins in Oregon, the Carson sink in Nevada, and the Western Coast of Mexico, 1 to 10 times each winter for pintails missing from central California. I censored (i.e., excluded data thereafter) pintails equipped with failing radios as evidenced by an intermittent, weakening or increasingly fast or slow signal at the time abnormal signals prevented daily tracking. Pintails that shed their radios were censored on the date their radios were shed. I excluded 14 of the 433 pintails that I radio-tagged from analyses because they failed to adjust to their radios, as evidenced by their failure to make normal feeding flights, and were killed by predators 1 - 6 days after marking. I included 25 AHY and 24 HY female pintails radio-tagged in SUISUN (Casazza 1995) and 3 AHY female pintails radio-tagged in Alaska (J. B. Grand, pers. comm.) in the analyses of local distribution and movements in the Grassland EA vicinity.

During 1991-92 and 1992-93, I followed 216 different randomly selected female pintails in the SJV, 1-15 times (mean = 3.74 times) in order to estimate time spent flying.

Of the 807 follows, 697 were in the Grassland EA, 48 in Mendota WA and 59 in Tulare Basin. Signals from flying radio-tagged pintails were much louder than from radio-tagged pintails that were on water or land so I used changes in signal strength to determine starting and ending times of all flights; I also recorded starting and ending locations. I ended a follow if the pintail left the SJV or if I caused the pintail to fly. Follows lasted 48-150 minutes (mean = 139 minutes) during DAWN (75 minutes before sunrise to 75 minutes after sunrise), 48-259 minutes (mean = 158 minutes) during DAY (76 minutes after sunrise to 76 minutes before sunset), 58 to 150 minutes (mean = 128 minutes) during DUSK (75 minutes before sunset to 75 minutes after sunset), and 52-235 minutes (mean = 165 minutes) during NIGHT (76 minutes after sunset to 76 minutes before sunrise). All DAWN follows started before and ended after sunrise and all DUSK follows started before and ended after sunset.

Data analysis

I estimated distribution among regions and local areas. I estimated weekly regional distribution of pintails among NORTH, SACV, DELTA-SUISUN-BAY, Grassland EA, Mendota WA, Tulare Basin and SOUTH. For some tests I grouped Grassland EA, Mendota WA and Tulare Basin into SJV, SACV and DELTA-SUISUN-BAY into OCC, and NORTH and SOUTH into NS to maintain adequate sample sizes. In the Grassland EA, I estimated weekly distribution of pintails during shoot (Sundays, Wednesdays, Saturdays during hunting intervals) and nonshoot days and nights among privately (North Grassland Clubs, South Grassland Clubs, East Grassland Clubs) and publicly-owned (Merced-Arena Plains NWRs, San Luis NWR, Kesterson NWR, Los Banos WA, and Volta-Salt Slough-China Island WAs) areas. In the Tulare Basin, I estimated weekly distribution of pintails during shoot (Wednesdays and Saturdays during hunting intervals) and nonshoot days and nights among preirrigated fields, Kern-Pixley NWRs, evaporation ponds, duck clubs and miscellaneous areas.

To reduce bias associated with unequal and multiple sampling of individual pintails each week, I apportioned multiple weekly (for regional analysis) or multiple day/night, shoot/nonshoot (for local analysis) locations among regions or local areas and used a "bird-week" as the sample unit. For instance, if bird A was in the SACV during Sunday-Wednesday but in NORTH during Thursday-Saturday, I apportioned 4/7 bird-weeks to SACV and 3/7 to NORTH for that week. Similarly, if during week 9 in HUNT1, bird B was located on San Luis NWR during the day on Wednesday and on Merced NWR during the day on Saturday, I apportioned 0.5 shoot-day bird-weeks to each of those areas. Thus, each pintail had a maximum of one bird-week per week for each day/night and shoot/nonshoot category. Weekly totals were grouped into intervals (PREHUNT, HUNT1, SPLIT, HUNT2, POSTHUNT); for some analyses I grouped intervals into hunting (HUNT1 and HUNT2) and nonhunting (PREHUNT, SPLIT, POSTHUNT). To pool or compare weekly distribution across years I used 1 September, 30 August, or 29 August as the start of week 1 for 1991-92, 1992-93 and 1993-94, respectively.

To investigate the relationship of various factors to weekly distribution of radio-tagged pintails among regions and within local areas I took two approaches in categorical modeling of repeated weekly measures. The first was to use categorical modeling (Sauer and Williams 1989) by week and apply the Bonferroni adjustment to maintain an alpha level of 0.05 when making multiple weekly comparisons (Johnson and Wichern 1982:197). The second was to use a generalized linear model (McCullagh and Nelder 1989) across weeks which accounts for correlation between repeated measures (Liang and Zeger 1986). By-week categorical modeling, implemented through PROC CATMOD (SAS Inst. Inc. 1989b) is suitable for comparing between two, three or more response categories but it can be cumbersome to summarize all by-week results. Generalized linear modeling (a form of logistic modeling) implemented through PROC GENMOD with a generalized estimating equations approach is suitable for describing overall effects across weeks but only between two response categories (SAS Inst. Inc. 1997). I used PROC CATMOD (SAS Inst. Inc. 1989b) to compare regional distribution each week among study years (1991-92, vs 1992-93 vs 1993-94), bird ages (HY vs AHY), bird capture locations (Grassland EA vs other [Mendota WA and Tulare Basin), bird capture periods (<1 September vs >17 September) and bird body weight at capture (above vs below age-class mean). I used PROC GENMOD to investigate the effects of bird age and condition on regional distribution across weeks and to investigate the effects of diurnal period (day vs night), study year (1991-92, vs 1992-93 vs 1993-94), bird age (HY vs AHY), bird capture location (Grassland EA vs other [Mendota WA, Tulare Basin, SUISUN, Alaska]) and bird body weight at capture (above vs below age-class mean) on local distribution across weeks. I used PROC CATMOD to determine if relationships between local distribution and variables that were found to be significant across weeks with PROC GENMOD were consistent among weeks. Hunting was obviously an important factor affecting local pintail distribution, so I conducted most local analyses separately for hunting and non-hunting weeks. For analysis of distribution in the Grassland EA during the hunting season, I added a factor (shoot vs non-shoot) to model the effects of greater hunting intensity on Sundays, Wednesdays and Saturdays. I also compared distribution among public and private areas on days or nights following a hunt day (i.e. Mondays and Thursday) with those two days after a hunt day (i.e. Tuesdays and Fridays). I followed Dobson (1990:98) and Milliken (1984:990-999) to assess the importance of explanatory variables and interactions using a step-down model selection method.

I used univariate analysis of variance (ANOVA) (PROC GLM; SAS Inst. Inc. 1989a) to test for effects of study year, bird age, diurnal period (DAWN, DAY, DUSK, NIGHT), interval and hunting (PREHUNT, HUNT1-Shoot, HUNT1-Nonshoot, SPLIT, HUNT2-Shoot, HUNT2-Nonshoot, POSTHUNT) on flight times. I used Fisher's protected LSD value to isolate pairwise differences in means if a factor effect was detected ($P < 0.05$) in ANOVA's (Milliken and Johnson 1984:31). I conducted two separate analyses; one with all follow data and one with data only from follows in the Grassland EA vicinity during the hunting season. I used the arcsine-square root transformation (Zar 1974) in order to more closely meet normality assumptions for tests comparing percent of total follow time a pintail was flying. I back-transformed Least Square means and used average DAY and NIGHT lengths during each interval to calculate total time spent flying during the winter interval.

I assumed that each pintail moved about independently even if captured under the same net. To test the validity of this assumption I conducted a nearest neighbor analysis (Rosing et. al. 1998).

I used univariate analysis of variance (ANOVA) (PROC GLM; SAS Inst. Inc. 1989a) to test for winter effects on body mass and morphometric variables. I preceded ANOVAs with a multivariate ANOVA (MANOVA) as a check against possible joint effect of winter on these variables (Johnson and Wichern 1988:169). I used Fisher's protected LSD value to isolate pairwise differences in means following effects in ANOVA's (Milliken and Johnson 1984:31). I set alpha at 0.05.

All tests were 2-tailed.

RESULTS

Distribution and movements among regions

I estimate that 94.3% of the 419 female northern pintails that I radio-tagged in the SJV wintered in central California (i.e., remained in central California until migrating to northern breeding areas during late January - late March) and 5.7% wintered in SOUTH. I found 4 radio-tagged pintails near Salton Sea, 4 along the southern Pacific coast of California, 1 in western Mexico and suspect that 15 birds that I lost at the same time as others that emigrated south, wintered in parts of Mexico or other southern areas that I did not search.

Of the 399 radio-tagged pintails that wintered in central California, 83% flew north to the SACV or DELTA during September - January, most leaving the SJV during

December (Figure I.5). Although 43% of the pintails that left revisited the SJV, return visits averaged only 17 days and 40% of the visits were < 7 days. No radio-tagged pintail made regular daily or weekly flights between the SJV and OCC. Likewise, within the SJV, none flew regularly between the Grassland EA, Mendota WA and Tulare Basin. Migration out of central California to northern breeding areas began in late January and peaked during late February - early March, but 12-18% were still in central California on 1 April (Figure I.5).

Pintail distribution during PREHUNT was similar each year except a greater (X^2 = 6.82, 2 df, $P < 0.05$) percentage of pintails emigrated north to other central California areas (esp., SACV and DELTA) during the dry 1991 PREHUNT (10%) than during 1992 (5%) or 1993 (3%) (Figure I.5). Pintails marked at Mendota WA remained there during PREHUNT, but 33% (1992-93) to 50% (1991-92 and 1993-94) of the pintails marked in the Tulare Basin flew north to the Grassland EA or Mendota WA. All of the birds that wintered SOUTH left during PREHUNT. Each year, two birds with worn flight feathers went to northeastern California, the SACV or SUISUN, where lack of flights indicated they molted their flight feathers. By opening day of the HUNT1 in 1991, 20% of the radioed pintails were outside the SJV. At the same time in 1992 and 1993, only 7% were outside the SJV (Figure I.5).

Movements and distribution of pintails during HUNT1 were also similar each year. Approximately 95% of all pintails at Mendota WA flew to the Grassland EA on opening morning of HUNT1 each year and most remaining at Mendota WA came to the Grassland EA during the next few days. Thus, after opening of HUNT1, <10% of all

Figure I.5. Percent of live radio-tagged female northern pintails present each week in the Grassland Ecological Area, Mendota Wildlife Area (WA), Tulare Basin, Delta-Suisun-San Francisco Bay [combined], Sacramento Valley, and in areas North (North) and South (South) of central California, during October-April, 1991-94. Pintails (115 in 1991, 123 in 1992 and 181 in 1993) were radio-tagged during 28 August - 6 October in the Grassland Ecological Area, Mendota Wildlife Area (WA) and Tulare Basin. Starting distribution of the radio-tagged sample is shown in the Cap (i.e., capture) column.

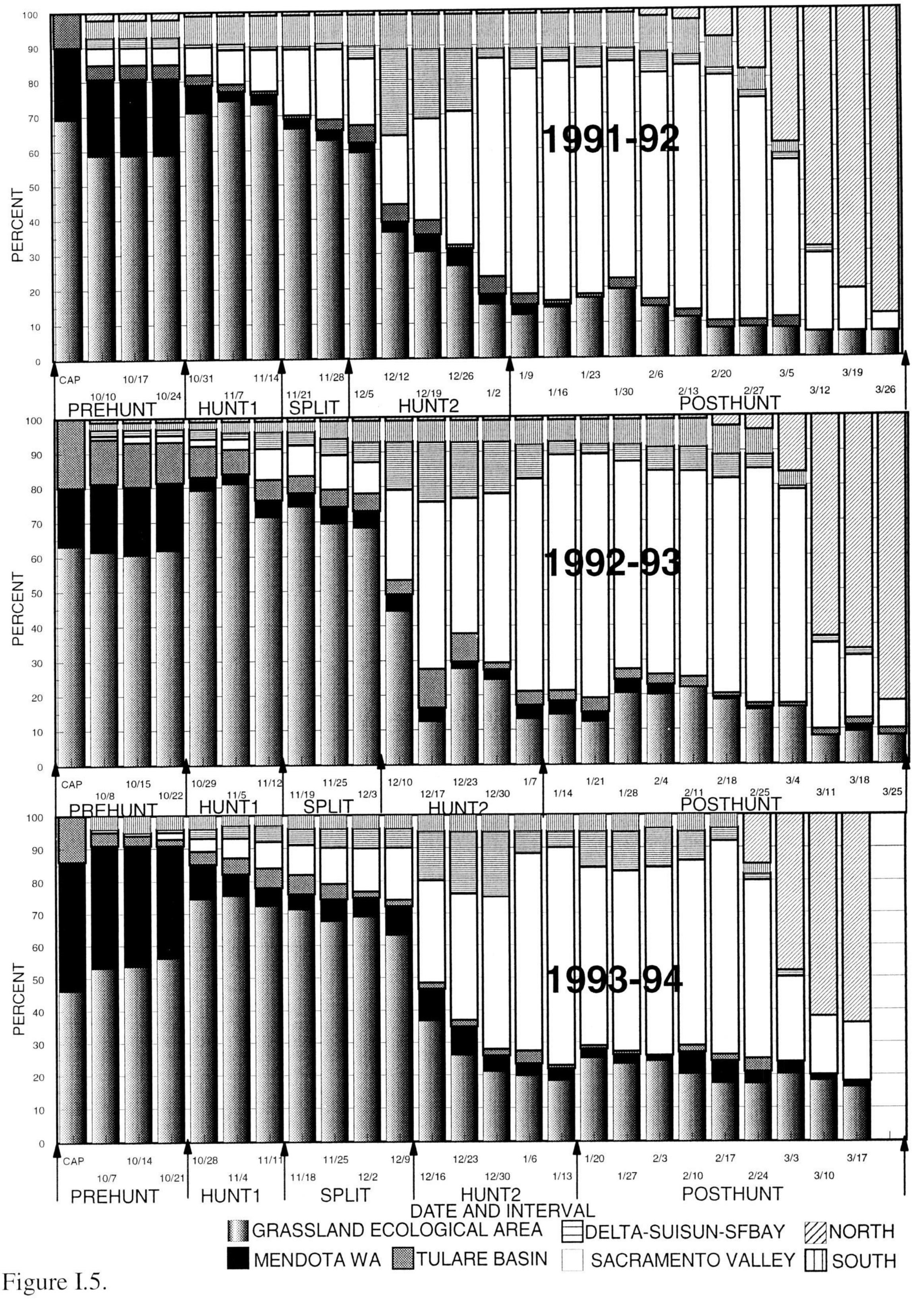

1991-92
PERCENT
100
90
80
70
60
50
40
30
20
10
0
CAP 10/10 10/17 10/24 10/31 11/7 11/14 11/21 11/28 12/5 12/12 12/19 12/26 1/2 1/9 1/16 1/23 1/30 2/6 2/13 2/20 2/27 3/5 3/12 3/19 3/26
PREHUNT HUNT1 SPLIT HUNT2 POSTHUNT
1992-93
CAP 10/8 10/15 10/22 10/29 11/5 11/12 11/19 11/25 12/3 12/10 12/17 12/23 12/30 1/7 1/14 1/21 1/28 2/4 2/11 2/18 2/25 3/4 3/11 3/18 3/25
PREHUNT HUNT1 SPLIT HUNT2 POSTHUNT
1993-94
CAP 10/7 10/14 10/21 10/28 11/4 11/11 11/18 11/25 12/2 12/9 12/16 12/23 12/30 1/6 1/13 1/20 1/27 2/3 2/10 2/17 2/24 3/3 3/10 3/17
PREHUNT HUNT1 SPLIT HUNT2 POSTHUNT
DATE AND INTERVAL
GRASSLAND ECOLOGICAL AREA
DELTA-SUISUN-SFBAY
NORTH
MENDOTA WA
TULARE BASIN
SACRAMENTO VALLEY
SOUTH

Figure I.5.

radio-tagged pintails were ever at Mendota WA (Figure I.5). Like during PREHUNT, the percentage of radio-tagged pintails in the Tulare Basin during HUNT1 declined (Figure I.5) as pintails there continued to emigrate to the Grassland EA. However, in 1993-94 several that had left during PREHUNT returned to the Tulare Basin and the percentage of radio-tagged pintails in the Tulare Basin increased during HUNT1 (Figure I.5). During HUNT1 in 1991 and 1993, about 2-3 pintails per week emigrated from the Grassland EA to the SACV; during 1992 the same number left but more abruptly during the last week of the interval. By the end of HUNT1 in 1991, 23% of the radioed pintails were outside the SJV, mostly in the SACV; at the same time in 1992 and 1993, 17% were outside the SJV (Figure I.5).

During the 13-day SPLIT in 1991, pintails continued to leave the Grassland EA for the SACV, so that by the end of the interval, 31% were outside the SJV (Figure I.5). Few pintails moved among regions during the 20-day SPLIT in 1992, and at the end of SPLIT in 1992, 22% were outside the SJV. During the 27-day SPLIT in 1993, the gradual exodus of pintails from the Grassland EA to the SACV continued so that by the end of the interval 26% were outside the SJV.

Emigration to the Delta and SACV increased during HUNT2 each year, so that when the hunting season closed, 77-83% were outside the SJV (Figure I.5). Mass (>10% of birds present) northerly movements began December 6-11 each year on hunting days during noticeable weather changes. For instance, on Wednesday morning December 11, 1991, the first morning of the winter with dense fog, one third of the radio-tagged pintails in the Grassland EA flew to the Delta and SACV. During the later two years, mass northerly movements were first initiated during opening weekend of HUNT2 during winter storms with strong winds from the south.

Few birds moved between regions until spring migration and distribution was similar during most POSTHUNT weeks (Figure I.5). Each year several pintails returned to the SJV from DELTA and SACV and most remained. At the end of the 1991-92 field season (April 1), 12% of the pintails were still in the central California; 18% were present at the end of the 1992-93 field season. When field work ended in 1993-94 (March 17), 36% of the pintails were still in central California. Radio-tagged pintails were located during February-May in northeastern California (n = 34), Nevada (n = 1), Utah (n = 1), Montana (n = 2), Idaho (n = 1), Alberta (n = 3), Oregon (n = 5), Washington (n = 4), British Columbia (n = 9) and Alaska (n = 4).

Factors related to regional movements

Movements of pintails among regions were related to bird age, condition at capture, capture location, study year and weather. There was no significant difference ($X^2 \leq 9.41$, 2 df, Bonferroni $P > 0.05$) in weekly regional distribution of AHY pintails captured in the Grassland EA during late August and AHY captured in the Grassland EA after 17 September.

Distribution of AHY and HY pintails among the SJV, OCC, and NS differed significantly ($X^2 \geq 13.13$, 2 df, Bonferroni $P < 0.05$) during weeks 17, 19 and 24 - 30, reflecting the lower percentage of HY females emigrating to OCC in December and NS in March, respectively (Figure I.6). The percent of both AHY and HY pintails in the SJV

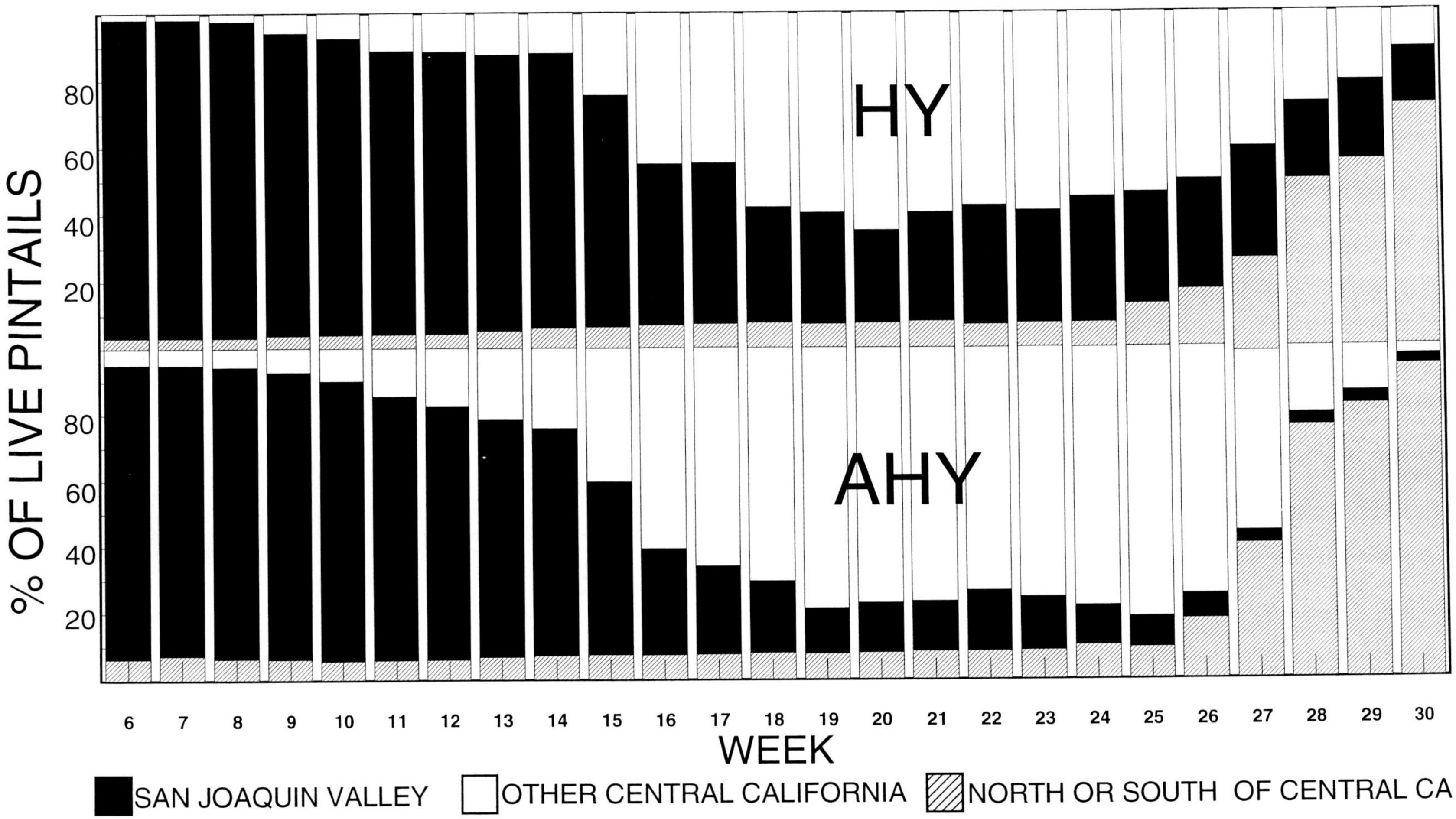


Figure I.6. Percent of live radio-tagged Hatch-Year (HY) and After-Hatch-Year (AHY) female northern pintails present each week during October - March, 1991-94, in the San Joaquin Valley, other Central California areas, and areas North or South of central California (i.e. northeast CA, OR, WA, AK, southern CA and Mexico). A total of 191 HY and 228 AHYpintails were radio-tagged 28 August - 6 October, in the San Joaquin Valley. Week 6 = Oct. 6-12, 1991, Oct. 4-10, 1992, Oct. 3-9, 1993.

decreased as winter progressed but the rate of departure from the SJV was greater for AHY than HY pintails ($Z = 2.83$, $P = 0.0046$). There was weak evidence that HY females were more likely to revisit the SJV than AHY females ($X^2 = 2.97$, 1df, $P = 0.085$).

AHY pintails tended to leave the SJV earlier than HY (Mean departure = Dec. 2 vs Dec. 19) but the effect of age varied with body condition ($F = 3.77$, 1 df, $P = 0.05$). The mean departure date (Nov. 27) for AHY pintails that were lighter than average at capture was significantly earlier ($t = 2.58$, 230 df, $P = 0.01$) than for lightweight HY pintails (Dec 26) whereas the mean departure dates of heavy birds did not differ Distribution among SJV, OCC, and NS of pintails heavier or lighter than average at time of capture did not differ during any week ($X^2 \leq 8.32$, 2 df, Bonferroni $P > 0.05$). Likewise, averaged across weeks, the percent of heavy and light female pintails that left the SJV did not differ significantly ($Z = 0.61$, $P = 0.54$).

Distribution among the SJV, OCC, and NS did not differ for pintails captured in the Grassland EA, Mendota WA, or Tulare Basin during any one week ($X^2 \leq 13.02$, 4 df, significantly ($t = 0.41$, 230 df, $P = 0.68$) for AHY (Dec 8) and HY (Dec. 12) pintails. Bonferroni $P > 0.05$). Also, averaged across weeks, the proportion from each capture site remaining in the SJV were similar ($Z = 0.51$, $P = 0.61$). However, the proportion of pintails from each capture site that are known ($X^2 = 13.06$, 2 df, $P = 0.002$) or were likely ($X^2 = 7.95$, 2 df, $P = 0.019$) to have wintered south of the SJV differed by capture location and was greater for pintails captured in the Tulare Basin than for pintails captured at Mendota WA or Grassland EA (Table I.3). Further, capture location

Table I.3. Percentage of female northern pintails radio-tagged (n = sample size) in the Grassland Ecological Area (EA), Mendota Wildlife Area (WA) and Tulare Basin that were known (in parenthesis) or suspected to have wintered south of the San Joaquin Valley (SJV), California, 1991-94.

	Year			
AREA	1991-92	1992-93	1993-94	ALL YEARS
Grassland EA	(2.6%) 6.5%[a] n = 78	(0.0%) 3.9% n = 78	(0.0%) 2.4% n = 83	(0.8%) 4.2% n = 239
Mendota WA	(0.0%) 8.7% n = 25	(4.8%) 9.5% n = 21	(0.0%) 2.9% n = 72	(0.9%) 5.3% n = 118
Tulare Basin	(0.0%) 12.5% n = 12	(4.2%) 4.2% n = 24	(19.2%) 23.1% n = 26	(10.3%) 13.8% n = 62
ALL AREAS	(1.9%) 7.4% n = 115	(1.7%) 5.0% n = 123	(2.8%) 5.6% n = 181	(2.2%) 5.9% n = 419

[a]Second column includes pintails that were known to have gone south (i.e., those located south of the SJV) and those that were suspected to have gone south (i.e., pintails with no indication of impending radio failure that became missing during the same time that pintails located south of the SJV left the SJV).

interacted with bird condition ($F = 4.42$, 1, 230 df, $P = 0.037$) with heavy pintails captured in the Tulare Basin and Mendota WA tending to leave the SJV earlier than lightweight birds (mean departure = Dec. 9 vs Dec. 24) whereas heavy pintails captured in the Grassland EA left later than lightweight birds (Dec. 13 vs Dec. 1).

Averaged across weeks, the percent leaving the SJV during winter was similar among years ($Z \leq 1.21$, $P \geq 0.22$). However, pintail distribution among the SJV, OCC and NS differed ($X^2 \geq 15.15$, 4 df, Bonferroni $P < 0.05$) among years during week 15 (i.e., 12/8/91-12/14/91, 12/6/92-12/12/92, 12/5/93-12/11/93) and week 27 (i.e., 3/1/92-3/7/92, 2/28/93-3/6/93, 2/27/94-3/5/94) (Figure I.5), reflecting slight differences in the timing of migration to the SACV in December and to northern breeding areas in March, respectively.

Slight differences in migration timing among years may have resulted from differences in weather. The likelihood of emigration from the SJV was greater on days with rain than without rain ($Z = 2.44$, $P = 0.015$) and years with more rain days had more emigrations ($Z = 5.11$, $P < 0.001$). The probability of emigration on days with dense, light or no fog did not differ significantly ($Z \leq 1.82$, $P > 0.07$) but years with more fog days had more emigrations ($Z = 4.95$, $P < 0.001$). Likewise, the probability of emigration on days with northerly, southerly, or light-calm winds was not significantly different ($Z \leq 1.22$, $P \geq 0.15$) but during 1992-93 ($Z = 3.63$, $P < 0.001$) and 1993-94 ($Z = 2.13$, $P = 0.03$), emigration was negatively associated with the number of days with southerly wind.

Distribution and movements within San Joaquin Valley areas

Distribution, daily movement patterns, flight distances and the portion of the winter spent flying varied for pintails in the Grassland EA, Mendota WA and Tulare Basin.

Local distribution - Use of public vs private areas in the Grassland EA vicinity

Overall during September through March, 64% of day and 85% of night locations in the Grassland EA were on private wetlands (i.e. North, South and East Clubs, Table I.4). However, the relative importance of public and private areas and factors related to use patterns varied greatly among weeks with and without hunting (Table I.4, Figure I.7).

During nonhunting weeks, the relative importance of public and private lands differed between day and night ($X^2 = 200.02$, 6 df, $P < 0.0001$) and among study years (1991-92, 1992-93, 1993-94, ($X^2 = 30.33$, 10 df, $P = 0.0007$). Averaged across all nonhunting weeks and winters, day use of private areas (73%) was less ($Z \geq 4.31$, $P < 0.0001$) than night use (86%) (Table I.4). However, the strength of the diurnal effect varied among weeks, so that day and night use differed significantly during only 3 of 5 PREHUNT ($X^2 \geq 4.65$, 2 df, $P \leq 0.03$), all (3/3) SPLIT ($X^2 \geq 13.65$, 1 df, $P < 0.001$), but no (0/5) POSTHUNT weeks ($X^2 \leq 0.11$, 1 df, $P \geq 0.74$) that I tested (other weeks had inadequate sample sizes). The relative importance of private and public areas during days was similar all three years ($Z < 1.18$, $P > 0.24$) but night use of private areas during nonhunting weeks in 1991-92 was less than in 1992-93 ($Z = 2.12$, $P = 0.034$) and 1993-94 ($Z = 3.30$, $P = 0.0009$) (Figure I.7). The relative importance of public and private areas

Table I.4. Percentage of radio-tagged female northern pintail locations in each area in the Grassland Ecological Area, California, during September - March, 1991-94.

		Areas in the Grassland Ecological Area									
Interval-Shoot status-Diurnal Period[1]	n[2]	North Clubs	South Clubs	East Clubs	Merced ArenaP[3] NWRs	Kes-terson NWR	Los Banos WA	San Luis NWR	Volta SaltSl Ch.Is.[4]	All Private Areas	All Public Areas
Pre-nonsh-Day	1295	39	29	1	1	7	7	3	13	69	31
Pre-nonsh-Night	1097	54	26	2	1	3	4	3	7	82	18
H1-nonsh-Day	1299	48	13	<1	9	8	2	17	2	62	38
H1-nonsh-Night	1122	72	17	<1	6	1	<1	2	<1	90	10
H1-shoot-Day	1103	8	3	<1	12	10	10	56	<1	12	88
H1-shoot-Night	556	60	15	1	11	2	6	4	<1	76	24
Spl-nonsh-Day	728	49	24	<1	5	9	1	11	<1	74	26
Spl-nonsh-Night	697	64	28	<1	4	1	1	<1	<1	93	7
H2-nonsh-Day	752	36	24	3	14	7	4	11	<1	63	37
H2-nonsh-Night	700	45	31	4	9	1	4	<1	5	80	20
H2-shoot-Day	758	12	8	2	21	15	9	33	<1	22	78
H2-shoot-Night	436	53	23	4	8	2	4	2	4	80	20
Post-nonsh-Day	385	23	42	18	6	<1	<1	2	5	83	17
Post-nonsh-Night	319	23	44	18	7	<1	1	<1	5	85	15
Nonhunt-Day	2393	40	29	4	3	6	5	5	7	73	27
Nonhunt-Night	2103	53	29	4	3	2	3	2	5	86	14
Hunt-non-Day	2043	44	17	1	11	8	3	15	2	62	38
Hunt-non-Night	1815	63	22	1	8	1	2	1	2	86	14
Hunt-shoot-Day	1856	10	5	2	16	12	9	47	<1	17	83
Hunt-shoot-Night	986	58	19	2	9	2	5	3	2	79	21
ALL-Day	4342	36	24	4	6	7	5	13	5	64	36
ALL-Night	3503	55	27	3	4	2	3	2	4	85	15

[1]Intervals are Prehunt (Pre), Hunt1 (H1), Split (Spl), Hunt2 (H2), Posthunt (Post); Shoot days are Wednesdays and weekends during H1 and H2 and nonshoot (nonsh) days are all others.
[2]Number of bird-weeks. Multiple day, night, shoot or nonshoot locations per week for a bird were apportioned to each area so bird-weeks =1 per week per bird for each day/night shoot/nonshoot category.
[3]Most use was on Merced NWR but also includes use of Arena Plains (ArenaP) NWR.
[4]Most use was on Volta WA during PREHUNT and Salt Slough (Salt Sl) WA during HUNT but also includes use of China Island (Ch. Is.) WA.

Figure I.7. Percentage of radio-tagged female northern pintail locations during the day and night each week on the San Luis Reservoir and California Department of Fish and Game Wildlife Areas (WAs), U.S. Fish and Wildlife Service National Wildlife Refuges (NWRs) and private waterfowl hunting clubs (CLUBS) in the Grassland Ecological Area, during August-April, 1991-92, 1992-93 and 1993-94. (Week 1 = 9/1/91-9/7/91, 8/30/92-9/5/92, 8/29/93-9/4/93, N# = Nonshoot days during week#, S# = Shoot days during week#). Number of radio-tagged pintails (and bird-weeks) each year was 9-31 during weeks 1-3, 21-99 during weeks 4-7, 51-112 during weeks 8-12, 28-93 during weeks 13-16, 11-40 during weeks 17-21 and 9-28 during weeks 22-29 (except <9 for week 8, 11, 15 and 16 shoot nights in 1993-94, week 8 shoot night in 1992-93 and all categories of week 19 in 1991-92).

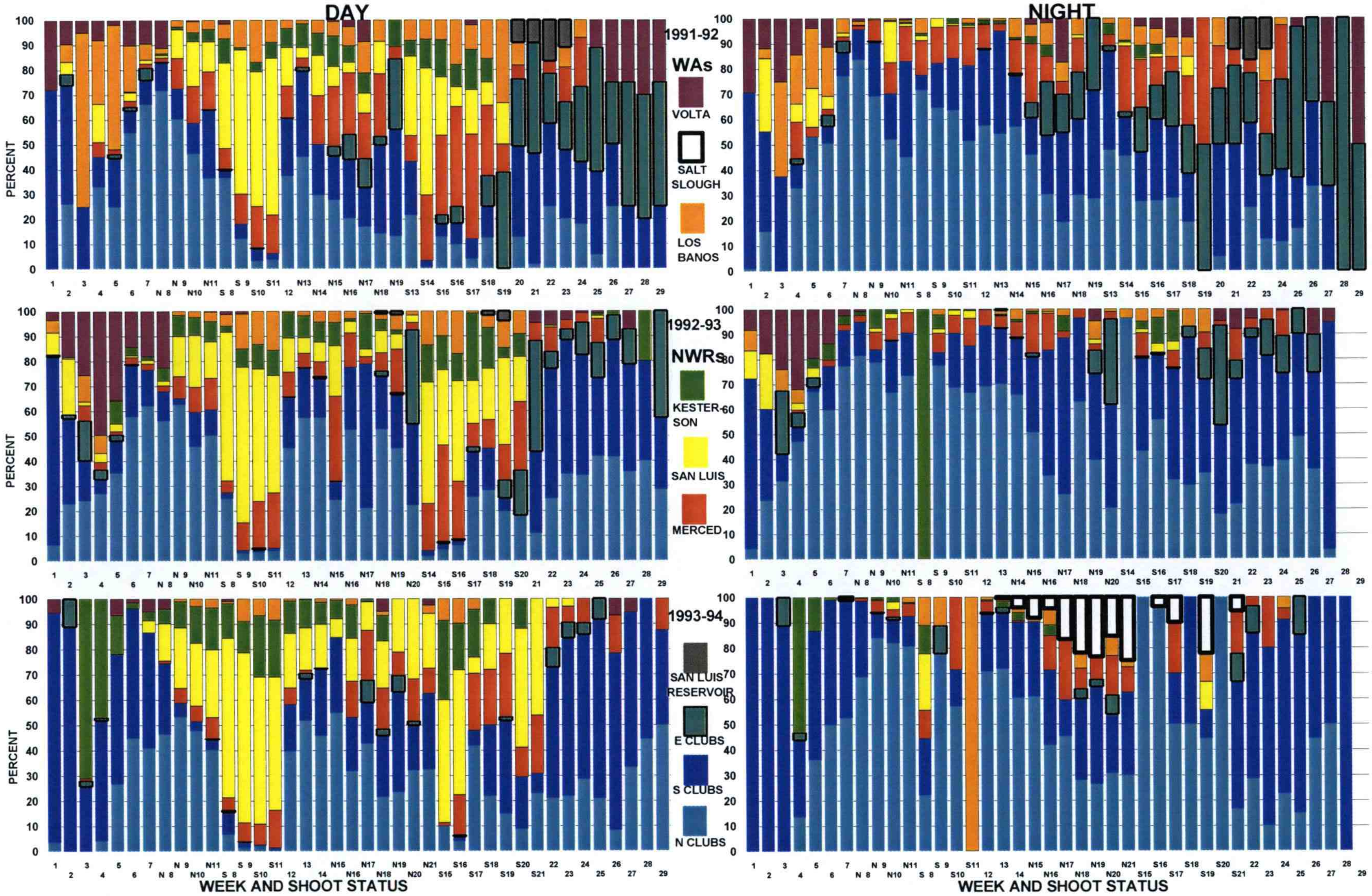

DAY
NIGHT
1991-92
WAs
VOLTA
SALT SLOUGH
LOS BANOS
1992-93
NWRs
KESTERSON
SAN LUIS
MERCED
1993-94
SAN LUIS RESERVOIR
E CLUBS
S CLUBS
N CLUBS
PERCENT
WEEK AND SHOOT STATUS

Figure I.7.

differed among study years during 3 of 5 PREHUNT weeks ($X^2 \geq 6.26$, 2 df, $P \leq 0.04$), but none of the SPLIT weeks ($X^2 \leq 0.79$, 2 df, $P \geq 0.67$) and 3 of 5 POSTHUNT weeks ($X^2 \geq 7.10$ 2 df, $P \leq 0.03$)(Figure I.7).

Use patterns during the hunting season were drastically different than when hunting was closed (Figure I.7) with most pintails quickly developing a pattern of seeking sanctuary in portions of public areas closed to hunting and flying out at dusk to feed in private hunting club wetlands (Figure I.8) . During the hunting season, shooting (i.e, shoot vs nonshoot dates, $X^2 = 1011.88$, 7 df, $P < 0.0001$), diurnal period (i.e., day vs night, $X^2 = 859.58$, 7 df, $P < 0.0001$), study year (i.e., 1991-92 vs 1992-93 vs 1993-94, $X^2 = 24.81$, 12 df, $P < 0.0157$) and bird age (i.e., HY vs AHY, $X^2 = 26.99$, 7 df, $P = 0.0003$) were related to the proportions of pintails on public and private areas.

Use of private lands was less during the day than at night in all three years during the hunting season ($Z = 14.83$, $P < 0.0001$) and the day-night difference was much greater than during nonhunting intervals (Table I.4, Figures I.7 and I.8). Shooting reduced use of private areas during both the day and night but the difference in use of private lands between shoot and nonshoot days ($Z = 30.35$, $P < 0.0001$) was much greater than between shoot nights (i.e., nights following a shoot day) and non-shoot nights ($Z = 4.33$, $P < 0.0001$)(Table I.4). The difference in private use on shoot and nonshoot days was greater during HUNT1 weeks ($X^2 \geq 95.93$, 1 df, $P < 0.0001$ than HUNT2 weeks ($X^2 \geq 4.75$, 1 df, $P \leq 0.03$). The impact at night, although consistent, was not as great and was significant ($X^2 \geq 17.75$, 1 df, $P \leq 0.0001$) only during the first week of HUNT1 (Figure I.7).

Figure I.8. Day and night locations (black dots) of radio-tagged female northern pintails in the Grassland Ecological Area vicinity during PREHUNT, POSTHUNT and on shoot (Wednesdays and weekends) and nonshoot days during the duck hunting season (HUNT, includes HUNT1, HUNT2 and SPLIT), 1991-94.

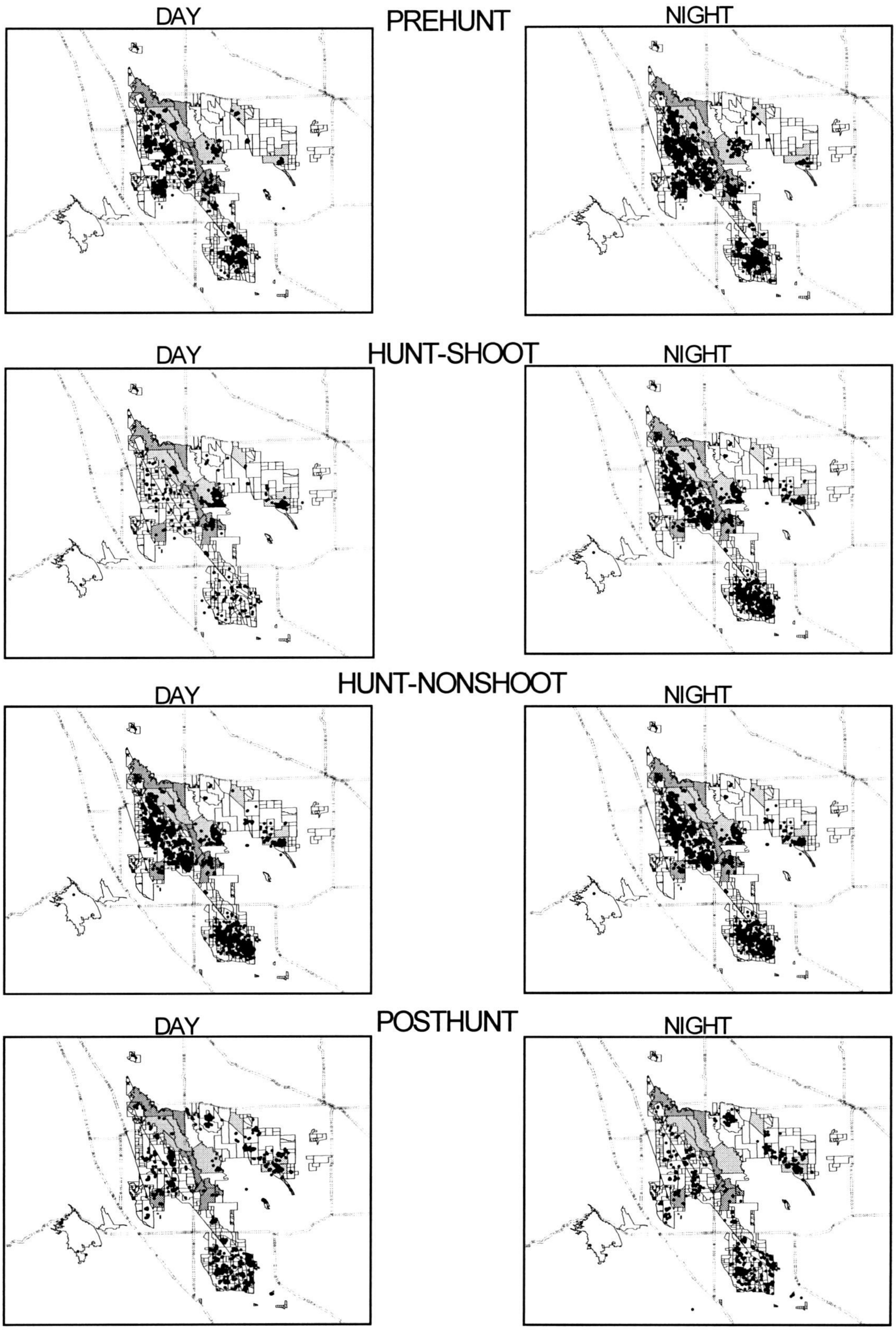

PREHUNT
DAY
NIGHT
HUNT-SHOOT
DAY
NIGHT
HUNT-NONSHOOT
DAY
NIGHT
POSTHUNT
DAY
NIGHT

Figure I.8.

Shooting reduced use of private areas all 3 years ($Z \geq 12.10$, $P < 0.0001$) but there was weak evidence that use of private areas was less in 1993-94 than earlier years. Averaged across diurnal periods, use of private areas on shoot dates in 1993-94 tended to be lower than in 1992-93 ($Z = 2.97$, $P = 0.0029$) and 1991-92 ($Z = 1.80$, $P = 0.07$); the relative importance of private areas was similar each year on non-shoot dates ($Z \leq 1.41$, $P \geq 0.16$). Averaged across shoot and nonshoot dates, day use of private areas in 1993-94 was less than in 1992-93 ($Z = 2.055$, $P = 0.039$) and 1991-92 ($Z = 1.81$, $P = 0.07$); night use of private areas during 1993-94 was also less than in 1992-93 ($Z = 2.13$, $P = 0.03$) but not in 1991-92 ($Z = 0.04$, $P = 0.97$). Annual differences in day use were significant during 7 of the 11 hunting weeks ($X^2 \geq 8.14$, 2 df, $P \leq 0.02$); night use differences were significant during only 3 of 7 HUNT2 weeks ($X^2 \geq 10.43$, 2 df, $P \leq 0.005$).

The effect of shooting lingered into non-shoot days ($X^2 = 57.09$, 7df, $P < 0.0001$) with the odds of being located on private areas two days after a shootday 46% (95% CI = 30% to 65%) greater ($Z = 6.22$, $P < 0.001$) than the odds of being located on a private area one day after a shoot day. The odds of private area night use the third night after a shoot day was only 9% (-16% to 42%) greater ($Z = 0.62$, $P = 0.53$) than the second night after shooting. The effect of the additional day after shooting on whether pintails used private or public areas was significant during all weeks of HUNT1 ($X^2 \geq 4.61$, 1 df, $P \leq 0.03$), but no weeks of HUNT2 ($X^2 \leq 1.99$, 1 df, $P \geq 0.16$). Use of private areas increased with the additional day after shooting all three years, but differences were significant only in 1991-92 and 1993-94 ($Z \geq 2.83$, $P \leq 0.005$). In addition, the proportions of pintail day use on private and public areas on Mondays was similar ($X^2 = 8.74$, 7df, $P = 0.27$) to

Thursdays (both 1 day after shooting) but proportions on Tuesdays and Fridays (both 2 days after shooting) differed during some years ($X^2 = 53.70$, 7df, $P < 0.0001$). Distribution on Tuesdays and Fridays did not differ significantly in 1991-92 ($Z = 0.84$, $P = 0.40$) but in 1992-93 the odds of being on private areas during the day on Fridays was 53% (42% to 63%) lower ($Z = 5.88$, $P < 0.0001$) than on Tuesdays. In 1993-94 the odds of being on private areas during the day on Fridays was 89% (39% to 157%) greater ($Z = 4.04$, $P < 0.0001$) than on Tuesdays.

The proportion of pintails on private and public areas also differed among shoot days ($X^2 = 42.79$, 14 df, $P < 0.0001$). Pairwise comparisons indicated that the odds of being on private areas during the day on Wednesdays during the hunting season was 82% (35% to 146%) greater than on Saturdays ($Z = 3.35$, $P = 0.0009$) and 62% (23% to 112%) greater ($Z = 3.47$, $P = 0.0005$) than on Sundays. The odds of being on private areas during the day on Saturdays and Sundays did not differ significantly ($Z = 0.77$, $P = 0.44$). The odds of private use on Wednesday night was 66% (23% to 124%) greater ($Z = 3.35$, $P = 0.0008$) than on Saturday nights and 294% (89% to 722%) greater than on Sunday night ($Z = 3.66$, $P = 0.0002$). The odds of being on private areas on Saturday nights was 137% (12% to 401%) greater than Sunday nights ($Z = 2.25$, $P = 0.02$).

Shooting reduced use of private lands by both AHY and HY pintails ($Z \geq 12.58$, $P < 0.0001$), and similar to non-hunting intervals, both AHY and HY pintails used private lands significantly less during the day than at night ($Z > 19.67$, $P < 0.0001$). Shoot day use of private lands was similarily ($Z = 0.75$, $P = 0.45$) low for HY and AHY pintails. However, the odds of a AHY pintail using private areas on a shoot night was 43% (16%

to 61%) less than for HY ($Z = 2.85$, $P = 0.0043$). This trend was consistent throughout the hunting period.

HY and AHY also differed in their distribution throughout the Grassland EA. HY consistently had a lower probability than AHY of being in east grasslands during the hunting season; the difference was significant during all hunting weeks (Bonferroni $P \leq 0.05$). There was also a consistent trend for greater use of the south grasslands by HY pintails but the difference was significant only in the first two weeks of HUNT1.

Local distribution - Use of specific areas in the Grassland EA vicinity

Pintail distribution and use of specific private (North Clubs, South Clubs, East Clubs) and public (Merced-Arena Plains NWRs, San Luis NWR, Kesterson NWR, Los Banos WA, Volta-Salt Slough-China Island WAs) areas in the Grassland EA varied greatly among intervals (Table I.4, Figure I.7).

During PREHUNT (weeks 1-8), most pintail use during the day (69%) and night (82%) occurred on North and South Clubs (Table I.4, Figure I.7 and I.8). The percentage of pintails using South Clubs was similar ($t = 1.68$, Bonferroni $P > 0.05$) during the day and night but use of the North Clubs was greater ($t = 7.35$, Bonferroni $P < 0.05$) at night than during the day (Table I.4). Most of the additional birds at night in North Clubs came from Kesterson NWR, Volta Wildlife Area and Los Banos Wildlife Area where day use was roughly double ($t \geq 2.80$, Bonferroni $P < 0.05$) night use (Table I.4). Use of other areas in the Grassland EA was low during PREHUNT and did not differ significantly ($t \leq 1.68$, Bonferroni $P > 0.05$) between day and night. Use of some areas during PREHUNT varied greatly among years, reflecting differences in where I captured pintails; use patterns for day and night were similar (Figure I.7).

During HUNT1 (weeks 8-11), 12% of shoot-day and 76% of shoot-night locations were on private lands (Table I.4). San Luis NWR was the most heavily used sanctuary but day use of Kesterson NWR increased over the three years (Figure I.7). Also, shoot-day use of Los Banos WA and Merced NWR was slightly lower and San Luis NWR slightly higher in 1993-94 then earlier years. Night and nonshoot-day use shifted from areas farthest from sanctuaries (i.e. South Clubs and Volta WA) to areas closer to sanctuaries (i.e. North Clubs)(Table I.4). Shoot day use of duck clubs was low after opening day (Figure I.7).

During the 2-4 week SPLIT, most pintails quickly responded to the lack of hunter disturbance by remaining on private clubs during the day and night (Table I.4, Figure I.7). Use of South Clubs increased to near PREHUNT levels but use of Volta and Los Banos WAs remained low. Day use of Kesterson and Merced NWRs was similar to HUNT1 but most birds that had been roosting on San Luis NWR did not return each morning as they did during HUNT1 and use was lower (Figure I.7). Day use of Kesterson NWR during the SPLIT increased slightly over the 3 years.

Use patterns during HUNT2 (weeks 14-18 in 1991-92, 15-19 in 1992-93 and 16-20 in 1993-94) were similar to HUNT1 except a greater percentage of shoot-day locations were on private areas and importance of South Clubs, East Clubs and Merced NWR increased whereas importance of San Luis NWR and North Clubs decreased. Annual trends in day use were like HUNT1 except shoot-day use of North Clubs during HUNT2 increased rather than decreased over the 3 years and nonshoot-day use of Kesterson NWR did not increase over the 3 years. Likewise, annual trends in night use during HUNT2 was similar to HUNT1 except night use of Salt Slough WA greatly increased in 1993-94 and use of East Clubs declined during the 3 years (Figure I.7).

During POSTHUNT, pintails quickly abandoned most public areas with sanctuaries, except Merced NWR, and settled into private wetlands (Table I.4, Figure I.7 and I.8). Pintails reduced movements and most used the same areas during the day and night. The importance of South and East Clubs peaked during POSTHUNT (Figure I.7). POSTHUNT use of South Clubs increased over the 3 years whereas use of East Clubs declined (Figure I.7). Use of North Clubs was lower in 1991-92 whereas use of Volta WA (at least during the day) was higher than later years.

Movements between day and night locations in the Grassland EA vicinity

Night destinations of pintails in the Grassland EA differed among day use areas, intervals and years (Table 1.5). In general, most pintails that used private areas (North Clubs, South Clubs, East Clubs) during the day (albeit few were on private areas on shoot days) stayed there at night whereas pintails on all public areas except Merced NWR tended to fly out to private areas at night. Except on shoot-days when few pintails used private clubs (Table I.4), $\geq$ 78% of the pintails on those areas during the day remained there at night (Table I.5). In contrast, except during PREHUNT, $\leq$ 10% of the pintails on San Luis NWR stayed there at night. During HUNT1, >71% of the pintails on San Luis NWR went to North Clubs at night and 11-23% went to South Clubs. Thereafter, the

Table I.5. Night locations of female radio-tagged northern pintails from major day use areas in the Grassland Ecological Area, September - March, 1991-94. Letters correspond to the areas where pintails were located at night (A=North Clubs, B=South Clubs, etc. as listed. S=Salt Slough WA). Numbers correspond to the percentage of pintails using that area at night (i.e., during PREHUNT in 1991, 97% of the pintails using North Clubs during the day were located on North Clubs at night, 3 % used other areas at night)[1].

	Major day-use areas in the Grassland Ecological Area[2]						
Interval. Yr. shoot status[3]	North Clubs (A)	South Clubs (B)	East Clubs (C)	Merced Arena Pl NWRs (D)	Kester-son NWR(E)	Los Banos WA(F)	San Luis NWR (G)
Pre 91	A97	B97	C92	D99		F84,A14	G62,A20,CFD6
nonsh92	A96	B96	C78,G11	D97	A69,E31	F71,A20	G68,A27
93	A97	B99		D99	E65,A35		A95
Hunt191	A95	B96		D95	A83,E11	A50,B32,F18	A71,B23,G6
nonsh 92	A96	B96		D76,A14,B10	A67,E32	A75,B25	A73,B15,G10
93	A98	B83,B17		D48,B35,A8	A92,E6	A94,B6	A80,B14
Hunt1 91	A73,B22			D87,B7	A85,E13	A63,B22,F6	A74,B19,G7
shoot 92	A85,B11			D41,A30,B27	A77,E22	A88,B11	A86,B11
93				D50,B28,A22	A89,E11	A86,B7,F7	A84,B12
Split 91	A97	B98		D88,A7	A87,E8	A60,F20,B20	A57,B32
nonsh 92	A98	B97		D81,B18	A99	F61,A30,B9	A75,B23
93	A93	B98			A88,E12	F43,A29,B29	A71,B13,S10
Hunt2 91	A95	B94	C93	D57,C25,B11	A79,E21	F83,B10,A7	A40,BCDF15
nonsh 92	A86,B6	B94	C78,B11	B45,D37,A16	A75,E19	A53,F26,B21	A54,B32,FG6
93	A90	B92		D76,B11,C9	A80,E20		S61,A25,F8,B6
Hunt2 91	A73,B20	B88,A8	C87A7D7	D44,C20,B19,A13	A80,E15	F41,A26,B23	A54,B24,CF7
shoot 92	A47,B38	B87,A13	C53B27	B51,D29,A19	A77,E14	A55,F22,B22	A70,B23
93	A78,S13			D64,A29,F7			A41,SB24,F7
Post 91	A97	B99	C94	D81,C16		F91,A9	
nonsh 92	A94	B99	C92	D94			
93	A97	B99		D86,C14			
Nonhn91	A97	B98	C93,D6	D87,C7	A87,E7	F77,A19	A48,B24,G17
92	A97	B97	C88,A6	D87,B10	A92,E8	F68,A24,B7	A56,B15,G27
93	A96	B99	C57,D21	D90,A10	A54,E46	F43,A29,B29	A80,B9,S8
Hunt 91	A95	B95	C93	D77,C12,B7	A80,E14	F60,A22,B18	A61B20,GIFC5
nonsh92	A94	B95	C78,B11	D62,B22,A15	A69,E28	A64,B23,F13	A69,B19,G9
93	A97	B89,B10		D62,B23,C8,A6	A92,E7	A80,F14,B6	A68,S14,B12
Hunt 91	A73,B21	B89,A8	C81AB6	D62,B14,C12,A10	A81,E14	A48,B26,F20	A69,B20
shoot 92	A57,B31	B83,A17	C53,B27	D38,B34,A27	A77,E19	A80,B13,F6	A81,B14
93	A81,S12	B50,A36		D56,A25,B16	A81,E14	A80,B13,F7	A74,B15,S6

[1]Includes pintails that went to or came from that area at night. Night areas listed only if >5% of pintails went to or came from that area. Night locations presented only for periods where day use sample size was ≥ 10.

[2]Not including Volta WA, a major day use area only during Prehunt, where 69, 57, and 94% flew to North Clubs (A) and 30, 42 and 3% stayed on Volta WA at night, during 1991, 1992, and 1993, respectively.

[3]Intervals are Prehunt (Pre), Hunt1 (H1), Split, Hunt2 (H2), Posthunt (Post). Shoot days are Wednesdays and weekends during hunt season. 1991(91), 1992(92) and 1993(93).

percentage from San Luis NWR going to North Clubs decreased as flights to South Clubs and Salt Slough WA (in 1993-94) increased. Salt Slough WA became a common night destination of San Luis NWR pintails during SPLIT 1993-94 and continued thereafter. Approximately 31-65% of the Kesterson NWR pintails remained on Kesterson NWR at night and 35-69% flew to North Clubs during PREHUNT, but 67-99% flew to North Clubs at night thereafter. Night destinations of Los Banos WA pintails varied greatly among intervals. Merced NWR was the only public area where a high percentage of pintails consistently stayed at night. Overall, a higher percentage of the Merced NWR pintails that left at night flew to South Clubs rather than to closer East or North Clubs. Few pintails using Kesterson NWR during the day flew to South Clubs at night but San Luis NWR and Los Banos WA pintails used both North and South Clubs at night.

During PREHUNT, most pintails using North Clubs, South Clubs, East Clubs, Merced NWR or Los Banos WA during the day stayed on those areas at night (Table I.5). In contrast, most Volta WA pintails flew to the North Clubs at night; 35-69% of the Kesterson pintails also used North Clubs at night during PREHUNT (Table I.5). The percentage of San Luis NWR and Kesterson pintails leaving at night for the North Clubs during PREHUNT varied greatly among years. Other movement patterns were similar among years.

During HUNT1, most pintails using North or South Clubs during the day stayed in those areas at night (Table I.5). Use of East Clubs and shoot day use of South Clubs was too low to determine patterns. Most Merced NWR pintails stayed on Merced NWR at night in 1991, but thereafter, many went to South Clubs or North Clubs. Kesterson

NWR pintails used North Clubs or Kesterson NWR at night. North Clubs was also the most common night destination for San Luis NWR and Los Banos WA pintails but 12-23% of San Luis NWR and 6-32% of Los Banos pintails went to South Clubs during HUNT1 nights. Movements were similar among years except the percentage of Los Banos WA pintails going to South Clubs at night decreased while the percentage going to North Clubs increased during the study (Table I.5). In contrast, the percentage of Merced NWR pintails going to South Clubs and North Clubs increased during the study.

Movement patterns during SPLIT were similar to nonshoot days of HUNT1 with most pintails on private areas and Merced NWR remaining on those areas at night while most on San Luis NWR and Kesterson NWR flew to North Clubs at night (Table I.5). However, a higher percentage (20-61%) of the pintails using Los Banos WA during the day remained there at night, albeit use was minimal during SPLIT(Table I.4). Also, a higher percentage of San Luis NWR pintails flew to South Clubs during 1991-92 and 1992-93; in 1993-94, 10% of San Luis pintails flew to Salt Slough WA at night and the percent going to South Clubs did not increase above HUNT1 levels.

Movement patterns during HUNT2 were similar to HUNT1 except a higher percentage of Los Banos WA pintails stayed on Los Banos WA at night (22-83% vs <1-18%) and Salt Slough WA became an important night destination for San Luis NWR pintails in 1993-94 (Table I.5). Also, in 1992-93, South Clubs was the most common night destination for Merced NWR pintails during HUNT2; in other years Merced NWR and East Clubs were more important. During POSTHUNT, most (>50% Volta WA, >81% all other areas) pintails stayed in the same area during day and night (Table I.5).

Local distribution and movements in Mendota WA and Tulare Basin

Distribution and movement patterns of pintails within Mendota WA were like those in the Grassland EA except most pintails returned to units closed to hunting even on nonshoot days. During PREHUNT, pintail distribution tracked wetland flooding but pintails were more concentrated during the day and dispersed within units and to other units at night (Figure I.9). On shoot days of HUNT1 and HUNT2, the few pintails that had not emigrated sought sanctuary on units closed to shooting and at night dispersed throughout the area. Most returned to sanctuary units on both shoot and nonshoot days. The few pintails present during POSTHUNT were dispersed throughout Mendota WA (Figure I.9)

Averaged over all intervals and years, 63.7% of all pintail locations in the Tulare Basin were on preirrigated agricultural fields in the Tulare Lake Bed (and west of Kern NWR in September, 1993); Kern NWR received 23.6% of the overall use and duck clubs near Kern NWR received 4.9% of all use (Figure I.10). Other areas, with more than 10 pintail locations included Tulare Lake Drainage District (TLDD) Hacienda (2.3%) and South (1.6%) Evaporation Ponds, Alpaugh Irrigation District water storage ponds (2.1%) and floodwaters in the vicinity of Huron, California (0.5%).

Distribution and daily movement of pintails in the Tulare Basin varied among intervals, years and on shoot and nonshoot dates (Figure I.11). During PREHUNT, most day ($\geq$ 70.4%) and night ($\geq$ 77.9%) use was on preirrigated agricultural fields in the Tulare Lake Bed or west of Kern NWR. PREHUNT day and night use of Kern NWR increased whereas importance of preirrigated fields declined during 1991-93 (Figure

Figure I.9. Day and night locations of radio-tagged female northern pintails on Mendota Wildlife Area (hunting not allowed in shaded area) during PREHUNT, POSTHUNT and on shoot (Wednesdays and weekends) and nonshoot days during the duck hunting season (HUNT includes HUNT1, HUNT2 and SPLIT), 1991-94.

Figure I.10. Day and night locations of radio-tagged female northern pintails in the Tulare Basin during PREHUNT, POSTHUNT and on shoot (Wednesdays and Saturdays) and nonshoot days during the duck hunting season (HUNT), 1991-94.

Figure I.11. Percent of live radio-tagged female northern pintails located on Tulare Basin areas during the day and night during PREHUNT, POSTHUNT and on shoot (Wednesdays and Saturdays) and nonshoot days during the duck hunting season (HUNT), 1991-92, 1992-93, and 1993-94. Pintails were radio-tagged 28 August - 6 October, in the San Joaquin Valley.

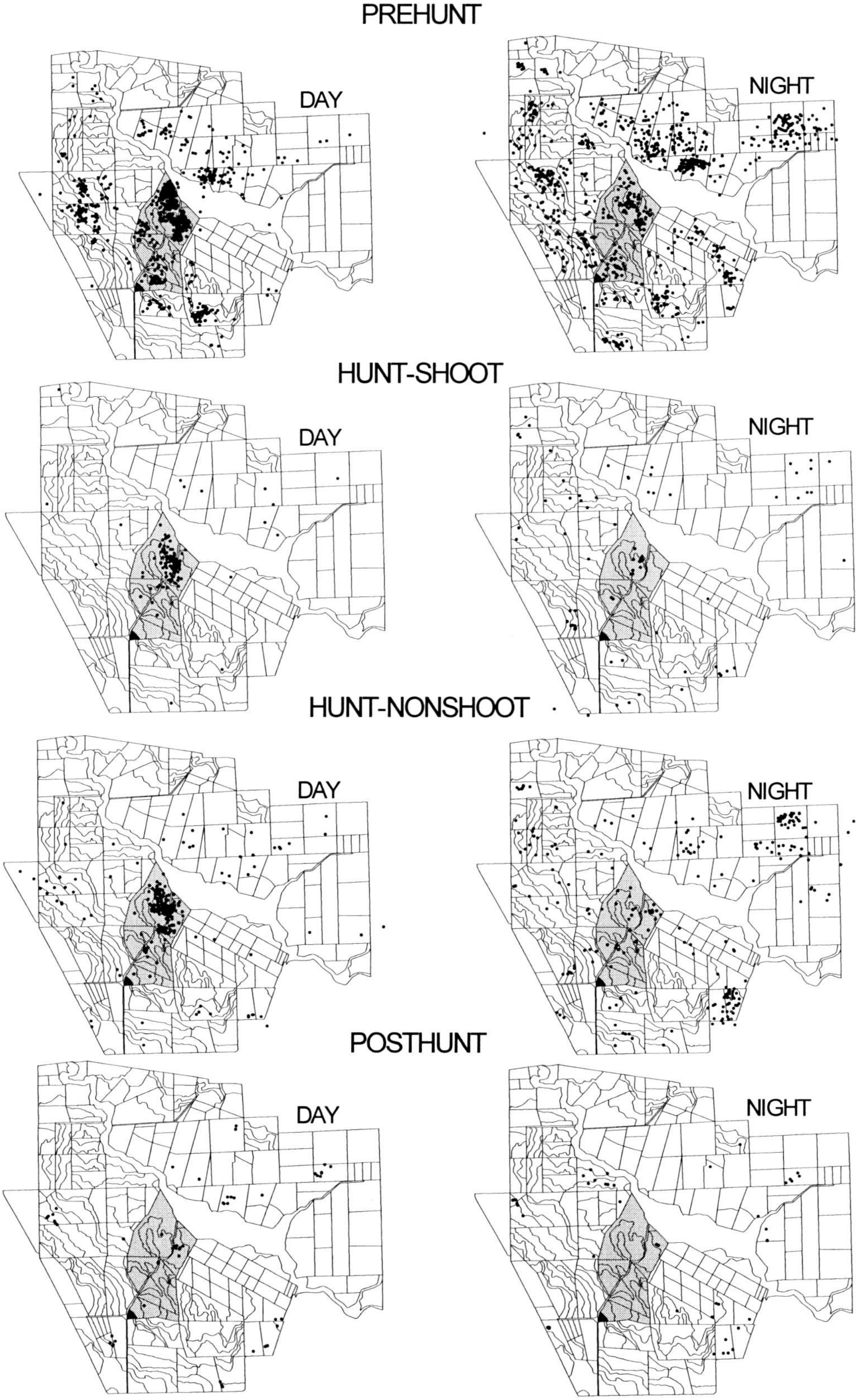

PREHUNT
DAY
NIGHT
HUNT-SHOOT
DAY
NIGHT
HUNT-NONSHOOT
DAY
NIGHT
POSTHUNT
DAY
NIGHT

Figure I.9.

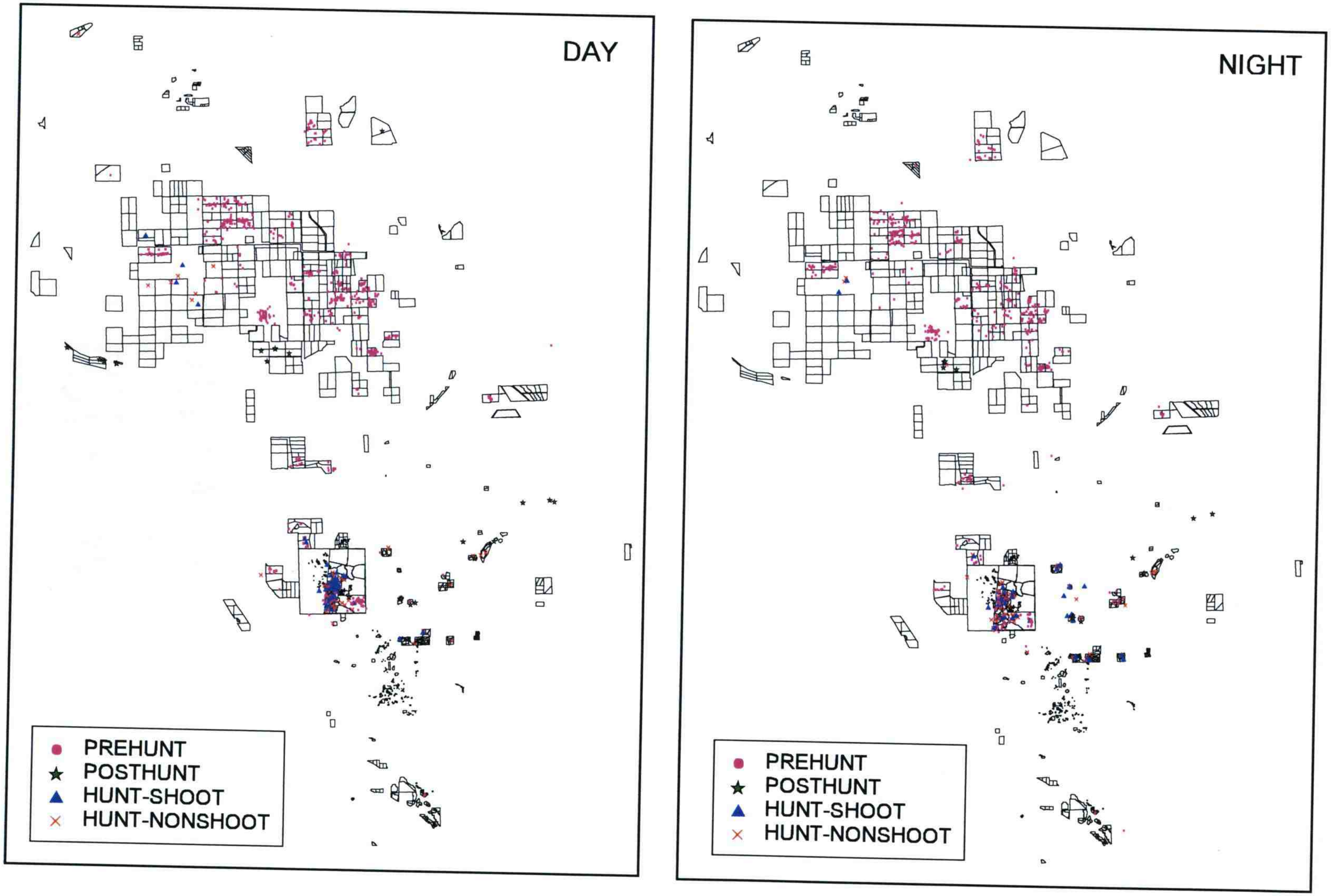
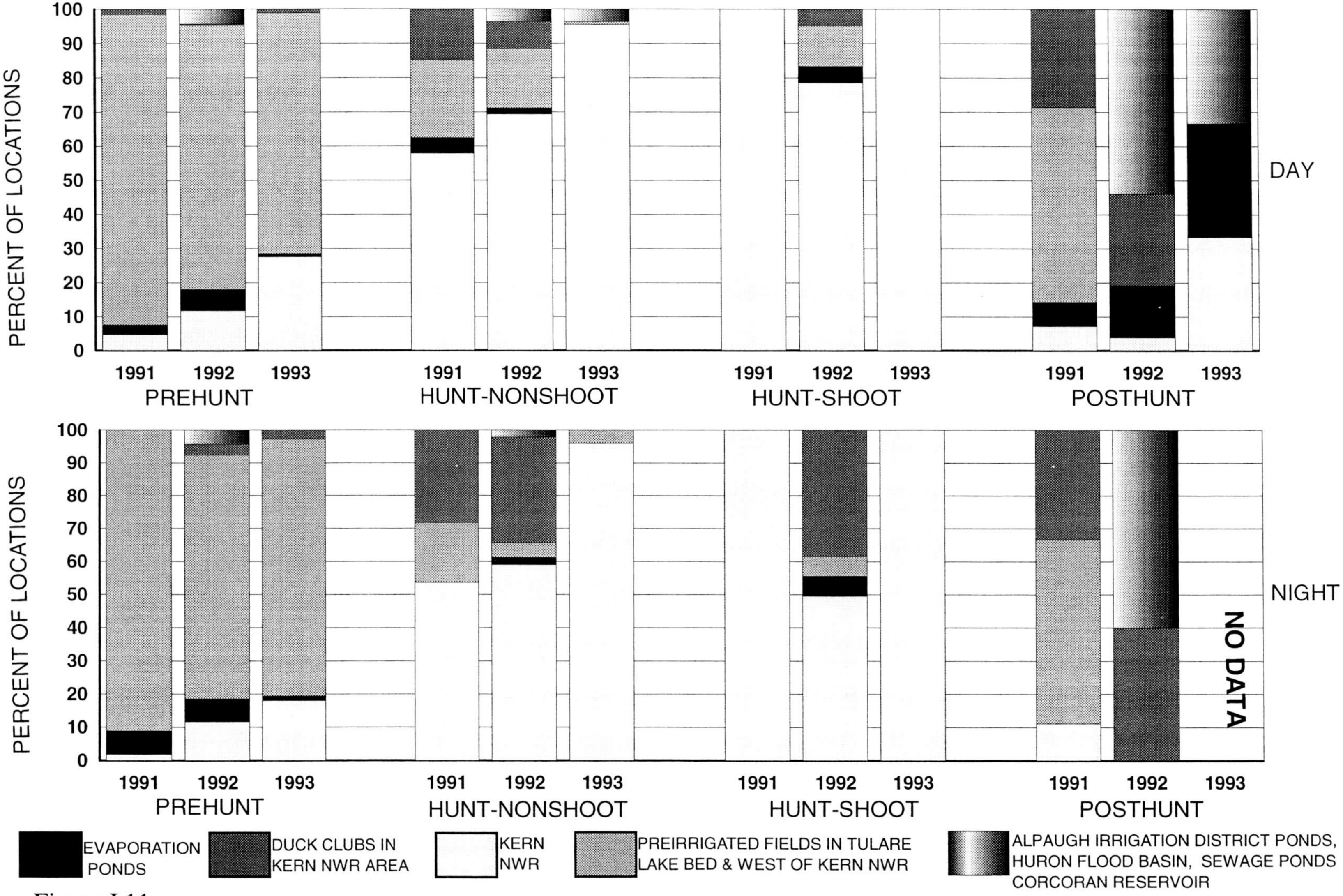

DAY
PREHUNT
POSTHUNT
HUNT-SHOOT
HUNT-NONSHOOT
NIGHT
PREHUNT
POSTHUNT
HUNT-SHOOT
HUNT-NONSHOOT

Figure I.10.



DAY
NIGHT
PERCENT OF LOCATIONS
100
90
80
70
60
50
40
30
20
10
0
1991 1992 1993
PREHUNT
HUNT-NONSHOOT
HUNT-SHOOT
POSTHUNT
NO DATA
EVAPORATION PONDS
DUCK CLUBS IN KERN NWR AREA
KERN NWR
PREIRRIGATED FIELDS IN TULARE LAKE BED & WEST OF KERN NWR
ALPAUGH IRRIGATION DISTRICT PONDS, HURON FLOOD BASIN, SEWAGE PONDS CORCORAN RESERVOIR

Figure I.11.

I.11). Most preirrigated fields were dry by the start of HUNT each mid-November (delayed start and no split in the Southern SJV hunting zone) and most pintails left the Tulare Basin as these fields drained (Figure I.5). Most pintails that stayed in the Tulare Basin during HUNT moved to Kern NWR (Figure I.11). The few pintails that remained during POSTHUNT were scattered throughout the Tulare Basin (Figure I.10 and I.11).

Night destinations of pintails roosting on Kern NWR, evaporation ponds, preirrigated fields, duck clubs and miscellaneous areas differed. Nearly all (≥ 97%) pintails using preirrigated fields, duck clubs and miscellaneous areas during the day stayed there at night. Most (81%) pintails using evaporation ponds also stayed there at night but 11% flew to preirrigated fields, 6% to Kern NWR and 3% to duck clubs. Likewise, most pintails on Kern NWR stayed on the refuge at night but more left during the hunting season (30%) than during PREHUNT (17%). During PREHUNT, 74% of the pintails that left Kern NWR at night flew to duck clubs; the remainder went to evaporation ponds and preirrigated fields. During HUNT, 95% of the pintail that left Kern NWR at night went to duck clubs. Use of Kern NWR was usually greater on shoot days and nights than on nonshoot days and night (Figure I.11). Like during PREHUNT, nonshoot day and night use of Kern NWR increased and nonshoot day and night use of preirrigated fields decreased during the study (Figure I.11). However, no annual trend was evident for shoot days and night use.

Flight distances between day and night locations in the San Joaquin Valley

Flight distances and the factors related to how far pintails flew between day and night locations differed during nonhunting and hunting intervals (Figure I.12). Pintail flight distances during nonhunting intervals varied by age class, area, capture location and study year (Table I.6). Overall, in the SJV during nonhunting intervals, HY females flew 19.7% farther ($Z = 2.48$, $P = 0.013$) than AHY females between their day and night locations. Pintails tended to fly farther in the Grassland EA (unwt. ageclass mean = 2,963m) than in Mendota WA (mean = 2,012m) and Tulare Basin (mean = 1,686m) but differences varied by the capture location of the bird (Grassland EA, Mendota WA, Tulare Basin) and among study years ($X^2 = 7.59$, 10 df, $P < 0.001$). For instance, flights in Mendota WA were significantly shorter than in the Grassland EA for pintails captured in Mendota WA ($Z = 2.89$, $P = 0.038$) but not for pintails captured in the Grassland EA ($Z = 1.80$, $P = 0.07$) or Tulare Basin ($Z = 0.26$, $P = 0.79$). Likewise, flights in the Tulare Basin were shorter than in the Grassland EA for pintails captured in the Tulare Basin ($Z = 5.54$, $P < 0.001$) but not for pintails captured in Mendota WA or Grassland EA ($Z \leq 1.62$, $P \geq 0.11$). Further, pintails captured in Mendota WA flew shorter distances in Mendota WA than in Tulare Basin ($Z = 2.87$, $P = 0.0038$) but pintails captured in Tulare Basin flew farther in Mendota WA than in Tulare Basin ($Z = 5.65$, $P < 0.001$); pintails captured in Grassland EA flew similar distances in Mendota WA and Tulare Basin ($Z = 0.69$, $P = 0.49$).

Just as the effect of region differed by capture location, the effect of capture location varied by region during nonhunting intervals (Table I.6). In the Grassland EA,

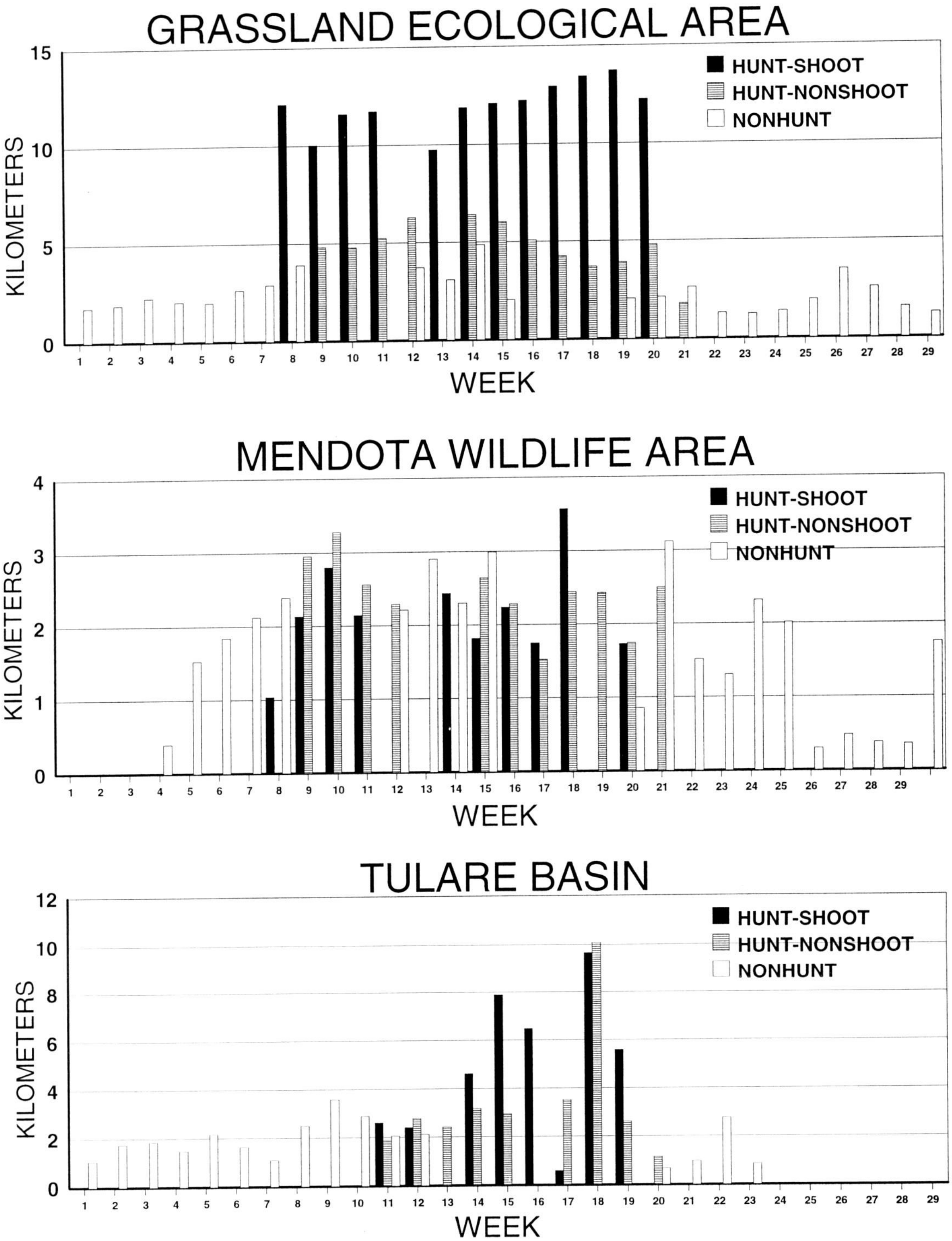


Figure I.12. Mean weekly distances between day and night locations of radio-tagged female northern pintails in three San Joaquin Valley areas during nonhunting weeks and on shoot and nonshoot days of hunting weeks, August - March, 1991-94. (Week 1 is 9/1/91-9/7/91, 8/30/92-9/5/92, 8/29/93-9/4/93)

Table I.6. Mean flight distance (meters) from day to night locations for female northern pintails in the Grassland Ecological Area (EA), Mendota Wildlife Area (WA) and Tulare Basin, California, during September - March, 1991-94.

Year, Age, Weight-group and Capture Location[2]	San Joaquin Valley Area, Season and Shooting status[1]								
	Grassland Ecological Area			Mendota Wildlife Area			Tulare Basin		
		Hunting			Hunting			Hunting	
	Nonhunt	Nonsh	Shoot	Nonhunt	Nonsh	Shoot	Nonhunt	Nonsh	Shoot
Overall	2,929	5,002	11,478	1,998	2,554	2,224	1,910	3,037	4,189
1991-92	2,845	4,187	11,262	1,685	2,373	1,958	1,397	654	7,841
1992-93	3,092	4,597	12,098	1,958	2,223	2,290	2,206	4,332	4,867
1993-94	2,839	5,840	9,050	2,101	2,696	2,551	1,595	1,546	1,260
HY	3,226	5,833	11,722	2,124	2,884	2,497	1,309	4,041	4,936
AHY	2,670	4,174	11,263	1,900	2,308	2,106	2,063	2,684	3,905
Thin	3,129	5,301	11,423	2,005	2,444	2,072	2,110	3,712	5,133
Heavy	2,747	4,722	11,528	1,988	2,759	2,506	1,088	1,301	2,227
Captured in Grass-land EA	2,873	4,619	11,133	1,989	2,634	2,305	1,454	521	3,870
Captured in Men-dota WA	3,188	6,295	12,635	1,376	2,261	1,769	2,677	1,552	1,142
Captured in Tulare Basin	3,036	4,580	11,899	2,525	2,269	2,131	1,907	3,418	4,721

[1]Nonhunt season composed of PREHUNT, SPLIT and POSTHUNT. Shoot days are Wednesdays and weekends during the hunting season; nonshoot (nonsh) days are all others.
[2]Factors related to flight distance (Z test, $P \leq 0.05$) were study year, age, e.g., Hatch-Year (HY) vs After-Hatch-Year (AHY), pintails ≤ mean weight at capture (thin) vs those > mean weight (heavy), and capture location.

flight distances did not vary by capture location ($Z < 0.97$, $P > 0.33$). In Mendota WA, pintails captured in Mendota WA flew shorter distances than pintails captured in Tulare Basin ($Z = 2.43$, $P = 0.015$) but distances of Grassland pintails did not differ from Mendota WA ($Z = 0.60$, $P = 0.55$) or Tulare Basin pintails ($Z = 1.48$, $P = 0.14$). In Tulare Basin, pintails captured in Tulare Basin flew shorter distances than Mendota WA pintails ($Z = 4.61$, $P < 0.001$) but distances for Grassland birds did not differ from Mendota WA ($Z = 1.0$, $P = 0.30$) or Tulare Basin birds ($Z = 0.16$, $P = 0.87$).

Nonhunting flight distances were similar among years in the Grassland EA ($Z \leq 1.88$, $P \geq 0.06$) and Tulare Basin ($Z \leq 0.67$, $P \geq 0.51$)(Table I.6). However, in Mendota WA, flights were shorter in 1991-92 than in 1992-93 ($Z = 2.22$, $P = 0.026$) and 1993-94 ($Z = 2.99$, $P = 0.0028$).

Flight distances during the hunting season differed between shoot and nonshoot days ($X^2 = 614.21$, 7 df, $P < 0.001$), for HY and AHY females ($X^2 = 27.04$ 2 df, $P < 0.001$), among birds in the Grassland EA, Mendota WA and Tulare Basin ($X^2 = 148.99$, 8 df, $P < 0.001$), among birds captured in those areas ($X^2 = 27.22$, 8 df, $P = 0.001$), among study years ($X^2 = 15.46$, 4 df, $P = 0.0038$) and between pintails above and below the mean weight at capture ($X^2 = 9.63$, 4 df, $P = 0.0081$) (Table I.6, Figure I.11).

Hunting had a large impact on how far pintails flew between day and night locations but the effect of hunting varied among areas and years (Figure I.11, Table I.6). Flight distances on shoot days were largely determined by juxtaposition of sanctuaries and feeding areas. Flight distances on shoot dates were significantly greater than on nonshoot dates in the Grassland EA ($Z = 20.29$, $P < 0.001$) but not in Mendota WA ($Z =$

1.36, $P = 0.17$) or Tulare Basin ($Z = 1.42$, $P = 0.15$). Flight distances varied among years but annual differences were inconsistent for shoot and nonshoot dates ($X^2 = 8.52$, 2 df, $P = 0.014$). Nonshoot flight distances in 1991-92 were less than during later years ($Z \geq 2.43$, $P \leq 0.015$) whereas shoot distances in 1992-93 were greater than in 1993-94 ($Z = 2.27$, $P = 0.02$); all other distances were similar among years ($Z \leq 1.77$, $P \geq 0.08$).

Hatch-Year pintails flew greater distances than adults throughout the hunting intervals ($X^2 = 27.09$, 2 df, $P < 0.001$) but age differences were greater on nonshoot (43% farther, $Z = 5.20$, $P < 0.001$) than shoot days (11% farther, $Z = 1.93$, $P = 0.05$) (Table I.6).

Pintails in the Grassland EA flew farther than in Mendota WA and Tulare Basin during the hunting season but differences were greater on shoot dates than on nonshoot dates (Table I.6). Also, distances varied by capture location. In Mendota WA, pintails captured in Mendota WA flew farther than those captured in Tulare Basin ($Z = 2.08$, $P = 0.037$). In the Grassland EA, Mendota WA pintails flew farther than those captured elsewhere ($Z \geq 1.94$, $P \leq 0.05$). In Tulare Basin, Mendota WA and Tulare Basin pintails flew farther than Grassland birds ($Z \geq 2.12$, $P \leq 0.03$); other distances were similar.

Heavy pintails flew farther than light pintails on shoot days ($Z = 2.84$, $p = 0.004$) but not on nonshoot days ($Z = 0.81$, $P = 0.42$). Also, the effect of condition on flight distance was not significant for pintails captured in Mendota WA ($Z = 0.92$, $p = 0.36$).

Time pintails in the San Joaquin Valley flew

The time pintails spent flying in the SJV varied by area, time of day, interval, hunting and bird age (Table I.7). Pintails flew a greater ($F = 7.25$, 1 df, $P = 0.0073$)

percentage of the time that I followed them in the Grassland EA (2.017 ± 0.026%) than elsewhere in the SJV (i.e., Tulare Basin and Mendota WA combined) (0.00065 ± 0.519 %).

Time spent flying (Table I.7) varied among the four diurnal periods (F = 9.23, 3 df, P < 0.0001), with pintails flying a greater percentage of DAWN (2.146 ± 0.239%) and DUSK (1.594 ± 0.234%) than DAY (0.078 ± 0.197%) and NIGHT (0.046 ± 0.238%). However, the diurnal effect varied among intervals and on shoot and nonshoot dates (F = 2.62, 18 df, P = 0.0003). During PREHUNT and POSTHUNT the percents of DAWN, DAY, DUSK and NIGHT bouts spent flying did not differ significantly (P ≥ 0.097). Pintails flew significantly less during NIGHT than during DUSK during all other intervals and significantly less during NIGHT than during DAWN during all other intervals except on nonshoot dates of HUNT2 (LSD, P ≤ 0.05). Pintails generally flew less during DAY than during DAWN and DUSK but differences were significant only on shoot dates during HUNT1. On average, pintails flew 17.68 ± 0.65% of the DAWN and 4.34 ± 0.75% of the DUSK on shoot dates during HUNT1, more than during any other time (Table I.7).

During hunting intervals in the Grassland EA, pintails flew more (F = 13.37, 1 df, P = 0.0003) on shoot dates (5.942 ± 0.105%) than nonshoot dates (2.145 ± 0.093%). The effect of shooting was consistent for all diurnal periods but the magnitude of the difference varied (F = 3.37, 1 df, P = 0.0196) so that the effect of shooting was significant only during DAWN (LSD, P < 0.0001). Pintails flew 18.54 ± 0.48% of shoot DAWNs and 4.27 ± 0.33% of nonshoot DAWNs.

Table I.7. Average percent (± 95% CI) of diurnal periods spent flying for 216 female northern pintails followed in the San Joaquin Valley, California, during September - March, 1991-93.

	DIURNAL PERIOD[1]			
Interval-Shoot status[2]	Dawn	Day	Dusk	Night
Prehunt-Nonshoot	1.972 ± 0.317%	0.296 ± 0.415%	1.771 ± 0.168%	0.679 ± 0.552%
Hunt1-Nonshoot	2.453 ± 0.558%	1.096 ± 0.590%	2.020 ± 0.484%	0.113 ± 0.442%
Hunt1-Shoot	17.685 ± 0.652%	0.002 ± 0.606%	4.336 ± 0.746%	0.010 ± 0.471%
Split-Nonshoot	0.945 ± 1.068%	0.071 ± 0.549%	1.170 ± 0.882%	0.352 ± 0.966%
Hunt2-Nonshoot	0.223 ± 1.372%	0.004 ± 1.180%	1.341 ± 0.796%	0.610 ± 1.870%
Hunt2-Shoot	1.803 ± 1.875%	0.019 ± 1.781%	1.958 ± 1.995%	0.959 ± 1.804%
Posthunt-Nonshoot	0.028 ± 0.996%	0.005 ± 0.840%	0.125 ± 0.939%	0.165 ± 0.983%
OVERALL	2.146 ± 0.239%	0.077 ± 0.197%	1.594 ± 0.234%	0.046 ± 0.238%

[1]Dawn is 75 minutes before to 75 minutes after sunrise, Day is 76 minutes after sunrise to 76 minutes before sunset, dusk is 75 minutes before to 75 minutes after sunset, and Night is 76 minutes after sunset to76 minutes before sunrise.
[2] Shoot days are Wednesdays and weekends during hunting season; nonshoot days are all others.

Likewise, HY females flew more ($F = 4.95$, 1 df, $P = 0.0277$) than AHY females ($5.665 \pm 0.172\%$ vs $2.320 \pm 0.185\%$) during hunting intervals in the Grassland EA. The age effect was consistent for all diurnal periods but the magnitude of the difference varied ($F = 3.27$, 1 df, $P = 0.0222$) so that the effect was significant only during DAWN when HY pintails flew $18.603 \pm 0.405\%$ and AHY pintails flew $4.238 \pm 0.471\%$ of the period.

Morphometrics of pintails captured

Morphometric variables (Table I.8) differed among age classes (MANOVA, Wilks' $\lambda = 0.8282$; $F = 28.35$, 3, 410 df; $P < 0.0001$) but not among years (MANOVA, Wilks' $\lambda = 0.9755$; $F = 1.71$, 6, 820 df; $P = 0.1160$) and there was no year by age class interaction (MANOVA, Wilks' $\lambda = 0.9882$; $F = 0.81$, 6, 820 df; $P = 0.5586$). Follow-up ANOVAs indicated that flat wing length differed among age classes ($F = 60.35$, 1, 412 df, $P < 0.0001$) but tarsus and culmen lengths did not ($F \leq 1.76$; 1, 412 df; $P \geq 0.1851$).

Body mass did not differ significantly ($F = 2.91$, 1, 413 df, $P = 0.0891$) among age classes but mass varied among years ($F = 3.80$, 2, 413 df; $P = 0.0231$); this effect however differed by age class ($F = 4.86$, 2, 413 df, $P = 0.0082$). The mean mass of HY females captured in 1991 was less than (Fisher's protected LSD, $P = \leq 0.0127$) all other HY and AHY annual averages (Table I.3). There were no other body mass differences (Fisher's protected LSD, $P = \geq 0.2402$) among age classes or years.

Table I.8. Summary statistics and analyses of variance for body mass and morphometry of After-Hatch-Year (AHY) and Hatch-Year (HY) female northern pintails radio-tagged during August-October, 1991-93 in San Joaquin Valley, California.

		Year							
		1991 (AHY n = 72) (HY n = 43)		1992 (AHY n = 65) (HY n = 58)		1993 (AHY n = 91) (HY n = 90)		Overall (AHY n = 228) (HY n = 191)	
Variable	Age	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Body mass (g)	AHY	783A[a]	10	773A	11	790A	9	782	6
	HY	731B	13	792A	11	780A	9	767	7
Wing chord (mm)	AHY	258.68A	0.77	259.35A	0.81	258.17A	0.69	258.74	0.44
	HY	252.21B	1.00	254.34B	0.86	254.22B	0.69	253.59	0.50
Culmen (mm)	AHY	47.15A	0.21	46.66A	0.22	46.75A	0.19	46.85	0.12
	HY	47.09A	0.27	47.20A	0.24	47.00A	0.19	47.10	0.14
Tarsus (mm)	AHY	49.38A	0.22	49.75A	0.23	49.81A	0.19	49.65	0.12
	HY	49.34A	0.28	50.02A	0.24	49.72A	0.19	49.69	0.14

[a]Annual means with a different letter for the same variable were different using Fisher's protected LSD value ($P \leq 0.05$). Overall means did not differ between age classes for any variable ($F \leq 1.76$, 1, 412 df, $P \geq 0.1851$) except wing chord ($F = 60.35$, 1, 412 df, $P < 0.0001$).

DISCUSSION

Has the percentage of SJV pintails wintering outside of central California increased?

Freshwater marsh habitat and waterfowl abundance along the west coast of mainland Mexico increased greatly during the 1950s to1980s as irrigated agriculture provided new feeding areas and field runoff converted saltwater to freshwater-brackish marshes (Kramer and Migoya 1989). Reports of 0.8 to >1.5 million pintails along the west coast of mainland Mexico during 1989-90 surveys (Migoya 1993) compared to 0.2-0.4 million during most of the 1980s, along with low pintail abundance in the SJV (USFWS unpubl. data), prompted concern that SJV pintails had shifted wintering areas.

A comparison of my data and earlier banding data (Mclean 1950, Rienecker 1987a) indicate that SJV pintails have not made a long-term shift to winter in Mexico. The percentage of SJV pintails that wintered outside central California during 1991-94 was equal to or less than during 1938-62. I estimate that 94% of the female pintails that I radio-tagged remained in central California during winter and 6% went elsewhere, most to Mexico or other southern areas. Only 2% of the mortalities of female pintails that I radio-tagged were from outside central California (Fleskes, unpubl. data). Likewise, >90% of the direct recoveries of pintails banded during PREHUNT in the Tulare Basin during 1938-45 (Mclean 1950) and Grassland EA during 1948-62 (Rienecker 1987a) were from central California. Rienecker (1987a) noted that pintails banded in the Grassland EA were more closely aligned with Mexico and other flyways than were pintails he banded in California areas farther north, but he still reported only 5.4% of

AHY and 9.9% of HY female direct recoveries were from outside central California. However, Rienecker (1987a) did not band pintails in the Tulare Basin, where a greater percentage than from the Grassland EA went south (Table I.3). Also, pintail harvest rates were probably lower in Mexico than in California (Migoya and Baldassarre 1995). Thus, it is likely that the actual percentages of pintails from the SJV that wintered outside California during 1948-62 was greater than the 5-10% of Grassland EA recoveries reported by Rienecker (1987a). This indicates that the percentage of the pintails present in the SJV during early fall that wintered outside central California during 1991-94 was not greater and probably less than during 1948-62.

There is some evidence that poor habitat conditions in SJV increases the percentage of SJV pintails that winter in Mexico. During 1991, 24% of the pintails wintering in Pacific Flyway states and west coast of mainland Mexico were counted along the west coast of mainland Mexico compared to a 1975-95 average of 18% (range 11% to 24%, SE = 1.4%) (USFWS unpubl. data). The percentage of my radio-tagged pintails that emigrated south from the SJV was greatest in 1991 (Table I.3), the year drought prevented summer-irrigation of wetlands and delayed flooding of some SJV habitats. I caution that I only sampled female pintails that were present in the SJV during late August and September. Drake pintails may be even more likely to leave when conditions are poor (Rienecker 1987a). Females that arrive later may emigrate at a greater rate, although all emigrations I observed occurred early in fall. Further, some pintails may bypass the SJV areas completely because of poor habitat conditions. Thus, maintaining the quality and quanity of fall habitat in the SJV is important to maintain wintering pintail populations in the SJV.

Distribution of pintails among central California regions

Changes in habitat conditions and land use patterns in California has altered waterfowl distribution in the state since at least the 1880s (Heitmeyer et. al. 1989). Evidence indicates that changes in pintail distribution are continuing. Pintail abundance during late winter has declined disproportionately in the SJV relative to the remainder of central California since the 1970s (Table I.1). The reason(s) for this disparate decline is(are) unclear but decline in habitat conditions relative to other Central Valley areas is obviously a likely factor.

My findings indicate that a decline in acreage of preirrigated habitat in the Tulare Basin (Houghten et al. 1985, Barnum and Euliss 1991) is a major factor in the late-winter decline of pintail abundance in the SJV. During most years since at least the 1960s, pintail abundance peaked during September in the Tulare Basin but not until November-December in the northern SJV (Figure I.13, Barnum and Euliss 1991, USFWS unpubl. data). Movements of pintails that I radio-tagged in the Tulare Basin show that at least some of the increase in pintail abundance in the northern SJV between September and November was due to an influx of pintails from Tulare Basin. Direct recoveries of pintails banded during preseason in Tulare Basin during 1938-45 (Mclean 1950) show that this northerly emigration from the Tulare Basin to the Grassland EA is a long-term pattern. Pintail abundance in the Tulare Basin throughout September-January has

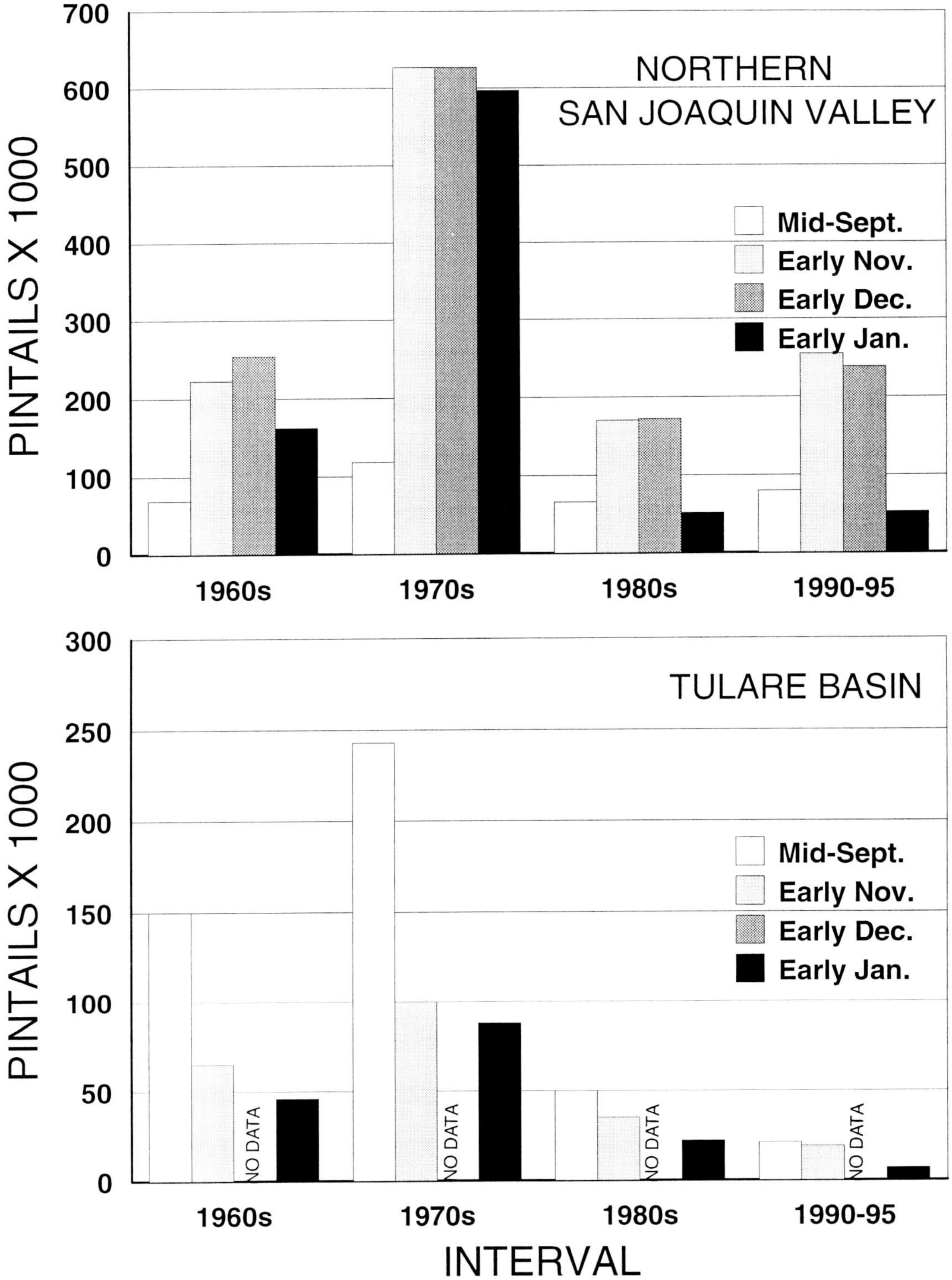


Figure I.13. Average pintail abundance during mid-September, early November, early December and early January in the northern San Joaquin Valley (includes Grassland Ecological Area and MendotaWildlife Area) and Tulare Basin during the 1960s, 1970s, 1980s and 1990-1995. (No early Dec. surveys in Tulare Basin).

declined drastically since the 1970s whereas pintail abundance in the northern SJV has not declined except after early December (Table I.1, Figure I.13). Early December is when I observed mass northerly emigrations of pintails from the Grassland EA to the SACV and DELTA each year. Direct recoveries of pintails banded in the Grassland EA during 1948-62 (Rienecker 1987a) and Tulare Basin during 1938-45 (Mclean 1950) show that this northerly emigration to OCC during winter is also a long-term pattern. Thus, SJV pintails have historically emigrated to OCC during winter. However, before the 1980s, pintail abundance in the northern SJV was maintained throughout the winter, at least partially, by immigration of pintails from the Tulare Basin. During most years since 1980, few pintails from the Tulare Basin were available to replace those that left the Grassland EA, resulting in low late-winter abundance in northern SJV.

There is some evidence that increased flooding of grain fields outside the SJV during 1985-1995, especially of rice fields in the SACV (CVHJV Tech. Comm. 1996, Elphick and Oring 1998), has decreased pintail abundance in the SJV by short-stopping pintails that would have migrated to the SJV. Rienecker (1987a) reported that 10.5% of the direct recoveries of adult female pintails he banded in the SACV during PREHUNT 1949-73 were from the SJV. During 1987-90, only 2.9% of the use days and 1 of 17 mortalities (6%) of adult female pintails radio-tagged during PREHUNT in the SACV occurred in the SJV (Miller et al. 1995). The actual short-stopping may be even greater than indicated by the observed decline in recoveries over time (i.e., 10.5% vs 6%) because the probability of harvest in the SJV relative to OCC was likely greater in the

1980s than during the 1960s and 1970s (Table I.1, i.e., 40% of the harvest and 8% of the population vs 32% of the harvest and 24% of the population).

Data are lacking to judge whether increased agricultural flooding in the SACV and DELTA has caused pintails to leave the SJV earlier. Flooded crop fields are obviously attractive to pintails (Miller 1985,1987, Cox and Afton 1997, Elphick and Oring 1998) and nearly all of the radio-tagged pintails that emigrated from the SJV during winter 1991-94 used flooded rice fields in the SACV. Further, the disparate late winter decline in northern SJV pintail abundance since the 1980s could be explained by an increase in the percentage of SJV pintails leaving for OCC in December. However, a comparison of the percentage of the direct recoveries of female pintails that Rienecker (1987a) banded in the Grassland EA during PREHUNT in 1949-73 that were from OCC (40%) with the percentage of the mortalities of my radio-tagged pintails that occurred in OCC (22%) seems to show that emigration from SJV to OCC has <u>declined</u> over time. At least part of this apparent "decline" is spurious because the probability of harvest in the SJV relative to OCC increased over time (Table I.1). However, data are lacking to determine the magnitude of the change in recovery probabilities and this comparison of recovery rates is not definitive for determining whether pintails are leaving earlier than in the past. Michny (1979) attributed decline in pintail abundance in the SUISUN between 1958-78 to increased availability of flooded corn in the DELTA, rice in SACV, and to a lesser degree, construction of reservoirs such as San Luis Reservoir. Recent data show that pintails do abandon SUISUN when corn fields in DELTA and rice fields in SACV flood (Casazza 1995) and the percentage of central California pintails wintering in

SUISUN remains low today (CDFG, unpubl. data). Even so, I can only speculate whether or not more pintails would have stayed in the SJV had not the availability of flooded habitat elsewhere increased.

Drought conditions in the Central Valley appeared to shift wintering populations north into the less arid SACV, where better established water rights (Gilmer et. al. 1982, Heitmeyer et al. 1989) apparently maintained better habitat conditions. Water deliveries for irrigation and flooding to wetlands in the Grassland EA were lowest on record during 1991(Grassland EA Water District, unpublished data) and the portion of my radio-tagged pintails that emigrated north to other Central California areas during PREHUNT was 2-3X that of later, more normal water delivery years. During dry years in the SACV, lipid content of pintails declined between February and March (Miller 1986). However, the decline of lipid content of pintails in the Tulare Basin during dry years began in September and averaged 7% per 100 days through March (Euliss et al. 1997). The effect of drought in California may depend on the age ratio of the wintering population. I found weak evidence that lightweight AHY females left the SJV earlier than heavy AHY females whereas the reverse was true for HY females. Cox (1996) found daily emigration probability did not differ by capture condition of pintails.

Food limitations may also cause pintails to leave the SJV. Refuging theory predicts that as food resources become depleted feeding-flight distances will increase until a critical distance is reached at which time birds either switch roost sites (if available) or emigrate (Hamilton and Watt 1970). Mass exodus of pintails from Grassland EA started each year during early-mid December (i.e., weeks 14 or 15, Figure

I.5). Although differences in weekly flight distances were not great, the timing of this exodus coincides with when nonshoot day-to-night flight distances peaked; shoot day-to-night distances showed no trend (Figure I.12). Likewise, the exodus coincided with when use of the more distant South Clubs increased (Figure I.7). It also coincided in 1991-92 and 1992-93 with a shift by some pintails from San Luis NWR to Merced NWR (Figure I.7). POSTHUNT night use of private areas was also less in 1991 than later years, further suggesting food production of private clubs was poor that year. At the start of POSTHUNT each year, some pintails quickly dispersed into fringe areas of the Grassland EA and other areas that had received relatively low use during the hunting season. This suggests that food was depleted in heavy use areas.

Lower availability of sanctuary in the SJV compared to in the SACV may also favor larger pintails populations in SACV. About 25% of managed wetland habitat is sanctuary in the SACV compared to 5-6% in the SJV (CVHJV Tech. Comm. 1996). The start of mass emigrations of radio-tagged pintails from Grassland EA coincided with the opening of HUNT2 during two years. Like my observations, Jeske et al. (1995) reported pintail emigrations coincided with hunting and precipitation. Cox (1996) reported that pintails were more likely to emigrate during hunting than nonhunting seasons, regardless of weather. However, pintails continued to emigrate from the Grassland EA during the SPLIT, so factors other than hunter disturbance and availability of sanctuary were also important. Human disturbance can be a major factor in pintail distribution on a local scale (Wolder 1993) but the effect on regional distribution needs further investigation.

Most pintails left Mendota WA during opening weekend of HUNT1 but the reason for the emigration is unclear. Mass exodus coinciding with hunting suggests that the 364 ha Mendota sanctuary was somehow inadequate to hold pintails. Cox and Afton (1998) reported low pintail use of 12 Louisiana sanctuaries 137 ha to 2,514 ha in size and blamed the placement in low pintail use areas, late flooding, dense vegetation and small size of sanctuaries. The Mendota WA sanctuary was surrounded by >2500 ha of flooded wetlands and both the sanctuary and surrounding wetlands were flooded during PREHUNT and used extensively by pintails (Figure I.9). Although the Mendota WA sancturary was about half the total area of the heavily used sanctuary at San Luis NWR, the Mendota WA sanctuary was larger than the Merced NWR sanctuary (CVHJV Tech. Comm., 1996) that also held large concentrations of pintails (CDFG, unpubl. data). Roads open to hunters surrounded and bisected sanctuaries on all three areas. The southern half of the Mendota WA sanctuary received little use during the hunting season (Figure I.9) indicatng these units did not serve as a functional sanctuary. Thus, any efforts to reduce opening-day exodus of pintails should first focus on why the southern part of the sanctuary received little use by pintails.

Low survival of SJV pintails relative to pintails in the SACV may have contributed to the disparate decline of pintails in the SJV. Female pintails show high fidelity to specific California wintering areas (Rienecker 1987a, Hestbeck 1993b) and overharvest can depress long term viability of local populations (Hestbeck 1993b). Hunting mortality of female pintails in the SJV was greater than in SACV during 1991-94 (Fleskes, unpubl. data). Comparisons of harvest and abundance indicate that higher harvest rates of pintails in the SJV than in OCC has occurred long-term and that as pintail abundance declined this difference increased (Table I.1). Pintails from SUISUN, another area showing disparate declines in pintail abundance, also had poor survival relative to the SACV (Miller et al. 1993).

Poor pintail recruitment may also be contributing to the disparate decline of late-winter pintails in the SJV. HY females tend to stay longer in the SJV than AHY and in years of poor recruitment HY females make up a smaller portion of the wintering population. Most pintails I radio-tagged emigrated north during December, primarily to rice fields in the SACV, but AHY females left at a faster rate than HY females. Cox (1996) also reported that AHY females were more likely (1.9 times) than HY females to make long range northerly movements during winter from southwestern Louisiana to rice fields. In contrast, Jeske et. al. (1995) reported no apparent differences in movement patterns. Rienecker (1987a) reported that a greater percentage of HY (41.6%) than AHY (31.9%) direct recoveries of female pintails banded during preseason in Grassland EA during 1948-62 (Rienecker 1987a) were from OCC. Comparisons of distribution based on banding data should be viewed with caution because band recovery probabilities may differ among areas and may change over time (Table I.1).

Is there a San Joaquin Valley subpopulation of pintails?

There is little evidence supporting the idea that subpopulations of wintering pintails exist in the Central Valley. Few pintails radio-tagged in the SACV during 1987-90 visited the SJV during winter (Miller et al. 1995b), indicating that a SACV population of wintering pintails may exist (Miller 1990). However, most pintails radio-tagged in the SJV (this study) and SUISUN (Casazza 1995) moved to the SACV during mid-winter, so mixing from all wintering areas does occur at least for part of the winter. Further, although Rienecker (1987a) identified Imperial Valley (i.e., Salton Sea area) pintails as a separate population, his band recoveries showed much mixing of pintails banded in the SJV and other central California areas.

Morphometrics of pintails do vary slightly among California regions. AHY female pintails that I captured in the SJV were on average slightly (< 1%) smaller (differences; culmen = 0.40 mm, tarsus = 0.46 mm, wing chord = 1.59 mm, $t \geq 2.35$, df = 416, $P < 0.025$) but of similar mass (difference = 3 g, $t = 0.37$, 416 df, $P > 0.7$) compared with pintails captured in the SACV during 1987-89 (Miller et al. 1995b). In contrast, pintails of both age classes captured in SUISUN and SJV during 1991 and 1992 (Casazza 1995) were structurally similar ($P > 0.10$), and SUISUN pintails were heavier than SJV pintails in 1991 (HY difference = 89 g, $t = 5.01$, 81 df, $P < 0.001$; AHY difference = 27 g, $t = 1.87$, 125 df, $P < 0.10$).

I can only speculate whether these small morphometric differences reflect measurement bias or true structural differences caused by genetic or environmental factors. Pintails rarely nest in the SACV but are regular nesters in the SJV and are common nesters in the SUISUN (G. Yarris, California Waterfowl Assoc., Sacramento, unpubl. data). Thus, locally nesting AHY and locally produced HY females, that may be structurally different than northern breeders, may have made up a greater portion of sample captured in the SUISUN, and to a lesser degree in the SJV, then in the SACV.

Casazza (1995) theorized that one reason HY pintails they captured in the SUISUN were especially heavy in 1991 was because many were local birds that had not suffered the weight loss caused by long migrations. Likewise, its possible that SACV pintails captured by Miller et al. (1995b) were relatively lean because they were captured earlier in the season than the SJV and SUISUN samples and had not yet replaced fat used during breeding and migration.

Smaller pintails in the SJV, which is south of the SACV, is consistent with Bergmann's Rule (Welty 1975). However, weather conditions are relatively mild and fairly similar throughout the Central Valley (National Oceanic and Atmospheric Administration, Asheville, NC, unpubl. data) so pressure during the wintering period for SACV and SJV pintails to evolve disparate body sizes is weak. However, large numbers of pintails once nested in the Tulare Lake area so possibly pintails now wintering in SJV are a genotype adapted for nesting in a more southern latitude. Unfortunately, information to determine if pintails from different wintering areas historically nested in different latitudes is lacking. Also, although numerous pintail genotypes exist, reflecting the wide geographic distribution of pintails (Rhodes et al. 1991), a high degree of exchange apparently exists among regions because genotypic frequency is similar among regions (Cronin et al. 1996). However, it should be noted that genetics of pintails nesting in the SJV have not been analyzed and one unique genotype was found among the SUISUN breeding population (Cronin et al. 1996). Alternately, diet may play a role in size differences. Invertebrates are more important in the winter diet of pintails in the SJV then in the SACV, where rice is dominate in their diet (Miller 1987), and body size differences may be reflecting these dietary differences.

Distribution and movements of pintails in the Grassland EA vicinity

Changing habitat conditions during the last 30 years have undoubtedly affected waterfowl distribution and movement patterns in the Grassland EA vicinity. Aerial surveys during the 1970s show that most pintails in the Grassland EA vicinity roosted on San Luis Reservoir during shoot days (CDFG, unpubl. data). Local hunters reported that these pintails flew to private wetlands and harvested corn fields during the evening to feed; on windy days pintails were forced off the open resevoir and flew to private wetlands to roost. During this study, pintails roosted on NWR and WA sanctuaries within the Grassland EA, San Luis Reservoir received almost no use, and corn fields were plowed, dry and received no use.

In general, local distribution and use patterns within the Grassland EA were similar among years. However, changes in local movements and distribution resulting from changes in habitat management were also evident during this study. For instance, Salt Slough WA, which was first fully flooded during the 1993-94 winter, became a common night destination of San Luis NWR pintails during SPLIT 1993-94 and thereafter some pintails that would have flown to North or South Clubs were seemingly short-stopped . Wetlands in the closed zone on Kesterson NWR (i.e. Gadwall ponds) were restored and closed to hunting beginning in 1992 and day use increased, both on shoot and nonshoot days. These changes may explain the lower shoot-day use of private areas in 1993-94 than in earlier years.

Efforts to increase waterfowl use of private duck clubs on nonshoot days by completely eliminating hunting in the Grassland EA on those days were not completely successful. After receiving numerous complaints in 1992-93 that some hunters were violating the "gentlemans" agreement not to shoot except on Wednesdays and weekends, the Grassland Water District increased efforts to encourage compliance. The impact of these efforts is unclear. In 1992-93, use of duck clubs was greater on Tuesdays than Fridays whereas in 1993-94 use was greater on Fridays than Tuesdays. Regardless, use of clubs overall on nonshoot days did not vary among years so the desired impact was not obtained. This situation is a good example of the "tragedy of the commons" (Hardin 1968), where a few cheaters take advantage of the efforts of many (to build-up of pintails on private clubs). Thus, its unlikely that voluntary efforts will eliminate this cheating.

Hunting obviously had a large impact on pintail distribution in the Grassland EA and differences in hunting intensity affected use patterns. Day use was greater on Wednesdays than Saturdays and Sundays. Most hunters were from other areas, especially the SFBAY area, and fewer made the trip for one day of shooting on Wednesday. Also, some clubs did not shoot on Sundays and many did not shoot on Sunday afternoon, so pintails had >2 days to build up on private clubs prior to the Wednesday shoot day. Vacant hunting blinds on Sundays also contributed to greater use of duck clubs during the later weeks of HUNT2 because pintails flew more during the day on HUNT 2 than HUNT1 shoot-days (Table I.7) and thus were more likely to discover and settle onto duck club units with vacant blinds during HUNT2. Also, except for opeing day, hunter success was greater during HUNT2 than HUNT1 (CDFG and Grassland Water District unpubl. data) so hunters probably bagged their limits more quickly, and left wetlands earlier during HUNT2. Foggy days, occurring mostly during HUNT2 (National Oceanic and Atmospheric Admin., Asheville, N.C., unpubl. data) also helped to visually isolate pintails from hunters and probably enabled some pintails to remain undisturbed on private clubs. The east grasslands flooded because of high precipitation during late winter in 1991-92 and 1992-93 making some areas inaccessible to hunters which perhaps contributed to increased use by pintails during HUNT2 and POSTHUNT during those years (Figure I.7).

Importance of other areas also varied among years because of annual variation in weather. For instance, importance of individual areas during PREHUNT differed among years because timing of flood-up, and thus pintail concentration areas and sites where I captured birds differed among years. The 1991 drought not only affected distribution by delaying fall flooding of some private clubs, but reduced water deliveries and the resulting poor seed production that year may also explain the lower night use of private wetlands during PREHUNT in the Grassland EA compared to later years. Limited food availability may also explain why more pintails flew to the more distant South Club wetlands in 1991 than other years.

Individual experience may also influence pintail movements and distribution. HY females tended to fly farther than AHY females between roosting and feeding sites, primarily because they returned to sanctuaries at a higher rate than AHY on nonshoot days. Use of private areas was greater two days after hunting than one day after hunting, indicating some pintails were using cues other than hunter presence in wetlands for when to return to sancturary areas. During nonhunting intervals in Mendota WA and Tulare Basin, pintails captured in other areas flew farther than pintails that were captured in that area, possibly because they were more familar with locations of prime feeding and roosting sites. It is unclear why this trend was opposite during the hunting season in some areas. HY pintails used private lands at a significantly greater rate than AHY pintail on shoot-nights and were more likely to be in the South Clubs far from sanctuary. HY females tend to pair later than AHY females, and unpaired and subdominate individuals may be excluded from preferred habitats (Hepp and Hair 1984). Combined with their trait of remaining longer in the SJV, greater use of duck clubs explains why survival of HY was below survival of AHY (Fleskes, unpubl. data).

The level of shoot-day use of duck clubs that I measured may underestimate actual exposure to hunters. Radio-tagged pintails must land in one location for at least a minute or two for me to triangulate their location. The liklihood of a pintail staying in one location in hunted areas on shoot days is less than in nonhunted areas. Although, missing a few minutes of use of particular wetlands does not critically bias estimates of distribution or habitat use, it does explain why hunting mortality was high (Fleskes, unpubl. data) relative to the low level of private use on shoot days that I measured. Pintails must only fly over or visit a hunted unit briefly in order to risk being harvested. Follows of individual pintails and interviews with hunters show that most harvest was due to pintails leaving late in the morning or arriving early in the evening. Thus, management actions that affect the rate of these behaviors will affect harvest.

Use patterns indicate that lack of roost sites on private areas may be limiting their use by pintails. During PREHUNT, some pintails used the same wetland during the day and night but many used different wetlands during the day and night. Many maintained a routine of roosting on Kesterson NWR or Volta WA during the day and flying out to private clubs at dusk. Also, some pintails continued to return to public areas in the morning even on nonshoot days and during the SPLIT. These daily movements indicate that preferred diurnal roosting sites were not available in all wetlands and may be lacking in many duck club wetlands.

Distribution and movements in Mendota WA and Tulare Basin

As in the Grassland EA, habitat and sanctuary availability affected distribution and movement patterns of pintails in Mendota WA and Tulare Basin. Flights were shortest in Mendota WA, the smallest of the three SJV habitat areas. Flight distances increased as PREHUNT progressed in Mendota WA because pintails took advantage of an expanding habitat base as new flooding occurred. Pintails flew farther during the hunting than nonhunting seasons but in Mendota WA the distance on shoot and nonshoot days was similar, reflecting their tendency to return to sanctuary units even on nonshoot days. In the Tulare Basin, and especially in the Grassland EA, pintails flew farther on shoot dates.

Use patterns in the Tulare Basin that I observed were similar to patterns reported by Barnum and Euliss (1991) during 1980-87, except I observed little use of duck clubs during September. Duck clubs flooded later during 1991-94 because the hunting season started 1-3 weeks later than during 1980-87 (11/9 - 11/20 vs 10/31 - 11/6, CDFG, unpubl. data). The relative importance of preirrigated habitat and Kern NWR did vary slightly among years but the greater importance of Kern NWR during PREHUNT was at least partially an artifact of my trapping pintails in fields closer to Kern NWR in 1993. Most pintails that I radio-tagged in Mendota WA and Tulare Basin emigrated to the Grassland EA during PREHUNT, and small sample sizes prevented testing for annual differences in use rates after PREHUNT.

Was my sample representative?

I used methods that minimized biases and allow wide application of results but effects of sampling constraints should be considered when my findings are applied.

Logistics prevented me from radio-tagging males and attempts to extend my findings to males should be done with an understanding that differences among sexes undoubtedly exist. Coincidental shifts in surveyed pintail abundance (CDFG, unpubl. data) and movements made by my radio-tagged female pintails indicate that general movement patterns within California are similar for males and females. However, recoveries of pintails banded in the Grassland EA during 1948-62 showed that, although males and HY females had similar recovery patterns, a greater percentage of male (52-65%) than AHY female (37%) recoveries were outside the SJV (Rienecker 1987). Thus, Rienecker's data suggest males and HY females were more wide ranging than AHY females. In contrast, I found that AHY females left the SJV at a higher rate than HY females. So, although my data on females are probably adequate for comparing general trends in pintail distribution and movements in California, studies of male pintail movement patterns are still needed.

To adequately sample the population, I distributed my sample in all 3 major SJV habitat areas in rough accordance with surveyed abundance rather than sampling only one SJV area over a short period of time. However, because it would have been logistically difficult to capture pintails throughout winter and continual trapping could disrupt normal movements and distribution, I restricted trapping to PREHUNT. Distribution and movements of pintails that arrive later in the SJV may be different than my sample. I don't believe this bias is severe because shifts in pintail abundance among regions (CDFG, unpubl. data) agreed with the timing of movements by my radio-tagged pintails.

PREHUNT distribution of radio-tagged pintails in the Grassland EA depended somewhat on where I captured pintails and because I was unable to capture pintails in all areas (i.e., Merced NWR, North Clubs) where pintails were abundant (CDFG, unpublished data) my sample was not perfectly representative of local pintail distribution during PREHUNT. The bias was not severe, even during PREHUNT, because many pintails that I radio-tagged elsewhere did move into areas where I did not trap (e.g., pintails radio-tagged in Volta WA and Kesterson NWR moved into North Clubs during PREHUNT). However, there was a relationship between capture location and use of some areas during PREHUNT. For instance, during all PREHUNT weeks, the likelihood of being in the south grasslands instead of in the north grasslands was significantly greater for pintails captured in the south grasslands than for pintails captured in the north grasslands ($X^2 \geq 30.07$, 2 df, $P \leq 0.0001$, Bonferroni $P < 0.05$). This capture effect ended (Bonferroni $P > 0.05$) once hunting began and pintails flocked from all areas to sanctuaries and intermingled. Thus, at least part of the reason for annual differences in PREHUNT distribution of radio-tagged pintails among Grassland EA areas was because I captured pintails in slightly different areas. However, because I radio-tagged pintails relative to their abundance, differences in flooding among years was the main underlying reason for annual differences, even during PREHUNT.

Although hunter-killed radio-tagged pintails weighed less than hunter-killed pintails without transmitters (Fleskes, unpubl. data), all evidence indicates that my radio-tagged pintails intermingled and moved about normally with the population they represented. As mentioned above, changes in pintail abundance among regions during 1991-94 (CDFG, unpubl. data) coincided well with regional movements made by my radio-tagged pintails. Pintails left major roost sites along with other pintails and used sites for feeding and roosting where other pintails were concentrated. Also, social status and flight behavior of radio-tagged pintails was similar to pintails without transmitters (Fleskes, unpubl. data). Thus, although pintails with backpack transmitters may not be appropriate for breeding studies (Pietz et al., 1993, 1995), I found no evidence of a serious bias for this study of winter movements and distribution.

Except during the trapping period and for 2-3 weeks afterwards, pintails captured under the same net (33 different multiple bird captures) or in the same specific area

(South Club, Volta WA, Los Banos WA, San Luis NWR, Kesterson NWR, Mendota WA, Tulare Basin) were no more likely to be nearest neighbor during the day or night then were pintails captured under different nets or in different specfic areas (Qstat P > 0.05). Thus, my assumption that each radio-tagged pintail could be considered an independent sample was valid for most of the winter.

CONCLUSIONS

Pintail distribution has changed in the past, both locally and regionally in response to changes in land use and habitat. This study shows that the process is ongoing. Future management decisions should consider potential impacts on pintail distribution.

The disparate decline in abundance of pintails wintering in the SJV is obviously related to poor habitat conditions there relative to other wintering areas in the Central Valley. Habitat improvements that increase the carrying capacity and winter survival of pintails in the SJV would likely increase SJV pintail populations. Adequate early season water availability is essential to maintain SJV populations. Restoration of Tulare Basin habitats is crucial to restore pintail abundance throughout the SJV, including the Grassland EA during late winter.

Caution should be used when creating new habitat so as not to redistribute waterfowl away from existing private wetlands. This could lower hunting success and discourage habitat management that could cause failure of some duck clubs. Conversion of their wetland habitats into other uses would ultimately lower survival and productivity for a wide array of wetland-dependent wildlife, including pintails. Understanding how pintails move about in a particular area can provide insight on the likely impact of habitat changes on pintail distribution. For instance, knowing that many Merced NWR pintails fly to South Clubs at night, I would predict that habitat improvements in the east grasslands may reduce pintail abundance in the south grasslands. Establishing a sanctuary in the south grasslands should increase use in that area.

Duck club managers can improve their harvest opportunities through proper habitat management. Most opportunity to harvest pintails during this study arose from pintails being drawn to feed on clubs and then either staying there in the morning or returning there early in the evening. Thus, practices that increase these behaviors should increase harvest opportunity. Enhancing food production on clubs should enhance harvest opportunities. Voluntary nonshoot days were shown to increase day use during this study and use two days after shooting was greater than one day after shooting. The fact that some pintails left some clubs to roost elsewhere, even during nonhunting intervals and on nonshoot days, indicates that availability of diurnal roost sites may be limiting pintail use of duck clubs. Thus, providing additional roosting sites on duck clubs, along with a continued or expanded program of nonshoot days, would likely improve harvest opportunity while at the same time distributing birds more widely and reducing risk of catastrophic losses to disease.

Changing agricultural and land use practices are continually modifying the landscape of central California, one of the most important waterfowl wintering areas in the world. Critical waterfowl habitat in central California is managed by a myriad of public and private interests with primary goals that sometimes diverge. The challenge to waterfowl managers facing the new millennium is to apply their knowledge of how waterfowl respond to habitat changes within this dynamic and complex system so that their efforts provide the maximum benefit for the waterfowl resource and those who enjoy it.

CHAPTER II. HABITAT USE OF FEMALE NORTHERN PINTAILS IN THE SAN JOAQUIN VALLEY, CALIFORNIA

INTRODUCTION

Northern pintail (Anas acuta) breeding populations in North America plunged to all time lows in the early 1990s (USFWS and CWS 1995) and although recent recovery is promising, midwinter pintail populations in California are still only about 25% of those recorded in the 1970s (USFWS, Portland, OR, unpubl. data). Because wintering habitats may affect the size of the pintail breeding population (Raveling and Heitmeyer 1989), effective management of northern pintails requires an understanding of their winter habitat selection. A thorough understanding of habitat selection is especially important in the Central Valley (Figure II.1), where over 90% of wetland habitat has been lost and yet where about half of the pintails in North America winter (Gilmer et al. 1982).

The need to intensively manage wetland habitats is especially crucial in the San Joaquin Valley (SJV), the southern and most arid part of the Central Valley. Unlike the Sacramento Valley, where winter-flooded rice fields have replaced wetlands, most SJV wetlands were converted into cotton fields and other agriculture that are left unflooded during winter due to restrictive water supplies, and thus provide little benefit to wintering waterfowl. In the Tulare Basin, the southern part of the SJV, water conservation efforts have led to even further reductions in the availability of agricultural fields that are flooded during fall-winter before planting (i.e. preirrigation) (Barnum and Euliss 1991).

Waterfowl habitats in the SJV are also undergoing changes that could reduce their appeal to pintails. For instance, an increasing discrepancy in the daily bag limit for

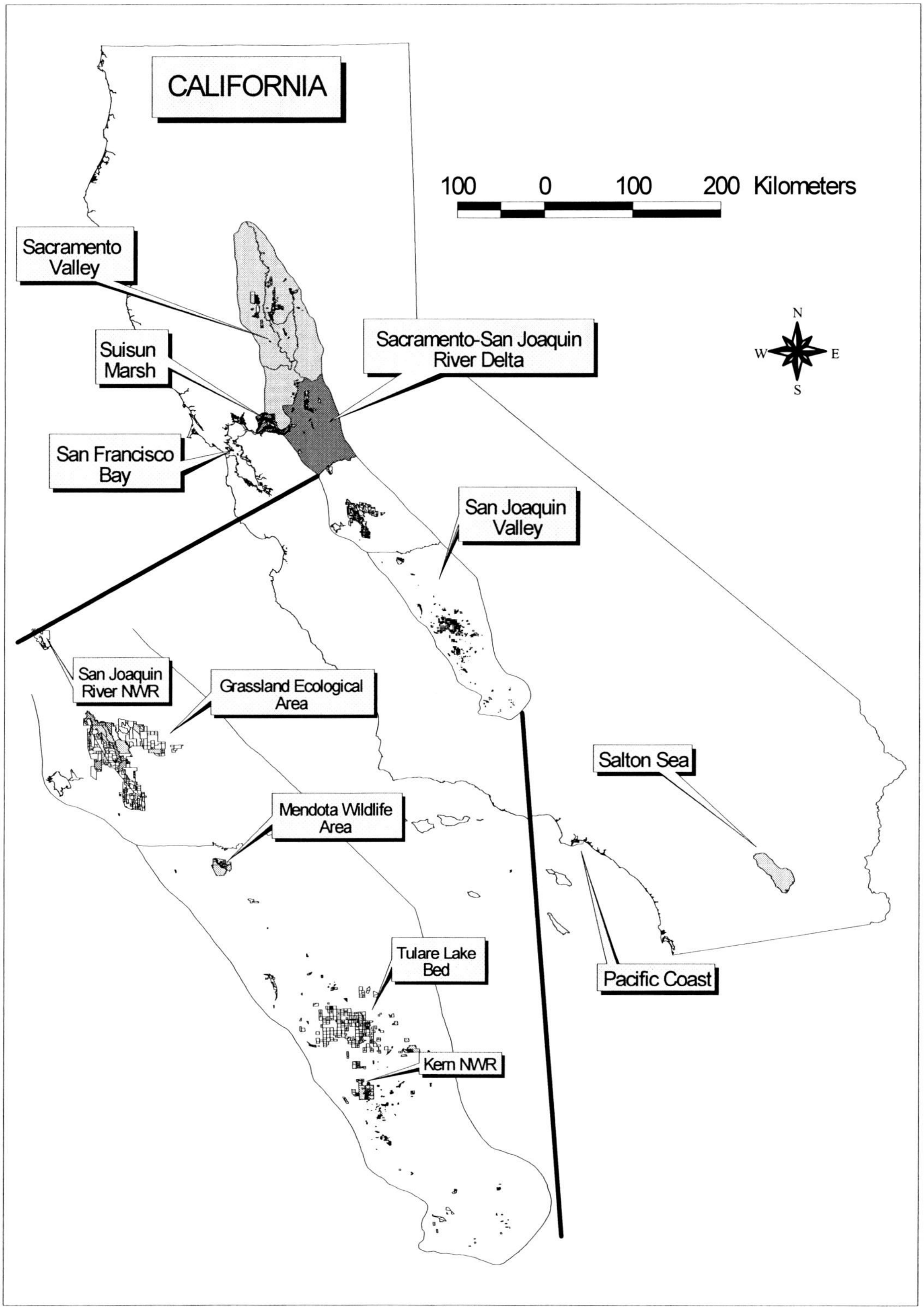


Figure II.1. Regions of California and areas within the San Joaquin Valley used by wintering northern pintails (<u>Anas</u> <u>acuta</u>) during 1991-94.

mallards and pintails (0 difference before 1988, 2-3 more mallards 1988-94, 4-6 more mallards 1995-99, CDFG, Sacramento, unpubl. data) has increased conversion of open ponds to ponds with more emergent vegetation that managers perceive as being more favorable for mallard harvest. Increased water availability due to the 1992 Central Valley Project Improvement Act (Davis 1992) has also allowed conversion of some swamp timothy (Heleochloa schoenoides) wetlands to plant types, such as watergrass (Echinochloa crusgalli), that require more water but can produce larger seed crops.

Information on pintail habitat selection in the SJV is lacking. Pintail habitat use has been studied in Louisiana (Cox and Afton 1997), Suisun Marsh (Casazza 1995) and Sacramento Valley (M. R. Miller, unpubl. data). Surveys (Coe 1990, USFWS unpubl. data) provide information on diurnal habitat use in the SJV but most were conducted on shoot days when pintails are concentrated on sanctuaries and pintails feed primarily at night during most of the winter (Miller 1985, Euliss 1984). Pintail food habits at Los Banos WA have been described (Beam and Gruenhagen 1980, Connelly and Cheesemore 1980) but these collections were made during day and most pintails leave Los Banos WA at night to feed on private duck clubs in the Grasslands Ecological Area (EA) (see Chapter I). Euliss and Harris (1987) collected pintails at night on Kern National Wildlife Refuge (NWR) and Euliss et al. (1991) collected pintails from evaporation ponds in the Tulare Basin but information on habitat selection throughout the Tulare Basin is lacking.

To provide information for wetland habitat program managers, I investigated habitat selection by female northern pintails in the three major habitat areas in the SJV (Grassland EA, Mendota WA, Tulare Basin) during August through March, 1991-94.

STUDY AREA

SJV waterfowl habitat (Figure II.1) consisted primarily of shallow, seasonal wetlands in three distinct blocks (Grassland EA, Mendota WA and Tulare Basin), separated by agricultural lands (e.g., orchards, cotton fields) that were rarely flooded and were of little value to waterfowl (Fleskes, unpubl. data). The Grassland EA vicinity (Figure II.2) was composed of the Grassland EA and nearby habitats, including the 6300 ha San Luis Reservoir (includes the O'Neill Forebay). Up to 23,313 ha of seasonal marsh, 1160 ha of semipermanent and permanent marsh, 1258 ha of flooded uplands, 245 ha of sewer ponds, 39 ha of evaporation ponds and 314 ha of flooded agricultural fields were available in the Grassland EA vicinity (Fleskes, unpubl. data). Grassland EA and vicinity (Figure II.2) was divided into north, south and east parts. The north grasslands was composed of public lands with some wetlands closed to hunting (San Luis NWR, Kesterson NWR, Los Banos WA), public areas without closed zones (Volta, Salt Slough and China Island WAs) and privately owned waterfowl hunting clubs (North Clubs). The Grassland State Park in the north grasslands was closed to hunting but had no waterfowl habitat. The south grasslands were composed entirely of private waterfowl hunting clubs (South Clubs). The east grasslands was composed of Merced and Arena Plains NWRs and private waterfowl hunting clubs and pasture (East Clubs).

Mendota WA was composed of up to 2459 ha of shallow marsh open to waterfowl hunting, 303 ha of shallow marsh closed to waterfowl hunting and a 364 ha central deep-water pool open to hunting (Figure II.3). The Tulare Basin (Figure II.4) was composed of up to 2399 ha of preirrigated fields (i.e., barley-wheat, safflower, alfalfa and

Figure II.2. Grassland Ecological Area vicinity in the San Joaquin Valley, including California Department of Fish and Game Wildlife Areas (WA), U.S. Fish and Wildlife Service National Wildlife Refuges (NWR), private waterfowl hunting clubs and San Luis Reservoir, during 1991-94.

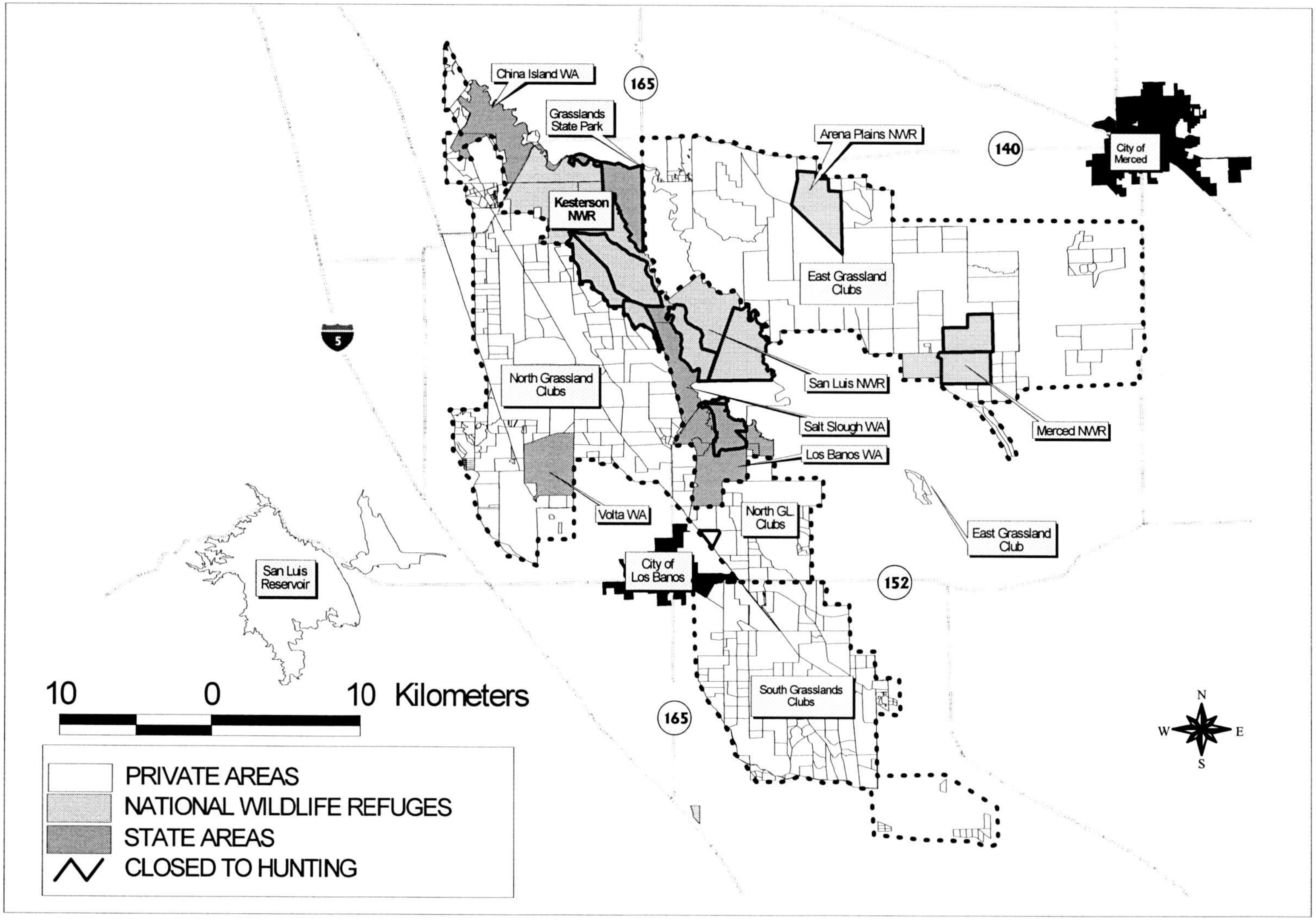

China Island WA
165
Grasslands State Park
Arena Plains NWR
140
City of Merced
Kesterson NWR
East Grassland Clubs
5
San Luis NWR
North Grassland Clubs
Salt Slough WA
Merced NWR
Los Banos WA
Volta WA
North GL Clubs
East Grassland Club
San Luis Reservoir
City of Los Banos
152
10 0 10 Kilometers
South Grasslands Clubs
165
N
W
E
S
PRIVATE AREAS
NATIONAL WILDLIFE REFUGES
STATE AREAS
CLOSED TO HUNTING

Figure II.2.

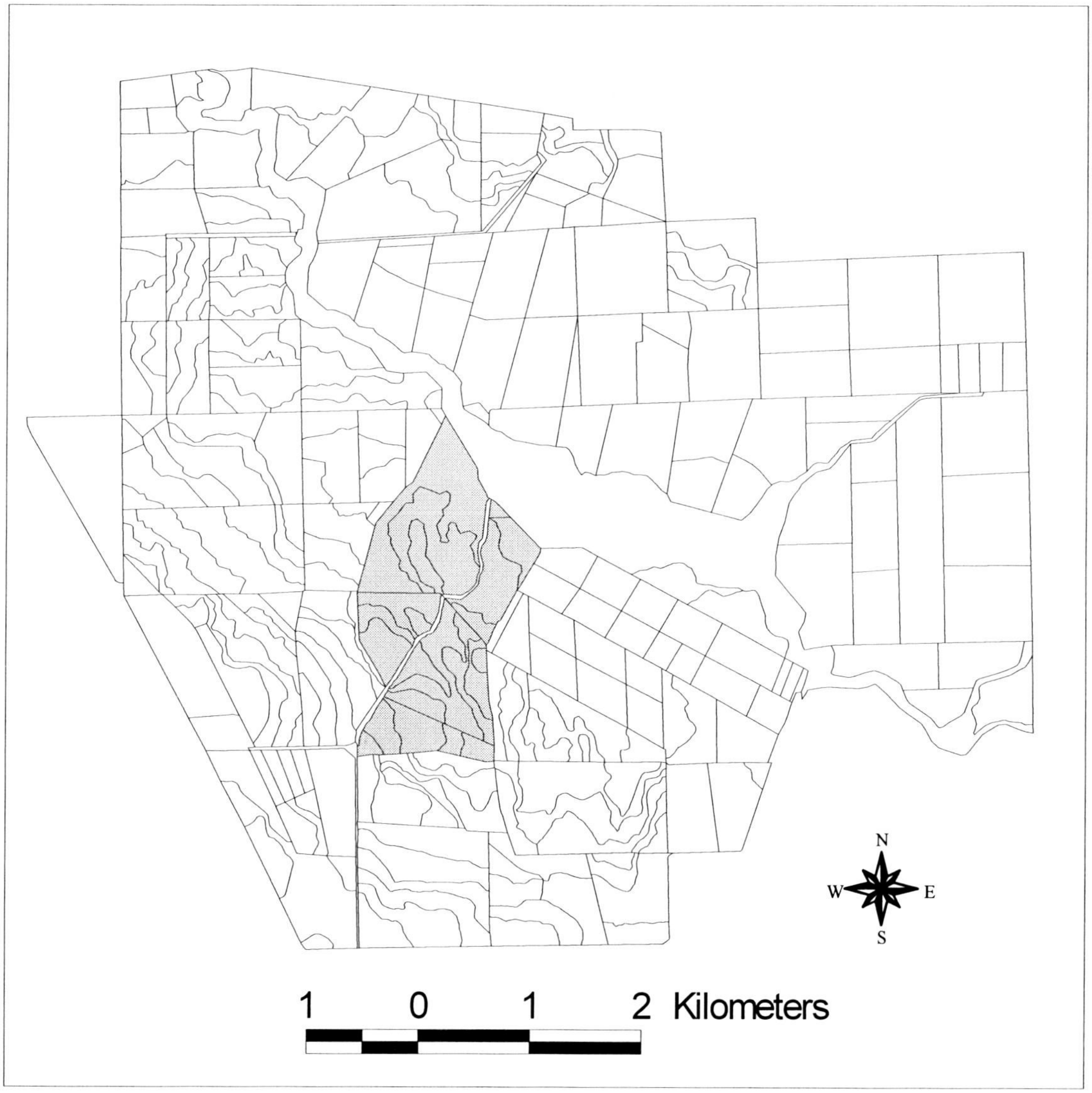


Figure II.3. Mendota Wildlife Area including the 364 ha central deepwater pool, the 303 ha shallow marsh area closed to waterfowl hunting (shaded area) and other shallow marsh units open to waterfowl hunting (up to 2459 ha flooded during 1991-94).

Figure II.4. Waterfowl habitats in the Tulare Basin during August-April, 1991-94. Areas south and west of Bakersfield were excluded from availability and use estimates because they were outside the daily flight range of radio-tagged pintails (Anas acuta) in the Tulare Basin.

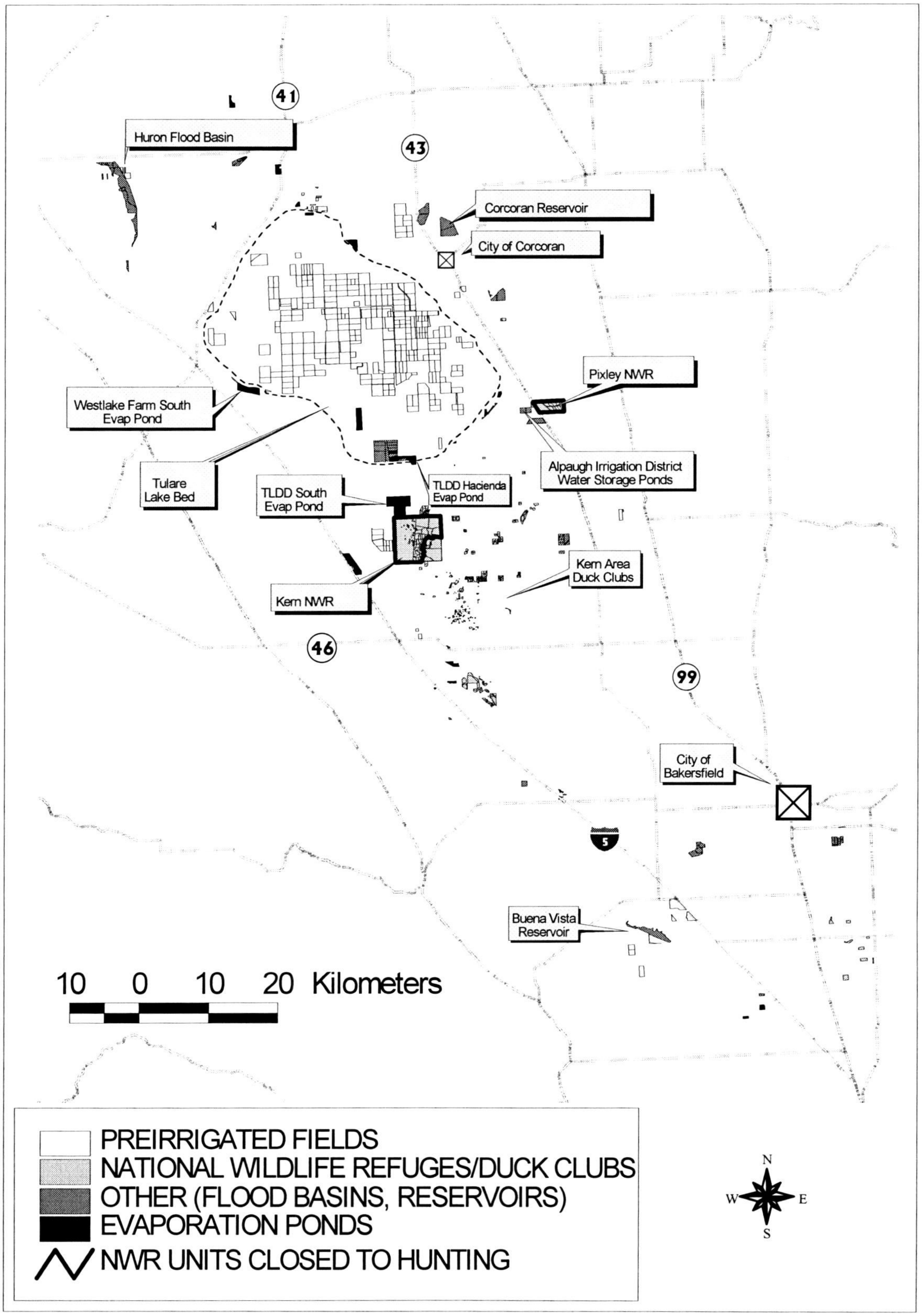

41
43
Huron Flood Basin
Corcoran Reservoir
City of Corcoran
Pixley NWR
Westlake Farm South Evap Pond
Alpaugh Irrigation District Water Storage Ponds
Tulare Lake Bed
TLDD South Evap Pond
TLDD Hacienda Evap Pond
Kern Area Duck Clubs
Kern NWR
46
99
City of Bakersfield
5
Buena Vista Reservoir
10 0 10 20 Kilometers
PREIRRIGATED FIELDS
NATIONAL WILDLIFE REFUGES/DUCK CLUBS
OTHER (FLOOD BASINS, RESERVOIRS)
EVAPORATION PONDS
NWR UNITS CLOSED TO HUNTING
N
W
E
S

Figure II.4.

cotton fields that were harvested and then disced and flooded before the next planting), up to 2946 ha of public and private wetlands, 1951 ha of agricultural-drainwater evaporation ponds, and miscellaneous habitats (0-1374 ha of flood basins, 82 ha of sewage treatment ponds, and 390-742 ha of reservoirs) in or near the Tulare Lake Bed and Kern NWR (Fleskes, unpubl. data).

Most wetlands in the Central Valley were dry during summer, irrigated periodically during the summer to promote seed production, and flooded during winter. Most initial flooding of wetlands and harvested croplands occurred during mid-August to late-October. Water for irrigation, fall flood-up and water-level maintenance was delivered from reservoirs that store Sierra snow-melt. Thus, the timing and amount of early-winter habitat varied with the previous winter's snowfall. Late-winter rains flooded additional habitat each year. Study area habitats are described in detail by USFWS (1978, 1979), Heitmeyer et al. (1989), Herbold and Moyle (1989), Kadlec and Smith (1989), Kramer and Migoya (1989), Kempka and Kollasch (1990), Baldassarre and Bolen (1994) and Ducks Unlimited (1994).

Precipitation and the quality and quantity of flooded habitat varied during the study. Reservoir levels were critically low in 1991 due to 4 years of below-normal precipitation; drought conditions in the San Joaquin River drainage were the worst on record (California Department of Water Resources 1991, National Oceanic and Atmospheric Administration, Asheville, NC, unpubl. data). In 1991, no water was delivered to the Grassland Water District for wetland plant irrigation during May-July, fall flood-up was delayed about 2 weeks, and August through mid-November and total water deliveries to the Grassland Water District were the lowest on record (Grassland Water District, Los Banos, CA, unpubl. data). Drought conditions prevailed through January 1992 but habitat conditions improved during 1992-93 because of near-normal precipitation and higher water level in reservoirs. Conditions during 1993-94 were good because above-average precipitation and enactment of the Central Valley Project Improvement Act (Davis 1992) nearly doubled the amount of water that was delivered to the Grassland Water District (Grassland Water District, Los Banos, CA, unpubl. data).

Wetland restoration also increased available habitats in 1993-94. Salt Slough WA was mostly dry until wetlands were restored and flooded in September, 1993. Also, the Gadwall ponds in the sanctuary part of Kesterson NWR were restored and flooded in 1993.

Duck hunting daily bag limits (4 ducks with 1 either-sex pintail) and season lengths (59 days) were identical throughout California during all years of the study (CDFG, Sacramento, unpubl. data). However, the timing of the hunting seasons differed among years and regions. The hunting season was a consecutive 59 days, starting in early-mid November in the southern SJV zone (includes the Tulare Basin but not the Mendota WA), and starting the second Saturday in October in the northeastern California zone. Elsewhere the season was split, with most areas (including the "remainder of the state zone", where almost all of my radio-tagged pintails wintered), having a 22-day late-October to mid-November first season (HUNT1) and a 37-day second season (HUNT2) starting after a 12 (in 1991), 19 (in 1992) or 27 (in 1993) day closure (SPLIT) of duck hunting after the end of the first season. In addition, nearly all duck clubs in the

Grassland EA and WAs and NWRs in central California allowed hunting only on Wednesdays, Saturdays, and Sundays (i.e., Shoot dates). Kern NWR was hunted only on Wednesdays and Saturdays and many clubs in the Tulare Basin adopted Wednesday and Saturday (not Sunday) as shoot dates. Many duck clubs outside the SJV, especially those that hunted rice fields in the SACV, also hunted on windy and rainy days or allowed hunting all 59 days of the season.

METHODS

Classifying and measuring available habitat

I mapped all areas in the study area that flooded during September - March, 1991-94. Areas were digitized using a Geographic Information System (GIS) and ARC/INFO (ESRI) computer program. I determined the area of each habitat type that was flooded each week, using 1 September, 30 August, and 29 August as the start of week 1 for 1991-92, 1992-93 and 1993-94, respectively. To best represent average habitat conditions available to pintails during the PREHUNT, HUNT (includes HUNT1, SPLIT and HUNT2) and POSTHUNT intervals, I weighted weekly availability estimates by the number of pintail locations obtained that week (to account for changing sample sizes) and then calculated interval averages. Habitat types and methods used to identify habitat type and estimate availability (i.e., flooded area) varied among the three SJV areas.

Grassland EA and vicinity

I classified all areas in the Grassland EA and vicinity (Figure II.2) that were flooded during August-March 1991-94 into 8 general habitat types; 1) seasonal marsh, which included most wetlands on duck clubs and NWRs and WAs but also included vernal pools (primarily in the East Grasslands); 2) permanent and semipermanent marshes (including "brood ponds", sloughs, shallow lakes, e.g., Buttonwillow lakes) and river oxbows that remained at least partially flooded throughout most years; 3) permanent deepwater reservoirs (primarily San Luis Reservoir and O'Neal Afterbay) and fish ponds; 4) agricultural drainwater evaporation ponds; 5) sewage treatment ponds; 6) uplands including idle grasslands and irrigated pasture; 7) rice fields and; 8) other agricultural crop fields.

I further classified marsh habitats (1 and 2 above) based on dominant vegetation as swamp timothy, watergrass or other. For NWRs and WAs, I used data provided by managers each year to classify wetlands. For private duck club units in the north and south Grasslands, I used vegetation data collected by Dale Garrison (San Luis NWR) during 1986 and 1987. I updated Garrison's vegetation maps by interviewing private managers and using NRCS photography to identify late-summer flooded units (potential watergrass units) which I then visited. I was unable to identify dominant vegetation for several wetlands in the East Grasslands and excluded these wetlands from the timothy vs watergrass vs other analyses.

I also classified marsh habitats as "open" (< 25%, most <5% of area with emergent vegetation) or "hemi-closed" (≥ 25%, most < 75% of area with emergent vegetation) based on the percentage of emergent cover identified from aerial photographs.

I used a variety of methods to map flooding. For NWRs and WAs, I used records provided by managers. Grassland Water District personnel provided fall floodup information for north and south grassland duck clubs in the Grassland Water District during 1991 and 1992. In 1993, for other areas, and for winter-spring flooding I mapped flooding from aerial photographs.

Mendota WA

Mendota WA was composed of a central permanent pool and numerous surrounding units to which water could be delivered (Figure II.3). Steve Bergerman, the area biologist, mapped vegetation and weekly flooding data for each unit. Based upon the dominant vegetation, I classified the Mendota WA units (excluding the center pool) and 3 privately-held inholdings as swamp timothy, watergrass, alkali bulrush (Scirpus paludosus), upland plants and other (primarily Juncus spp., Paspalum distichum, smartweed [Polygonum spp.]). I further classified units (excluding the center pool) 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".

Tulare Basin

I classified flooded habitats in the Tulare Basin (Figure II.4) into 6 general types; 1) managed wetlands (mostly seasonal but also some temporary and semi-permanent) on duck hunting clubs and Kern-Pixley NWRs that were flooded by delivered water; 2) floodwater retention basins and other areas inundated by natural floodwaters; 3) preirrigated fallow fields and harvested-then-disced barley-wheat, safflower, cotton, and alfalfa fields that were flooded for ≥ one week during September through March; 4) agricultural drain-water evaporation ponds; 5) sewage treatment ponds and; 6) deepwater reservoirs. I further classified managed wetlands with <25% (most with <5%) of surface area with emergent vegetation and preirrigated fields, evaporation ponds, sewer ponds and reservoirs (all with <1% emergent vegetation) as "open" habitats and managed wetlands with ≥ 25% (most 25-75%) of surface area with emergent vegetation as "hemi-closed" habitats. I was not able to survey floodwater areas for vegetation cover so I excluded them from the "open vs hemi-closed" analysis.

To classify preirrigated fields in 1991, I mapped the crop types of all fields in mid-August before harvest and flood-up. I compared this information with crop type information that I obtained from the NRCS. Proving to be accurate, I relied solely on NRCS information to identify crop types of flooded preirrigated fields in later years. I mapped other habitats from the air and tracked flooding each week during September - March by driving to or flying over flooded areas and visually estimating the percent of each area inundated by water.

Measuring habitat use

Pintail capture and marking

I captured and radio-tagged female pintails 29 August - 6 October 1991, 31 August - 5 October 1992 and 28 August - 25 September 1993 in the Grassland EA, Mendota WA and Tulare Basin (Table II.1) roughly in proportion to pintail abundance in the SJV as determined by September aerial surveys (G. Gerstenberg, CDFG, Los Banos, unpubl. data). I captured 4 - 275 ($\bar{x}$ = 76) northern pintails with each of 11 - 14 rocket-net (Schemnitz 1994) shots each year at rice-baited and unbaited wetland sites on Volta,

Table II.1. Number of After-Hatch-Year (AHY) and Hatch-Year (HY) female northern pintails radio-tagged in the Grassland Ecological Area, Mendota Wildlife Area (WA) and Tulare Basin of the San Joaquin Valley, California, 1991-93.

	Year and Age Class											
	1991			1992			1993			All Years		
Area	AHY	HY	Both	AHY	HY	Both	AHY	HY	Both	AHY	HY	Both
Grassland EA	41	37	78	30	48	78	44(20)[a]	39(18)	83	115	124	239
Mendota WA	21	4	25	17	4	21	33(14)	39(19)	72	71	47	118
Tulare Basin	10	2	12	18	6	24	14(6)	12(5)	26	42	20	62
Total	72	43	115	65	58	123	91(40)	90(42)	181	228	191	419

[a]Number of spear-suture type radio-tags (in parenthesis), included in cell totals. All other radio-tags were harness backpack type.

Mendota and Los Banos WAs; Merced, San Luis, and Kesterson NWRs; Clear Lake and Stillbow duck clubs in the south grasslands; and flooded agricultural lands in the Tulare Basin. Age ratios were skewed heavily toward after-hatch years (AHY) in the captures, especially before late September. Thus, in order to radio-tag pintails of both age classes during a similar period, I radio-tagged all hatch-year (HY) females that I captured until the annual goal was reached but released randomly selected AHY females without radios. Even so, mean radio-tagging dates in 1991 and 1992 were about 2 weeks earlier for AHY (42 days before hunting season opened) than HY (27-28 days before hunting season opened) females because few or no HY pintails were captured until late September in those years due to poor or late production (USFWS and CWS 1991, 1992). In 1993, pintail production improved (USFWS 1993), HY pintails were more common in early captures and mean radio-tagging dates were similar for AHY (35 days before hunting season opened) and HY (32 days before hunting season opened) females. I weighed ($\pm$ 5 g), measured (flat wing, culmen 1, total tarsus [Dzubin and Cooch 1992] $\pm$ 0.01 mm), aged (HY or AHY, Larson and Taber 1980, Duncun 1985, Carney 1992) and legbanded some male and all female pintails. Pintails were released at the capture location from <1 to 19 ($\bar{x}$ = 7.7) hours after capture. During the first two years I exclusively attached 20-21-g (2.0-3.2% of body mass) radio transmitters with back-mounted harnesses (Dwyer 1972). In 1993, I radio-tagged pintails with either harness (n = 98) or spear-suture transmitters (n = 83). The spear-suture transmitters were similar in design to that described by Pietz et al. (1995), except for a circular (20 mm diameter x 12 mm high) rather then rectangular body and weighing 8-9 g rather than 4 g. All transmitters had a unique signal, a mortality sensor, life expectancy ≥ 210 days and an initial minimum range of 3.2 km ground-to-ground using 150-db receivers and dual 4-element Yagi antennas mounted on the roof of pick-up trucks. All transmitters were imprinted with a contact address, phone number and identification number. Project descriptions, that requested hunters to report radio-tagged ducks they shot or found and informed them that they were welcome to keep the radio-tags and would receive information about the bird, were posted at public hunting check stations and published in state-wide media.

I censored (i.e., excluded data thereafter) pintails equipped with failing radios as evidenced by an intermittent, weakening or increasingly fast or slow signal at the time abnormal signals prevented daily tracking. Pintails that shed their radios were censored on the date their radios were shed. I excluded 14 of the 433 pintails that I radio-tagged from analyses because they failed to adjust to their radios, as evidenced by their failure to make normal feeding flights, and were killed by predators 1 - 6 days after marking.

Radio telemetry

Trackers scanned the entire study area and determined the location of each pintail during at least 2 shoot days and nights (Sundays, Wednesdays, Saturdays) and 2 nonshoot days and nights (Mondays, Tuesdays, Thursdays and Fridays) each week during HUNT and at least 2 days and nights each week during PREHUNT and POSTHUNT. Two bearings using a vehicle-mounted dual-Yagi null-peak telemetry system (Cochran and Lord 1963) were taken from known locations. Two, rather than ≥ 3, bearings were taken to minimize time between locations and because preliminary testing showed that more bearings did not increase location accuracy in the flat, open terrain that composed nearly all of the study area. The network of roads in the study area allowed good access and >89% of all locations were taken < 1.6 km from the bird with angles between bearings of 50-130 degrees. Most locations farther than 1.6 km were in the Tulare Basin, where the size of habitat polygons was larger (average polygon size = 34.6 ha) than in Mendota WA (average polygon size = 17.2 ha) and Grassland EA (average polygon size = 20.3 ha). Warnock (1994) 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 a system identical to the one used during this study.

Truck location and azimuth, bird ID and azimuth, time, date, observer and truck ID were entered into a computer. Bird locations were calculated using a modified version of XYLOG and UTMTEL (Dodge et al. 1986, Dodge and Steiner 1986). I intersected these locations in the GIS with digitized habitat maps and identified the polygon ID with associated habitat attributes for each location. Locations falling on islands, levees and shorelines of units were classified as being in those units.

Habitat selection analysis

I used compositional analysis (Aitchison 1986, Aebischer et al. 1993) to examine day and night habitat selection by female northern pintails during PREHUNT, HUNT (includes HUNT1, SPLIT and HUNT2) and POSTHUNT intervals in the Grassland EA vicinity, Mendota WA and Tulare Basin. I used compositional analysis because, unlike other methods (Neu et al. 1974), it treats each bird rather than each location as the sample unit, it accounts for nonindependence of habitat proportions (i.e. proportions sum to 1), and it allows comparsion of selection among groups (Johnson 1980). I used multivariate analysis of variance (Johnson and Wichern 1988, 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). I compared habitat selection among study years (1991-92, 1992-93, 1993-94), bird age classes (HY, AHY), bird body weight at capture (above or below age-class mean) and on shoot and nonshoot days during HUNT.

Waterfowl habitat in the SJV occurred in 3 easily definable, widely separated areas (Figure II.I). I included only flooded areas as habitat because I observed no pintails using dry lands (except levees, shorelines and islands) in the SJV during this study. I counted all flooded habitats in each of the 3 habitat areas (i.e. Grassland EA vicinity, Mendota WA, Tulare Basin) that was within the maximum daily flight range (43 km) from major roost sites as available to each pintail in that particular area (Figures II.2-4). Thus, I included all flooded habitat in each area as available except for the few flooded areas south and west of Bakersfield that were beyond the daily flight range (and were never used by my radio-tagged pintails). I used maximum daily flight distance, rather than restricting availability estimates for each pintail to include only habitats within a home range as measured by ground locations, because while following individual pintails, I frequently observed them flying throughout an individual area (i.e., Grassland EA vicinty) before selecting a wetland or field to land in (where it could be located). Thus, rather than using a standard home range estimate based on ground observations that would underestimate the true availability of habitats to pintails, I followed Morton et al. (1989) who suggested that "distance moved between foraging and roosting sites is a more biologically valid datum than traditional measurements of home range". The range of day-to-night flight distances that I measured showed pintails could select any of the flooded habitats within each habitat area but habitats in the next nearest area were outside even the maximum daily flight distance. Further, home range estimates can vary greatly depending upon the method used (Lawson and Rodgers 1997) and can provide inaccurate results (White and Garrott 1990:201), especially if sample sizes are not large. I did not attempt to meet minimum sample sizes for home range calculations by pooling locations across PREHUNT, HUNT and POSTHUNT because sample sizes, daily pintail movement patterns, habitat availability, food habits (Beam and Gruenhagen 1980, Connelly and Chesemore 1980, Miller 1987) and weather varied greatly among intervals.

RESULTS

Habitat availability and composition

Habitat availability (Tables II.2 - 4) and composition (Tables II.5 - 7) varied greatly among areas, intervals and years. Total area of flooded habitat in the Grassland EA vicinity was approximately 5-7 times greater than in Mendota WA and Tulare Basin. The amount of flooded nonpermanent wetland habitat (i.e., Grassland EA marsh, Mendota WA shallow marsh and Tulare Basin managed wetlands) varied among years

Table II.2. Mean weekly flooded hectares of evaporation ponds (EvapP), sewer ponds (SewerP), reservoirs (Reserv.), idle and grazed uplands (Upland), rice fields (Rice), other agricultural fields (OthAg), permanent-semipermanent marsh (PMarsh) and seasonal marsh (SMarsh) in the vicinity of the Grassland Ecological Area, California during PREHUNT, HUNT and POSTHUNT, 1991-94. Availability of swamp timothy (T), watergrass (W) and other (O) marshes and open and hemi-closed (HemiCl) habitats are also presented[1].

	PREHUNT			HUNT			POSTHUNT		
Habitat	1991-92	1992-93	1993-94	1991-92	1992-93	1993-94	1991-92	1992-93	1993-94
EvapP	39	39	21	39	31	15	39	1	6
SewerP	200	194	219	208	221	236	208	245	245
Reserv.	6,359	6,355	6,352	6,359	6,349	6,353	6,372	6,348	6,353
Upland	41	96	75	146	190	187	220	1,024	1,258
Rice	0	0	0	34	15	26	56	10	25
OthAg	5	9	132	16	26	40	18	144	189
Pmarsh	703	733	772	748	900	1,010	852	1,112	1,160
Smarsh	5,385	6,698	9,630	19,358	19,915	22,713	20,011	21,206	23,313
T	2,478	2,979	4,561	9,773	10,020	10,338	9,940	10,104	10,358
W	871	866	986	1,591	1,556	2,441	1,644	1,614	2,494
O	1,680	2,118	3,007	5,991	6,285	7,150	6,125	6,454	7,224
Open	3,494	4,346	6,630	14,119	14,454	15,753	6,125	15,290	16,196
HemiCl	2,286	2,785	3,441	5,693	5,967	7,503	6,125	6,459	7,700

[1]Area of swamp timothy (T), watergrass (W) and other (O) does not sum to total marsh area because vegetation of some marshes was not known. Likewise, area of open and hemi-closed will not sum to total of all habitats because reservoirs were excluded and some habitats were not classified.

Table II.3. Mean weekly flooded hectares of deep pool (Deep) and shallow marshes (Shallow) at Mendota WA during PREHUNT, HUNT and POSTHUNT, 1991-94. Flooded hectares of shallow marshes where swamp timothy (T), watergrass (W), alkali bulrush (A), other wetland (O) or upland plants (U) were the dominant plants and open, hemi and closed shallow habitats (not including deep pool) 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
Deep	364	364	364	364	364	337	364	364	269
Shallow	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**

Table II.4. Mean weekly flooded hectares of managed wetlands (MWet), floodwater areas (FldW), evaporation ponds (EvapP), sewer ponds (SewerP), reservoirs (Reserv.) and preirrigated (Preirrig.) fallow (PI-FF), safflower (PI-SA), barley-wheat (PI-BW), alfalfa (PI-AL) and cotton (PI-CT) fields in the Tulare Basin, California during PREHUNT, HUNT and POSTHUNT, 1991-94. Flooded hectares of open and hemi-closed (HemiCl) habitats are also presented[1].

	PREHUNT			HUNT			POSTHUNT		
Habitat	1991-92	1992-93	1993-94	1991-92	1992-93	1993-94	1991-92	1992-93	1993-94
MWet	491	490	1,005	1,625	1,675	2,394	2,168	2,579	2,946
FldW	36	0	69	42	20	266	387	955	1,374
EvapP	1,246	1,545	1,458	1,441	1,593	1,428	1,817	1,951	1,468
SewerP	82	82	114	82	82	82	82	82	82
Reserv.	404	448	730	390	470	738	415	552	742
Preirrig.	2,399	1,802	1,595	567	288	30	427	61	0
PI-FF	*0*	*0*	*135*	*0*	*0*	*0*	*0*	*0*	*0*
PI-SA	*1,008*	*1,510*	*1,102*	*54*	*3*	*0*	*5*	*0*	*0*
PI-BW	*540*	*91*	*222*	*21*	*0*	*0*	*10*	*0*	*0*
PI-AL	*761*	*201*	*91*	*371*	*27*	*0*	*21*	*0*	*0*
PI-CT	*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**
HemiCl	**128**	**103**	**395**	**546**	**541**	**946**	**660**	**656**	**946**

[1]Area of open and hemi-closed will not sum to total of all habitats because floodwater habitats were not classified.

Table II.5. Mean 1991-94 proportions during PREHUNT, HUNT and POSTHUNT of evaporation ponds (EvapP), sewer ponds (SewerP), reservoirs (Reserv.), idle and grazed uplands (Upland), rice fields (Rice), other agricultural fields (OthAg), permanent-semipermanent marsh (PMarsh) and seasonal marsh (Smarsh) that were available (avail.) and used by radio-tagged female northern pintails during the day and night in the vicinity of the Grassland Ecological Area, California[1]. Proportions for swamp timothy (T), watergrass (W) and other (O) marshes and for open and hemi-closed (HemiCl) habitats are also presented.

Habitat	PREHUNT			HUNT			POSTHUNT		
Type	Avail.	DayUse	NightUse	Avail.	DayUse	NightUse	Avail.	DayUse	NightUse
EvapP	0.002	<0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001
SewerP	0.011	<0.001	<0.001	0.008	0.005	<0.001	0.008	<0.001	<0.001
Reserv.	0.346	<0.001	<0.001	0.226	0.004	0.001	0.210	0.044	0.048
Upland	0.005	0.013	0.006	0.005	0.006	0.014	0.032	0.069	0.089
Rice	0	-	-	0.001	<0.001	0.001	0.001	0.004	0.002
OthAg	0.002	0.002	0.004	0.001	0.005	0.002	0.004	0.034	0.044
PMarsh	0.042	0.020	0.015	0.032	0.078	0.007	0.034	0.013	0.030
SMarsh	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**
HemiCl	**0.33**	**0.29**	**0.19**	**0.30**	**0.37**	**0.14**	**0.30**	**0.22**	**0.24**

[1]Availability for each interval calculated from weekly proportions that were weighted by the number of use locations.

Table II.6. Mean 1991-94 proportions during PREHUNT, HUNT and POSTHUNT of available (avail.) and day and night use by radio-tagged female northern pintails of deep pool (Deep) and shallow marshes (Shallow) where swamp timothy (T), watergrass (W), alkali bulrush (A), other wetland (O) or upland plants (U) were the prominant seed plants in Mendota WA[1]. Proportions for open, hemi, and closed habitats are also presented.

Habitat	PREHUNT			HUNT			POSTHUNT		
Type	Avail.	DayUse	NightUse	Avail.	DayUse	NightUse	Avail.	DayUse	NightUse
Deep	0.20	<0.01	<0.01	0.12	<0.01	0.01	0.11	<0.01	0.08
Shallow	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**

[1]Availability for each interval calculated from weekly proportions that were weighted by the number of use locations.

Table II.7. Mean 1991-94 proportions during PREHUNT, HUNT and POSTHUNT of available (avail.) and day and night use by radio-tagged female northern pintails of managed wetlands (MWet), floodwater areas (FldW), evaporation ponds (EvapP), sewer ponds (SewerP), reservoirs (Reserv.) and preirrigated (Preirrig.) fallow (PI-FF), safflower (PI-SA), barley-wheat (PI-BW), alfalfa (PI-AL) and cotton (PI-CT) fields in the Tulare Basin, California[1]. Proportions for open and hemi-closed (HemiCl) habitats are also presented.

Habitat	PREHUNT			HUNT			POSTHUNT		
Type	Avail.	DayUse	NightUse	Avail.	DayUse	NightUse	Avail.	DayUse	NightUse
MWet	0.11	0.11	0.09	0.44	0.66	0.57	0.42	0.49	0.33
FldW	0.01	<0.01	0.06	0.02	0.17	0.26	0.11	0.13	0.50
EvapP	0.31	0.02	0.04	0.34	<0.01	<0.01	0.31	0.20	<0.01
SewerP	0.02	<0.01	<0.01	0.02	0.03	<0.01	0.02	<0.01	<0.01
Reserv.	0.11	0.03	0.04	0.12	<0.01	<0.01	0.09	0.07	<0.01
Preirrig.	0.44	0.84	0.77	0.06	0.13	0.17	0.05	0.11	0.17
PI-FF	*0.01*	*0.17*	*0.07*	*0*	-	-	*0*	-	-
PI-SA	*0.63*	*0.56*	*0.68*	*0.02*	*0.03*	*0.37*	*0.01*	*<0.01*	*<0.01*
PI-BW	*0.18*	*0.19*	*0.22*	*0.01*	*<0.01*	*<0.01*	*0.01*	*0.50*	*0.50*
PI-AL	*0.16*	*0.08*	*0.03*	*0.31*	*<0.01*	*0.50*	*0.01*	*0.50*	*0.50*
PI-CT	*0.02*	*<0.01*	*<0.01*	*0.66*	*0.97*	*0.13*	*0.97*	*<0.01*	*<0.01*
Open	**0.97**	**0.89**	**0.93**	**0.84**	**0.65**	**0.69**	**0.97**	**0.98**	**0.99**
HemiCl	**0.03**	**0.11**	**0.07**	**0.16**	**0.35**	**0.31**	**0.03**	**0.02**	**0.01**

[1]Availability for each interval calculated from weekly proportions that were weighted by the number of use locations.

and was 2-4 times greater during HUNT and POSTHUNT than during PREHUNT in each area. For example, mean weekly availability of seasonal marsh in the Grassland EA vicinity, ranged from 5,385 ha - 9,630 ha during PREHUNT and 19,358 ha - 22,713 ha during HUNT, 1991-94 (Table II.2). The availability of evaporation ponds, sewer ponds, and reservoirs was similar among years and among intervals in each area. Flooded agricultural lands were important only in the Tulare Basin whereas wetland habitats dominated availability in Mendota WA and the Grassland EA vicinity.

Grassland EA vicinity

Seasonal wetlands composed 59-73% of the available habitat in the Grassland EA vicinity (Table II.5). PREHUNT mean weekly availability of seasonal wetlands during the drought year of 1991-92 was about 56% (5,385 ha vs 9,630 ha) of availability during 1993-94 (Table II.2). Low availability of wetlands in PREHUNT 1991 was mainly because delivery of water to wetlands was delayed until late in PREHUNT and the amount of water delivered was reduced. Seasonal wetland availability increased slightly from HUNT to POSTHUNT each year because few managers followed the past practice of draining wetlands immediately after HUNT and late winter rains flooded emphemoral wetlands in the East Grasslands.

Deepwater reservoirs, mainly San Luis Reservoir (and associated O'Neill Forebay) composed 21-35% of the available habitat. The decline in the proportion of reservoir habitat was due to flood-up of seasonal marsh as winter progressed; reservoir area (approx. 6,350 ha) remained constant among intervals and years.

The composition of marsh habitat (i.e., swamp timothy, watergrass, other) was similar throughout the winter. Swamp timothy was the dominant vegetation in 54-55% of the wetlands; watergrass was dominant in 10-12% and other plants in 34-35%. As in other SJV areas, most flooded habitats in the Grassland EA vicinity were covered by <25% emergent vegetation.

Mendota WA

Swamp timothy marsh was the primary habitat type available in Mendota WA (Table II.6). Composition of flooded habitats in Mendota WA was similar among intervals while in Tulare Basin and Grassland EA vicinity composition varied greatly among the 3 intervals. Mean weekly availability of shallow marsh in Mendota WA ranged from 949 ha - 1, 256 ha during PREHUNT and 2,568 ha - 2,762 ha during HUNT and POSTHUNT, 1991-94 (Table II.3). Mean availability of shallow marsh during PREHUNT was slightly greater in 1991-92 than in later years; availability during HUNT and POSTHUNT was similar among years. The size of the deepwater pool was constant (364 ha) except in 1993-94 when it was drawn down during late winter to allow maintenance of water control and delivery structures. Most Mendota WA wetlands were open or hemi marshes.

Tulare Basin

In the Tulare Basin, preirrigated fields were the most abundant habitat during PREHUNT but managed wetlands were most abundant thereafter (Table II.7).

Evaporation ponds (1,246 ha - 1,951 ha) composed 31-34% of the available habitat in the Tulare Basin throughout the study.

Availability of preirrigated fields declined during the study (e.g., during PREHUNT, 2,399 ha in 1991 to 1,595 ha in 1993 (Table II.4). Safflower was the most abundant type (63%) of preirrigated field during PREHUNT but cotton composed 66-97% thereafter. Preirrigated fallow fields were available only during PREHUNT in 1993-94. Nearly all Tulare Basin habitats had <25% of their area covered by emergent vegetation.

Habitat Selection

Habitat selection by HY and AHY female pintails was generally similar but rankings differed significantly less often for HY females. Habitat selection did not differ among female pintails that were lighter or heavier than average at capture.

Grassland EA vicinity-general habitat selection

During all intervals, female pintails in the vicinity of the Grassland EA selected temporary-seasonal wetlands and avoided deepwater reservoirs (i.e. San Luis Reservoir) and sewer ponds-evaporation ponds (Table II.8). Semi-permanent/permanent lakes and sloughs ranked higher during the day (especially shoot-days) than at night. Flooded rice fields and other agricultural fields (primarily irrigated pasture during PREHUNT) were selected above all habitats except temporary-seasonal wetlands; flooded uplands were selected during POSTHUNT in 1991.

Table II.8. Day and night selection of flooded seasonal marsh (M), semipermanent-permanent marsh (P), idle or grazed uplands (U), rice fields (I), other agriculture fields (F), sewer-evaporation ponds (S), and deepwater reservoirs (R) by female radio-tagged northern pintails in the vicinity of the Grassland Ecological Area, California, during PREHUNT, HUNT and POSTHUNT, 1991-94.

Interval	N	Study Year	Pintail Age	Shoot Status	Habitat Ranking[1]
Prehunt Day	275	Pooled. p< 0.001[2]	Pooled. p=0.034	Nonshoot	M>>F>>U>>P>S>R
	85	1991-92	Pooled	Nonshoot	M>>F>>U>>P>S>R
	89	1992-93	Pooled	Nonshoot	M>>F>>U>P>S>>R
	101	1993-94	Pooled	Nonshoot	M>>F>U>P>S>R
	137	Pooled	HY	Nonshoot	M>>F>>U>>S>P>>R
	138	Pooled	AHY	Nonshoot	M>>F>>U>>P>S>>R
Prehunt Night	274	Pooled. p<0.001	Pooled, p<0.001	Nonshoot	M>>F>>U>>S>P>>R
	85	1991-92	Pooled	Nonshoot	M>>F>>U>>S>P>>R
	89	1992-93	Pooled	Nonshoot	M>>F>>U>>P>S>R
	101	1993-94	Pooled	Nonshoot	M>>F>U>P>S>>R
	136	Pooled	HY	Nonshoot	M>>F>>U>>S>P>>R
	138	Pooled	AHY	Nonshoot	M>>F>>U>>S>P>>R
Hunt Day	365	Pooled, p<0.001	Pooled, p=0.193	Pooled,p<0.001	M>>I>>F>>U>>P>>S>>R
	172	1991-92	Pooled	Pooled	M>>I>F>P >>U>>S>>R
	240	1992-93	Pooled	Pooled	M>>I>P>F>>U>>S>>R
	272	1993-94	Pooled	Pooled	M>>F>I>>P>U>>S>>R
	347	Pooled	Pooled	Shoot	M>>I>P>F>>G>>S>>R
	337	Pooled	Pooled	Nonshoot	M>>I>F>>P>U>>S>>R
Hunt Night	557	Pooled, p<0.001	Pooled, p=0.091	Pooled,p=0.415	M>>I>>F>>U>>S>>P>>R
	168	1991-92	Pooled	Pooled	M>>I>F>>U>>S>P>>R
	230	1992-93	Pooled	Pooled	M>>I>>F>>U>>S>>P>>R
	159	1993-94	Pooled	Pooled	M>>F>I>>U>>S>>P>>R

Table II.8 (Continued)

Interval	N	Study Year	Pintail Age	Shoot Status	Habitat Ranking[1]
Posthunt Day	75	Pooled, p<0.001	Pooled, p=0.291	Nonshoot	M>>I>F>U>>S>P>>R
	16	1991-92	Pooled	Nonshoot	M>F>U>I>P>S>R
	36	1992-93	Pooled	Nonshoot	M>>I>U>F>>S>P>>R
	23	1993-94	Pooled	Nonshoot	M>>F>I>>U>P>>S>R
Posthunt Night	71	Pooled, p<0.001	Pooled, p=0.306	Nonshoot	M>>I>F>U>>S>P>>R
	15	1991-92	Pooled	Nonshoot	U>F>M>I>P>S>R
	32	1992-93	Pooled	Nonshoot	M>>I>U>F>S>P>>R
	24	1993-94	Pooled	Nonshoot	M>>F>I>>U>S>P>R

[1]Habitat rankings seperated by >> differ significantly (t-test, p < 0.05). Habitats seperated by > or underlined by a contiguous line are not significantly different.

[2]Probability of greater F-value, Wilks' Lambda test for effect of study year, pintail age or shoot status.

Habitat selection did never differ significantly by pintail condition and is not presented.

Grassland EA vicinity-wetland vegetation selection

The type of wetland selected by female pintails varied among intervals and during day and night (Table II.9). At night, pintails selected wetlands where swamp timothy was the dominant or major understory plant during all intervals; watergrass wetlands ranked lowest and wetlands without significant amounts of timothy or watergrass (i.e., other) were ranked in the middle. Each evening during HUNT, most radio-tagged pintails in the Grassland EA vicinity left San Luis NWR and all its watergrass fields, flew directly over watergrass fields on Salt Slough WA, and went to swamp timothy wetlands on private duck clubs. Selection during the day varied among intervals. Pintails selected swamp timothy wetlands during PREHUNT and POSTHUNT days; ranking of watergrass and other varied among years. Selection during HUNT days varied. On shoot days, watergrass wetlands were selected whereas swamp timothy wetlands were selected on nonshoot days. The high ranking of watergrass wetlands on shoot days was probably coincidental because, with the exception of Salt Slough WA, most watergrass wetlands in the Grassland EA were in the sanctuaries of San Luis NWR and Merced NWR.

Grassland EA vicinity-open vs hemi-closed wetland selection

Female pintails in the Grassland EA selected open wetlands over hemi-closed wetlands at night during all intervals ($t \geq 4.74$, $P < 0.001$) and during PREHUNT and POSTHUNT days ($t \geq 5.34$, $P < 0.001$). During HUNT, pintails selected open wetlands on nonshoot days ($t = 7.07$, $P < 0.001$) but hemi-closed wetlands on shoot days ($t = 7.13$, $P < 0.001$).

Table II.9. Day and night selection of swamp timothy (T), watergrass (W), and other (O) marshes by female radio-tagged northern pintails in the vicinity of the Grassland Ecological Area, California, during PREHUNT, HUNT and POSTHUNT, 1991-94.

Interval	N	Study Year	Pintail Age	Shoot Status	Habitat Ranking[1]
Prehunt Day	275	Pooled, p< 0.002[2]	Pooled, p=0.155	Nonshoot	T>>O>W
	85	1991-92	Pooled	Nonshoot	T>>W>O
	89	1992-93	Pooled	Nonshoot	T>>O>>W
	101	1993-94	Pooled	Nonshoot	T>>W>O
Prehunt Night	273	Pooled, p<0.001	Pooled, p=0.003	Nonshoot	T>>O>>W
	84	1991-92	Pooled	Nonshoot	T>O>>W
	88	1992-93	Pooled	Nonshoot	T>>O>>W
	101	1993-94	Pooled	Nonshoot	T>>O>>W
	136	Pooled	HY	Nonshoot	T>>O>>W
	137	Pooled	AHY	Nonshoot	T>>O>>W
Hunt Day	666	Pooled, p<0.001	Pooled, p=0.464	Pooled,p<0.001	W>>T>>O
	167	1991-92	Pooled	Pooled	W>>T>>O
	236	1992-93	Pooled	Pooled	W>>T>>O
	263	1993-94	Pooled	Pooled	W>>T>>O
	331	Pooled	Pooled	Shoot	W>>T>>O
	335	Pooled	Pooled	Nonshoot	W>>T>>O
Hunt Night	548	Pooled, p=0.029	Pooled, p=0.187	Pooled,p=0.137	T>>O>>W
	167	1991-92	Pooled	Pooled	T>>O>>W
	226	1992-93	Pooled	Pooled	T>>O>>W
	155	1993-94	Pooled	Pooled	T>>O>>W
Posthunt Day	68	Pooled, p=0.705	Pooled, p=0.265	Nonshoot	T>>O>>W
Posthunt Night	61	Pooled, p<0.001	Pooled, p=0.033	Nonshoot	T>>O>>W
	31	Pooled	HY	Nonshoot	T>O>W
	30	Pooled	AHY	Nonshoot	T>>O>>W

[1]Habitats seperated by >> differ significantly (t-test, p < 0.05); habitats underlined by a contiguous line do not.
[2]Probability of greater F-value, Wilks' Lambda test for effect of study year, pintail age or shoot status.
Habitat selection never differed significantly by pintail body condition and is not presented.

Mendota WA -deep pool vs shallow wetland selection

Female pintails avoided the deep large pool in the middle of the Mendota WA in favor of the shallow wetlands throughout the rest of the area ($t \geq 21.70$, $P < 0.001$). Except for POSTHUNT nights, $\leq 1\%$ of the locations were in the pool (Table II.6).

Mendota WA - wetland vegetation selection

Composed of numerous wetlands with known vegetation composition and flooding regime and surrounded by dry agricultural lands, Mendota WA provided an excellent setting to test wetland selection by female pintails, at least during PREHUNT before most emigrated to the Grassland EA. During all intervals at Mendota WA, female pintails selected timothy wetlands (Table II.10). Watergrass wetlands were avoided during the day but along with timothy wetlands were selected at night during most years. Flooded uplands and wetlands where alkali bulrush or other "non-timothy or watergrass" plants were primary understory plants ranked in the middle during the day but were avoided at night during most intervals and years. Selection strength differed among years and between shoot and nonshoot dates but rankings were similar.

Mendota WA - open vs hemi vs closed wetland selection

Pintails selected open and avoided closed wetlands at night; selection during the day varied among intervals and years (Table II.11). During PREHUNT, open wetlands were selected in 1991 and 1992 but closed wetlands were selected in 1993. During HUNT, closed or hemi marshes were selected. During POSTHUNT, open wetlands were selected.

Table II.10. Day and night selection of swamp timothy (T), watergrass (W), alkali bulrush (A), other wetland (O) or upland plant (U) units by female radio-tagged northern pintails in Mendota Wildlife Area, California, during PREHUNT, HUNT and POSTHUNT, 1991-94.

Interval	N	Study Year	Pintail Age	Shoot Status	Habitat Ranking[1]
Prehunt Day	131	Pooled, p< 0.001[2]	Pooled, p=0.334	Nonshoot	T>>A>O>U>>W
	28	1991-92	Pooled	Nonshoot	T>>O>>U>>A>W
	27	1992-93	Pooled	Nonshoot	T>>O>>A>U>W
	76	1993-94	Pooled	Nonshoot	T>>A>U>>O>W
Prehunt Night	131	Pooled, p=0.708	Pooled, p=0.737	Nonshoot	T>>W>O>A>U
Hunt Day	70	Pooled, p<0.001	Pooled, p=0.570	Pooled,p=0.046	T>>A>>U>O>>W
	17	1991-92	Pooled	Pooled	T>>U>O>A>W
	13	1992-93	Pooled	Pooled	T>>A>U>O>W
	40	1993-94	Pooled	Pooled	T>>A>>U>O>W
	59	Pooled	Pooled	Shoot	T>>A>>U>O>W
	53	Pooled	Pooled	Nonshoot	T>>A>>U>O>W
Hunt Night	57	Pooled, p<0.001	Pooled, p=0.807	Pooled,p=0.003	T>>W>O>A>U
	13	1991-92	Pooled	Pooled	T>W>U>A>O
	11	1992-93	Pooled	Pooled	T>>A>O>W>U
	33	1993-94	Pooled	Pooled	T>W>>A>>O>U
	26	Pooled	Pooled	Shoot	T>>A>W>U>>O
	51	Pooled	Pooled	Nonshoot	T>W>>A>>O>U
Posthunt Day	12	Pooled, p=0.543	Pooled, p=0.664	Nonshoot	T>>A>W>U>O
Posthunt Night	8	Pooled, p=0.009	Pooled, p=0.019	Nonshoot	W>T>>A>O>U

[1] Habitat rankings seperated by >> differ significantly (t-test, p < 0.05). Habitats seperated by > or underlined by a contiguous line are not significantly different.

[2] Probability of greater F-value, Wilks' Lambda test for effect of study year, pintail age or shoot status. Habitat selection did never differ significantly by pintail condition and is not presented.

Table II.11. Day and night selection of open (O), hemi (H) and closed (C) units by female radio-tagged northern pintails at Mendota Wildlife Area, California, during PREHUNT, HUNT and POSTHUNT, 1991-94.

Interval	N	Study Year	Pintail Age	Habitat Ranking[1]
Prehunt Day	131	Pooled, p< 0.001[2]	Pooled, p=0.032	C>>H>O
	28	1991-92	Pooled	O>H>C
	27	1992-93	Pooled	O>>H>C
	76	1993-94	Pooled	C>>H>>O
	80	Pooled	HY	C>>H>O
	51	Pooled	AHY	C>O>H
Prehunt Night	131	Pooled, p<0.001	Pooled, p=0.166	O>>H>>C
	27	1991-92	Pooled	O>H >C
	25	1992-93	Pooled	O>>H >C
	79	1993-94	Pooled	O>>H>>C
Hunt Day	70	Pooled,p=0.048	Pooled, p=0.533	C>H>>O
	17	1991-92	Pooled	C>O>H
	13	1992-93	Pooled	C>H>O
	40	1993-94	Pooled	H>C>O
Hunt Night	57	Pooled,p=0.017	Pooled, p=0.268	O>>H>C
	13	1991-92	Pooled	O>H>C
	11	1992-93	Pooled	O>H>>C
	33	1993-94	Pooled	O>>C>>H
Posthunt Day	12	Pooled,p=0.722	Pooled,p=0.224	O>>H>C
Posthunt Night	8	Pooled,p=0.426	Pooled,p=0.465	O>H>C

[1]Habitat rankings seperated by >> differ significantly (t-test, p < 0.05). Habitats underlined by a contiguous line are not significantly different.
[2]Probability of greater F-value, Wilks' Lambda test for effect of study year or pintail age. Habitat selection never differed significantly by shoot status or pintail condition and are not presented.

Tulare Basin-general habitat selection

During PREHUNT, female pintails selected preirrigated agricultural fields during both day and night (Table II.12). Managed wetlands and floodwater areas ranked lower but above evaporation ponds-sewer ponds and reservoirs. Habitat selection varied among years and between HY and AHY females. However, annual differences were mainly due to absense of floodwater areas in 1992 (Table II.4). Also, although habitat selection strength differed, rankings of habitats were similar among years and age classes.

During HUNT, pintail selection of preirrigated fields declined and selection of managed wetlands and floodwater areas increased (Table II.12). Habitat composition was different than during PREHUNT (Table II.7) as most preirrigated fields were drained and managed wetlands on private duck clubs and Kern NWR were flooded during late PREHUNT and early HUNT. Rankings indicated managed wetlands were most highly selected during the day while floodwater areas were selected at night but differences were not always significant. Like during PREHUNT, annual differences were largely due to changing availability of habitats and ranking of habitats was similar. Selection of habitats by HY was not as strong as by AHY female pintails.

Habitat selection during POSTHUNT was like that during HUNT.

Tulare Basin-types of preirrigated fields selected

Pintail selection of preirrigated fields during PREHUNT varied greatly among years. In 1993, when all five PI types were available, flooded fallow and safflower fields ranked highest during both day and night (Table II.13). Rankings of other types of

Table II.12. Day and night selection of Preirrigated fields (PI), Floodwater areas (FW), Managed Wetlands (MW), Reservoirs (RS) and Evaporation Ponds-Sewer Ponds (EPSP) by female radio-tagged northern pintails in the Tulare Basin, California, during PREHUNT, HUNT and POSTHUNT, 1991-94.

Interval	N	Study Year	Pintail Age	Habitat Ranking[1]
Prehunt Day	70	Pooled, p< 0.001[2]	Pooled, p=0.011	PI>>FW>>MW>>RS>EPSP
	13	1991-92	Pooled	PI>>FW>>MW>EPSP>RS
	26	1992-93	Pooled	PI>>MW>RS>EPSP
	31	1993-94	Pooled	PI>>MW>FW>>RS>EPSP
	22	Pooled	HY	PI>>FW>>MW>RS>EPSP
	48	Pooled	AHY	PI>>FW>>MW>>RS>EPSP
Prehunt Night	59	Pooled, p=0.129	Pooled, p=0.025	PI>>FW>>MW>>RS>EPSP
	17	Pooled	HY	PI>FW>>RS>MW>EPSP
	42	Pooled	AHY	PI>>FW>>MW>>EPSP>RS
Hunt Day	41	Pooled, p=0.001	Pooled, p=0.018	MW>FW>PI>>RS>EPSP
	3	1991-92	Pooled	-
	34	1992-93	Pooled	MW>PI>>RS>EPSP
	22	1993-94	Pooled	MW>FW>PI>RS>EPSP
	23	Pooled	HY	FW>PI>MW>>RS>EPSP
	39	Pooled	AHY	MW>>FW>>PI>>RS>EPSP
Hunt Night	37	Pooled, p=0.087	Pooled, p=0.278	FW>MW>PI>>RS>EPSP
Posthunt Day	9	Pooled, p=0.878	Pooled, p=0.464	MW>PI>FW>RS>EPSP
Posthunt Night	6	Pooled, p=0.560	Pooled, p=0.429	FW>PI>MW>RS>>EPSP

[1]Habitat rankings seperated by >> differ significantly (t-test, p < 0.05). Habitats seperated by > or underlined by a contiguous line are not significantly different.

[2]Probability of greater F-value, Wilks' Lambda test for effect of study year or pintail age. Habitat selection never differed significantly by shoot status or pintail condition and are not presented.

Table II.13. Day and night selection of preirrigated fallow (FF), safflower (SA), barley-wheat (BW), alfalfa (AL) and cotton (CT) fields by female radio-tagged northern pintails in the Tulare Basin, California, during PREHUNT, HUNT and POSTHUNT, 1991-94.

Interval	N	Study Year	Pintail Age	Habitat Ranking[2]
Prehunt Day	65	Pooled, p< 0.001[1]	Pooled, p=0.399	FF>>SA>>BW>CT>AL
	13	1991-92	Pooled	SA>AL>BW>>CT
	25	1992-93	Pooled	BW>>SA>>AL
	27	1993-94	Pooled	FF>>SA>>AL>CT>>BW
Prehunt Night	54	Pooled, p<0.001	Pooled, p=0.225	SA>FF>>CT>BW>>AL
	11	1991-92	Pooled	BW>SA>>CT>AL
	23	1992-93	Pooled	SA>>BW>>AL
	20	1993-94	Pooled	SA>FF>>BW>CT>AL
Hunt Day	10	1992-93	Pooled, p=0.208	FF>BW>CT>>SA>AL
Hunt Night	5	1991-92,1992-93	Pooled, p=0.500	FF>SA>BW>AL>CT
Posthunt Day	1	1991	-	-
Posthunt Night	1	1991	-	-

[1]Habitat rankings seperated by >> differ significantly (t-test, p < 0.05). Habitats underlined by a contiguous line are not significantly different.
[2]Probability of greater F-value, Wilks' Lambda test for effect of study year or pintail age. Habitat selection never differed significantly by shoot status or pintail condition and are not presented.

preirrigated fields, especially barley-wheat, varied greatly among years. Alfalfa and cotton were consistently avoided, especially at night. Interpretation of habitat use during HUNT is complicated by small sample sizes and lack of barley-wheat, alfalfa and safflower in some years, but overall, rankings were similar to PREHUNT. Availability and use of preirrigation habitats during POSTHUNT was too low to test selection. Nearly all (>94%) of the preirrigated acreage available during POSTHUNT was cotton and few pintails remained in the Tulare Basin.

Tulare Basin-open vs. hemi-closed wetland selection

During PREHUNT, pintails selected open wetlands (0-24% [most <10%] of basin with emergent vegetation) over vegetated wetlands (>24% [most 25-50%] of basin with emergents) during day ($t = 5.11$, $p < 0.0001$) and night ($t = 5.43$, $p < 0.0001$). Selection during HUNT varied among years (Table II.14). In 1991 ($t = 1.74$, $P = 0.18$) and 1993 ($t = 2.51$, $P = 0.02$) pintails selected vegetated wetlands during the day; in 1992 they selected open wetlands ($t = 2.28$, $P = 0.03$). Open wetlands ranked higher during HUNT nights but selection was not significant ($t = 0.74$, $p = 0.46$). During POSTHUNT days and nights, pintails selected open wetlands over vegetated wetlands ($t \geq 5.66$, $P \leq 0.001$).

DISCUSSION

Habitat functions

Pintails select habitats on wintering areas for two major functions, resting and feeding. During PREHUNT, pintails feed extensively during both day and night on seeds

Table II.14. Day and night selection of open (O) and hemi-closed (HC) habitats by female radio-tagged northern pintails in the Tulare Basin, California, during PREHUNT, HUNT and POSTHUNT, 1991-94.

Interval	N	Study Year	Pintail Age	Shoot Status	Habitat Ranking[2]
Prehunt Day	70	Pooled, p= 0.211[1]	Pooled, p=0.280	Nonshoot	O>>HC
Prehunt Night	57	Pooled, p=0.066	Pooled, p=0.664	Nonshoot	O>>HC
Hunt Day	56	Pooled, p=0.002	Pooled, p=0.069	Pooled, p=0.038	HC>O
	4	1991-92	Pooled	Pooled	HC>O
	34	1992-93	Pooled	Pooled	O>>HC
	18	1993-94	Pooled	Pooled	HC>>O
	24	Pooled	Pooled	Shoot	HC>O
	32	Pooled	Pooled	Nonshoot	O>HC
Hunt Night	27	Pooled, p=0.463	Pooled, p=0.106	Pooled,p=0.237	O>HC
Posthunt Day	7	Pooled, p=0.342	Pooled, p=0.182	Nonshoot	O>>HC
Posthunt Night	3	Pooled, p=0.477	Pooled, p=0.655	Nonshoot	O>>HC

[1]Habitat rankings seperated by >> differ significantly (t-test, $p < 0.05$). Habitats underlined by a contiguous line do not differ significantly.
[2]Probability of greater F-value, Wilks' Lambda test for effect of study year, pintail age or shoot status. Habitat selection did never differ significantly by pintail condition and is not presented.

(Beam and Gruenhagen 1980, Connelly and Cheesemore 1980, Euliss 1984) to replenish fat reserves depleted by breeding and fall migration (Miller 1985, 1986). Loafing is an important daytime activity throughout all intervals but it is the primary day activity during HUNT when most feeding is done at night (Miller 1985). Daytime feeding rates increase again during POSTHUNT as pintails prepare for spring migration and nesting. Thus, habitat selection during the day reflects availability of suitable loafing sites in addition to availability of pintail foods whereas selection of night habitats is primarily indictative of suitable feeding sites.

Habitat selection by HY and AHY female pintails was generally similar, although ranking differences for HY were more often not significant. Immature birds have been reported to be less selective in the habitats they use (Draulans and Vessen 1985, Warnock and Takekawa 1995), but the less significant rankings that I observed in some instances (i.e. Tulare Basin) could also be due to my smaller sample sizes for HY.

Feeding habitats

Pintails in the SJV feed primarily on seeds during PREHUNT but invertebrates make up a major portion of the diet as early as November (Beam and Gruenhagen 1980, Connelly and Cheesemore 1980, Euliss 1984). Thus, availability of preferred seeds is likely a key factor when pintails select feeding habitats during PREHUNT but availability of preferred invertebrates becomes more important as winter progresses.

The switch to invertebrates is thought to occur to provide protein necessary for rapid growth of reproductive organs (Miller 1987). However, the reliance on invertebrates by SJV pintails during early winter may be related to low availability of seeds or high availability of invertebrates. Pintails began to fly to the only two rice fields in the Grassland EA vicinity as soon as they were flooded. Selection for rice seeds is apparently strong, considering that these rice fields were situated southeast of the south grasslands and were among the most distant habitats from sanctuary in the Grassland EA vicinity. Pintails in the Grassland EA vicinity made an even longer flight to feed in rice fields when they emigrated to the Sacramento Valley during December (see Chapter I).

Pintail morphology affects selection of feeding habitats. Although pintails will dive for food (Miller 1983), they normally use their long neck while dabbling or tipping. This is one reason they prefer shallow (i.e., seasonal wetlands, preirrigated fields) rather than deep habitats (i.e., evaporation ponds, sewer ponds, deep Mendota pool, reservoirs) for feeding. Deep, more permanent habitats usually also produce few seeds.

A bill structure which allows pintails to efficiently collect small seeds (Krapu 1974) may give them an advantage over larger-billed species, such as mallards, in collecting swamp timothy seeds. Swamp timothy produces a tiny seed that often windrows along wetland edges. Pintails I studied selected swamp timothy wetlands over all other types; watergrass wetlands ranked second at night in Mendota but were largely avoided in the Grassland EA. Euliss and Harris (1987) reported high pintail night use of watergrass fields at Kern NWR in the Tulare Basin. The reason(s) for differing ranking of watergrass among areas is unclear. Just as pintails may have an advantage gathering the small swamp timothy seeds, mallards are probably as good or better at gathering the larger watergrass seeds. Mallards are more abundant in the Grassland EA than in the

Tulare Basin and Mendota WA (CDFG unpubl. data) and pintails in the Grassland EA may be avoiding competition with mallards by selecting swamp timothy wetlands over watergrass wetlands. An additional or alternative explanation is that watergrass fields at Kern NWR and Mendota WA may differ in some way that make them more attractive to pintails than most watergrass fields in the Grassland EA. For instance, Mendota WA watergrass fields are usually drained earlier than those at Salt Slough WA (in the Grassland EA) and allowed to dry before reflooding. (Gerstenberg, pers. comm.). This produces a shorter, less dense stand and allows seeds to ripen and disperse when reflooded. Factors affecting waterfowl use of watergrass fields need additional study.

My finding of pintail selection of swamp timothy and watergrass wetlands is consistent with food habit studies at Los Banos WA (Beam and Gruenhagen 1980, Connelly and Chesemore 1980) and Kern NWR (Euliss and Harris 1987) where seeds of these two plants were the most common vegetative food found in collected birds. Beam and Gruenhagen (1980) reported that although swamp timothy decreased in importance during winter as watergrass (and associated sprangletop [Leptochloa spp.]) increased in importance, pintails did not use watergrass in greater proportion than its availability. They concluded that swamp timothy was the most sought after food by pintails. Miller (1983) observed pintails diving for swamp timothy seeds in the Sacramento Valley. Severson (1987) reported that swamp timothy and watergrass fields produced greater total biomass of invertebrates than alkali bulrush and smartweed wetlands.

Selection of feeding habitats is also affected by habitat availability. Habitat availability changed rapidly during PREHUNT as water was delivered to seasonal wetlands. Habitat availability also varied among years. For instance, in the Tulare Basin pintails were only able to select preirrigated fallow areas in 1993 after drought conditions had subsided. Pintails in the Tulare Basin selected preirrigated fallow and safflower fields during PREHUNT and managed wetlands during HUNT. Their selection of preirrigated fallow areas and managed marsh was likely due to high availability of seeds as these areas were flooded. Similar selection of managed marsh and floodwater areas is not surprising during PREHUNT because floodwater areas available during fall had held water from the previous spring runoff and developed vegetation and appearance very similar to some managed marshes.

Why pintails selected preirrigated safflower over barley-wheat fields is unclear. Its possible that the intensive disking that most crop fields undergo before preirrigation integrates a greater percentage of barley-wheat than safflower seeds into the substrate. Safflower seeds are high in oil and these boyount seeds may be readily available on the surface and more easily gathered by pintails. The wide variance in selection of barley-wheat fields may reflect differences in disking intensity that I did not measure. However, pintail food habits in preirrigated fields have not been studied and rankings of preirrigated fields may reflect differences in availability of non-seed foods (i.e. invertebrates) among crop types.

Pintails selected open habitats during the night in all areas. Euliss (1984) also reported that open-water ponds on Kern NWR received the bulk of the daytime use by pintails. However, he reported that densely vegetated units (especially watergrass units) received essentially all the nocturnal use and concluded that pintails avoided open ponds at night. Its unclear why our findings on night use disagree. Perhaps males, which I did not study, avoid open wetlands at night. However, I suggest that the spotlight technique Euliss used to survey night use allowed some pintails to leave open wetlands or move into vegetation before Euliss surveyed them and some pintails that I located in "open" wetlands during my study were in the vegetated sections of those wetlands. Open habitats with no emergent vegetation such as preirrigated crop fields and timothy wetlands were used heavily by female pintails during this study. Thus, I reject Euliss's conclusion that pintails avoid open wetlands at night.

Roosting habitats

Selection of roosting habitats is also influenced by numerous factors. If undisturbed, pintails may choose to roost in preferred feeding ponds (e.g., during PREHUNT, on nonshoot days, druing POSTHUNT). Pintails selected shallow habitats for roosting but they will use deepwater habitats to avoid hunting if shallow sanctuaries are unavailable. For instance, use of lakes increased on shoot days, primarily as a result of pintails roosting on Buttonwillow Lakes on the Los Banos WA sanctuary. Before San Luis NWR and other sanctuaries were established within the Grassland Ecolgical Area most pintails rafted on San Luis Reservoir during the hunting season.

Pintails selected habitats that allowed them to avoid disturbance. Hunting concentrated pintails into sanctuaries on shoot days and habitat choices were restricted to types available in sanctuaries. Like elsewere in the SJV, female pintails at Mendota WA selected open habitats at night. However, during PREHUNT and HUNT at Mendota

WA, wetlands with >75% emergent cover were sometimes selected over more open habitats during the day. Mendota is open for fishing and dove hunting during PREHUNT and waterfowl hunting on shoot days during HUNT. In addition, flooding of units during PREHUNT require daily monitoring by managers. Most units at Mendota WA are ringed by roads. Thus, pintails likely selected vegetated wetlands during PREHUNT and HUNT days that provided visual isolation to avoid disturbance from humans.

CONCLUSIONS

The emigration of most pintails from the SJV during December (see Chapter I) indicates that the current mix of habitats there may not include adequate amounts of habitats preferred by female pintails during late winter. Most wetlands in the SJV are intensively managed to maximize production of seed crops and are flooded fully by early November to allow waterfowl hunting or to provide sanctuary. This system apparently provides good early winter habitat but has only partially mitigated the loss of late winter habitat. Future management efforts should focus on providing preferred habitats during late winter. This could be accomplished by delaying flooding of some existing or new wetlands until December. Also, incentives could be provided to farmers to flood SJV rice fields that are currently disked and left dry during winter.

Female northern pintails in the SJV clearly preferred shallow-water habitats over deep-water habitats during all intervals. Thus, habitat restoration efforts for pintails should emphasize shallow habitats. Also, given adequate high quality shallow-water habitats, the risk to female pintails from contaminants or disease sometimes associated with evaporation ponds and sewer ponds would be low.

The type of shallow-water habitat selected by female pintails was not always consistent among intervals and areas. Thus, its not possible to promote a single habitat type for restoration. Pintails selected preirrigated fallow and safflower fields and swamp timothy marshes whenever available. Thus, additional amounts of these habitats should benefit pintails. Females consistently selected open habitats during both day and night but hemi and closed marshes were sometimes selected, apparently to allow pintails to avoid disturbance. Also, at night in Mendota WA, watergrass units were ranked second only to timothy units. Pintails avoided preirrigated cotton fields and any increase in cotton that replaces preferred habitats will likely reduce pintail use.

Additional research is needed to determine why pintails selected watergrass for night feeding at Kern NWR (Euliss and Harris 1987) and Mendota WA but not in the Grassland EA. Improved water supplies in the SJV has provided managers with the opportunity to provide a more diverse array of habitats. For managers hoping to improve mallard harvest this may lead to conversion of some timothy marshes to watergrass marshes. Managed correctly, watergrass fields have potential to provide late winter seeds that pintails are apparently seeking when they emigrate to Sacramento Valley rice fields. However, in contrast to concern of the past trend towards open marshes (Euliss and Harris 1987), I caution that further study is needed to determine if a shift towards more closed habitats would reduce pintail use in the Grassland EA.

CHAPTER III. SURVIVAL OF FEMALE NORTHERN PINTAILS

INTRODUCTION

Northern pintails (Anas acuta) (hereafter "pintails") have been the most abundant duck in the Pacific Flyway (United States Fish and Wildlife Service [USFWS] 1978) and most important duck to California hunters (Gilmer et al. 1989). Half of the pintails in North America migrate to and winter in the Central Valley of California (Bellrose 1980, USFWS 1978), arriving as early as the first week of August and remaining through March. This 6 - 8 month stay in the Central Valley may have a large impact on the size and productivity of the pintail population. Pintails rely heavily on nutrient reserves during nesting (Krapu 1974b, Esler and Grand 1994), and conditions on the wintering grounds may influence the amount and quality of these reserves and ultimately affect recruitment (Heitmeyer and Fredrickson 1981, Anderson and Batt 1983, Raveling and Heitmeyer 1989, Carlson et al. 1993). Past increases in Pacific Flyway pintail populations were associated with high annual survival rates for females (Hestbeck 1993a) suggesting that female mortality may be a key determinant of population trends. Data on the magnitude, timing, and causes of female pintail mortality during winter are needed to effectively manage the pintail population (USFWS and Canadian Wildlife Service [CWS] 1986, Reynolds et al. 1995).

Pintail breeding populations in North America plunged to all time lows in the early 1990s (USFWS and CWS 1995) and although recent recovery is promising, midwinter pintail populations in California are still only about 25% of those recorded in the 1970s (Pacific Flyway waterfowl reports and USFWS, Portland, OR, unpubl. data). The decline of pintails has been especially prevalent in the San Joaquin Valley (SJV), the southern portion of the Central Valley (Figure III.1). For instance, during surveys of the Central Valley in the 1970s about 50% of pintails counted in mid-September and 24% of the pintails counted in early January occurred in the SJV (Table III.1). However, during the 1980s, only 24% of pintails in mid-September and 8% of pintails in early January occurred in the SJV portion (Calif. Dept. Fish and Game [CDFG], Sacramento, and USFWS, Portland, OR, unpubl. data). Most data indicate that low recruitment because of persistent drought and poor nest success is the main reason for the decline of continental pintail populations (USFWS and CWS 1992). However, because pintails, especially females, exhibit high fidelity to wintering grounds (Rienecker 1987a, Hestbeck 1993b) over-harvesting or high natural mortality during winter may depress long-term viability of local populations (Hestbeck 1993b).

Miller et al., (1995b) used radio-telemetry to study survival of female pintails during winter, 1987-90, in the Sacramento Valley (SACV), the northern part of the Central Valley (Figure III.1). Over-winter survival of after-hatch-year (AHY) females during that study was high (88%) (Miller et al. 1995b). However, hatch-year (HY) females were not studied and little was learned about survival in the SJV because few SACV pintails visited the SJV. Banding data from 1949-63 (Rienecker 1987b) shows annual survival of female pintails banded in the SJV to be lower than female pintails banded in the SACV but these data were collected before population declines and do not identify the timing or causes of mortality.

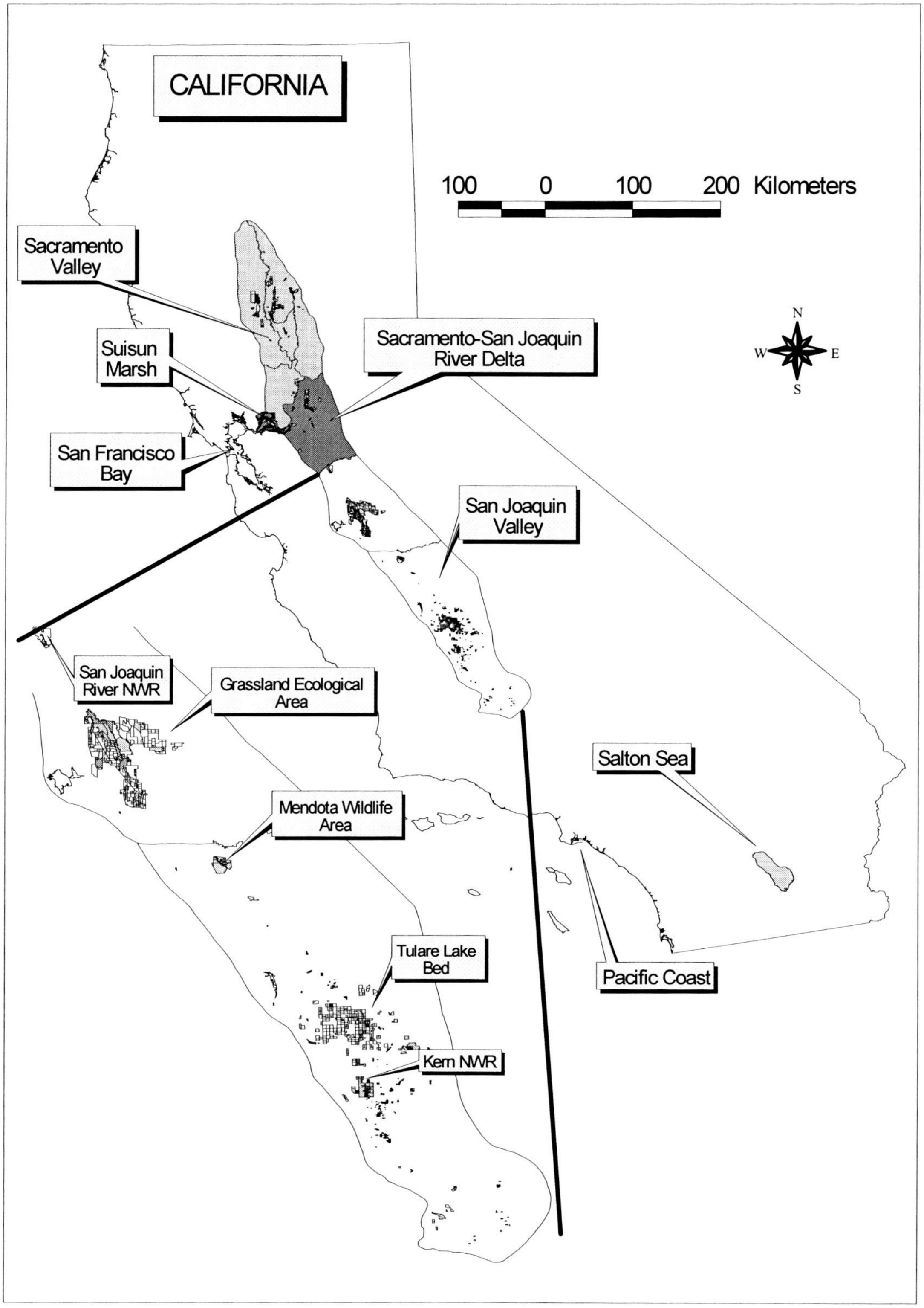


Figure III.1. Regions of California and areas within the San Joaquin Valley used by wintering northern pintails (Anas acuta) during 1991-94.

Table III.1. Percentage of central California northern pintails surveyed and harvested in the San Joaquin Valley (SJV). Central California includes the SJV, Sacramento Valley (SACV), San Joaquin-Sacramento River Delta (Delta), Suisun Marsh and San Francisco Bay (SFB).

	Percent of pintails surveyed in central California that occurred in the San Joaquin Valley[a]			Percent of central CA pintail harvest
Period	Mid-Sept.	Late Oct. - Early Nov.	Late Dec. - Early Jan.	occurring in SJV[b]
1960s	<[c]39	<<[d]20	13	33
1970s	<50	<30	24	32
1980s	<24	<<24	8	40
1991-94	<<31	<<32	8	36

[a]Pacific Flyway waterfowl reports and U. S. Fish and Wildl. Serv., Portland, OR, Unpubl. data.
[b]Carney et al. (1975, 1983) and U. S. Fish and Wildl. Serv., Portland, OR, Unpubl. data..
[c]Mid-September surveys overestimates actual percentage of central California pintails occurring in the SJV at that time because SFB never surveyed, Delta not surveyed 5 years during the 1980s and in 1991, and no private lands in the SACV surveyed in 1993.
[d]Late Oct. - Early Nov. surveys overestimate actual percentage of central California pintails occurring in the SJV at that time because SFB never surveyed, Delta not surveyed during the 1960s, and no or few private lands in the SACV surveyed during the 1980s and 1991-94.

To obtain information important for management of pintails, I radio-tagged HY and AHY female pintails throughout the SJV, after their late summer arrival, and monitored their survival during winter, 1991-94. I identified causes, location and timing of mortalities, measured survival and its relation to several variables, and compared survival in the SJV and other regions.

STUDY AREA

The study area was composed of 3 regions. The monitoring frequency of radio-tagged pintails differed in each region as follows: a) the SJV (Figure III.1), where I captured and radio-tagged pintails and determined their status at least once every 2 days (most daily) after their release, b) other central California regions (Figure III.1), composed of the SACV, the Sacramento-San Joaquin River Delta (Delta), Suisun Marsh and San Francisco Bay (SFB) where I determined the status of birds at least once a week (most every other day), and c) other Pacific Flyway areas (includes other California areas, esp. northeastern, coastal, and Salton Sea [Figure III.1]; Malheur, Wilamette and Klamath basins in Oregon, the Carson sink in Nevada, and the Western Coast of Mexico) where I and cooperators searched 1 to 10 times a winter for pintails missing from central California.

SJV waterfowl habitat consisted primarily of shallow, seasonal wetlands in three distinct blocks (up to 23,313 ha in the Grassland EA, 2762 ha in Mendota WA and 2946 ha in the Tulare Basin) that were separated by agricultural lands (e.g., orchards, cotton fields) that were rarely flooded and were of little value to waterfowl (Fleskes, unpubl.

data). In contrast, the 20,000-27,000 ha of wetlands in the SACV were interspersed among 24,000 - 60,000 ha of rice fields flooded after harvest (Central Valley Habitat Joint Venture Technical Committee 1996) which provided a relatively contiguous block of important waterfowl habitat. In the DELTA, approximately 12,000 ha of grain fields that were flooded after harvest, (Central Valley Habitat Joint Venture Technical Committee 1996) and 7,000 ha of wetlands (Heitmeyer et al.1989) provided waterfowl habitat. SUISUN provided 22,000 ha of brackish wetland habitat (Heitmeyer et al.1989). Salt ponds, tidal and diked marsh and open bay were available in the heavily industrialized and urbanized SFBAY.

Most wetlands in the Central Valley were dry during summer, irrigated periodically during the summer to promote seed production, and flooded during winter. Most initial flooding of wetlands and harvested croplands occurred during mid-August to late-October. Water for irrigation, fall flood-up and water-level maintenance was delivered from reservoirs that stored Sierra snow-melt. Thus, the timing and amount of early-winter habitat varied with the previous winter's snowfall. Late-winter rains flooded additional habitat each year. Study area habitats are described by USFWS (1978, 1979), Heitmeyer et al. (1989), Herbold and Moyle (1989), Kadlec and Smith (1989), Kramer and Migoya (1989), Kempka and Kollasch (1990), Baldassarre and Bolen (1994) and Ducks Unlimited (1994).

Precipitation and the quality and quantity of flooded habitat varied during the study. Reservoir levels were critically low in 1991 due to 4 years of below-normal precipitation; drought conditions in the San Joaquin River drainage were the worst on record (California Department of Water Resources 1991, National Oceanic and Atmospheric Administration, Asheville, NC, unpubl. data). In 1991, no water was delivered to the Grasslands Water District for wetland plant irrigation during May-July, fall flood-up was delayed about 2 weeks, and water deliveries to the Grasslands from August through mid-November and for the entire year were the lowest on record (Grasslands Water District, Los Banos, CA, unpubl. data). Drought conditions prevailed through January 1992 but habitat conditions improved during 1992-93 because of near-normal precipitation and higher water level in reservoirs. Conditions during 1993-94 were good because above-average precipitation and enactment of the Central Valley Project Improvement Act (Davis 1992) nearly doubled the amount of water that was delivered to the Grasslands (Grasslands Water District, Los Banos, CA, unpubl. data).

Duck hunting daily bag limits (4 ducks with 1 either-sex pintail) and season lengths (59 days) were identical throughout California during all years of the study (CDFG, Sacramento, unpubl. data). However, the timing of the hunting seasons differed among years and regions. The hunting season was a consecutive 59 days, starting in early-mid November in the southern SJV zone (includes the Tulare Lake Basin but not the Mendota Wildlife Area), and starting the second Saturday in October in the northeastern California zone. Elsewhere the season was split, with most areas (including the "remainder of the state zone", where almost all of my radio-tagged pintails wintered), having a 22-day late-October to mid-November first season and a 37-day second season starting 12 (in 1991), 19 (in 1992) or 27 (in 1993) days after the end of the first season. In addition, WAs, NWRs and most private duck clubs were hunted only on Wednesdays, Saturdays, and Sundays. Kern NWR was hunted only on Wednesdays and Saturdays. Some clubs, especially those that hunted in rice fields in the SACV, also hunted on windy and rainy days or allowed hunting all 59 days of the season.

METHODS

Field procedures

I captured and radio-tagged female pintails 29 August - 6 October 1991, 31 August - 5 October 1992 and 28 August - 25 September 1993 in the Tulare Lake Basin, Mendota WA, and Grasslands Ecological Area (Table III.2) roughly in proportion to pintail abundance in the SJV as determined by September aerial surveys (G. Gerstenberg, CDFG, Los Banos, unpubl. data). I captured 4 - 275 ($\bar{x}$ = 76) northern pintails with each of 11 - 14 rocket-net (Schemnitz 1994) shots each year at rice-baited and unbaited wetland sites on Volta, Mendota and Los Banos WAs; Merced, San Luis, and Kesterson NWRs; Clear Lake and Stillbow duck clubs in the south Grasslands; and flooded agricultural lands in the Tulare Lake Basin. Age ratios were skewed heavily toward adults in the captures, especially before late September. Thus, in order to radio-tag pintails of both age classes during a similar period, I radio-tagged all HY females that I captured until the annual goal was reached but released randomly selected AHY females without radios. Even so, mean radio-tagging dates in 1991 and 1992 were about 2 weeks earlier for AHY (42 days before hunting season opened) than HY (27-28 days before hunting season opened) females because few or no HY pintails were captured until late September in those years due to poor or late production (USFWS and CWS 1991, 1992).

Table III.2. Number of After-Hatch-Year (AHY) and Hatch-Year (HY) female northern pintails radio-tagged in the Grassland Ecological Area (EA), Mendota Wildlife Area (WA) and Tulare Basin of the San Joaquin Valley, California, 1991-93.

	Year and Age Class											
	1991			1992			1993			All Years		
Area	AHY	HY	Both	AHY	HY	Both	AHY	HY	Both	AHY	HY	Both
Grassland EA	41	37	78	30	48	78	44(20)[a]	39(18)	83	115	124	239
Mendota WA	21	4	25	17	4	21	33(14)	39(19)	72	71	47	118
Tulare Basin	10	2	12	18	6	24	14(6)	12(5)	26	42	20	62
Total	72	43	115	65	58	123	91(40)	90(42)	181	228	191	419

[a]Number of spear-suture type radio-tags (in parenthesis), included in cell totals. All other radio-tags were harness backpack type.

In 1993, pintail production improved (USFWS 1993), HY pintails were more common in early captures and mean radio-tagging dates were similar for AHY (35 days before hunting season opened) and HY (32 days before hunting season opened) females. I weighed (± 5 g), measured (flat wing, culmen 1, total tarsus [Dzubin and Cooch 1992] ± 0.01 mm), aged (HY or AHY, Larson and Taber 1980, Duncun 1985, Carney 1992) and legbanded some male and all female pintails. Pintails were released at the capture location from <1 to 19 ($\bar{x} = 7.7$) hours after capture. During the first two years I exclusively attached 20-21-g (2.0-3.2% of body mass) radio transmitters with back-mounted harnesses (Dwyer 1972). In 1993, I radio-tagged pintails with either harness (n = 98) or spear-suture transmitters (n = 83). The spear-suture transmitters were similar in design to that described by Pietz et al. (1995), except for a circular (20 mm diameter x 12 mm high) rather then rectangular body and weighing 8-9 g rather than 4 g. All transmitters had a unique signal, a mortality sensor, life expectancy ≥ 210 days and an initial minimum range of 3.2 km ground-to-ground using 150-db receivers and dual 4-element Yagi antennas mounted on the roof of pick-up trucks. All transmitters were imprinted with a contact address, phone number and identification number. Project descriptions, that requested hunters to report radio-tagged ducks they shot or found and informed them that they were welcome to keep the radio-tags and would receive information about the bird's movements, were posted at public hunting check stations and published in state-wide media.

I recorded status (location, alive or dead) of each pintail 1-2 times a day during the hunting season and at least every other day during the non-hunting intervals in SJV, and at least weekly in other central California areas from the date of the first pintail capture until 20 March each year (202 - 205 days). I conducted aerial searches (Gilmer et al. 1981), including overflights of waterfowl habitat and urban areas, for missing pintails weekly throughout the SJV and other central California regions, and irregularly elsewhere. I censored (i.e., excluded data thereafter) pintails equipped with failing radios as evidenced by an intermittent, weakening or increasingly fast or slow signal at the time abnormal signals prevented daily tracking. Pintails that shed their radios were censored on the date their radios were shed. I excluded 14 of the 433 pintails that I radio-tagged from analyses because they failed to adjust to their radios, as evidenced by their failure to make normal feeding flights, and were killed by predators 1 - 6 days after marking.

I determined the timing and cause of death by site and carcass evidence and a review of the bird's movements. If the radio-tagged bird's carcass contained at least one fresh shot wound I attributed the death to hunting, otherwise I sent the remains of radio-tagged birds, and any other ducks found dead in the same pond at the same time, to the National Wildlife Health Research Center in Madison, Wisconsin for diagnoses of the cause of death. If remains of the radio-tagged bird were inadequate for a definitive diagnosis I classified the cause of death as: a) "cholera", if other carcasses were present in the pond, fields signs were consistent with Pasteurella multocida (Friend 1987) and all (but at least one) definitive necropsies of other carcasses collected at the same time from the pond revealed that they (it) had died of cholera, b) "unspecified disease or poison" if the only carcass found was the radio-tagged bird, the carcass was whole with no wounds, and only emaciation was determined; or if the radio-tagged bird carcass was not whole and remains of other birds were present in the field at the same time but no specific cause of death could be determined, c) "hunter-shot, not retrieved" if the bird died in a pond that was being hunted and had been moving normally just before its death and there was no evidence of a disease outbreak or other mortality cause (i.e. no other carcasses), d) "killed by predator" if the bird was moving normally just before its death and there was no evidence of disease or hunting in the pond at the time of death and the carcass showed non-shot wounds or was partially consumed.

I also recorded deaths reported by hunters and other observers. I weighed shot radio-tagged females whenever possible and interviewed the hunters about the behavior, flock size and body condition of the radio-tagged pintail. Similarly, at public hunting areas in the SJV, I weighed untagged pintails and interviewed hunters about the flock size of the pintail they harvested.

Data analysis

All tests were 2-tailed. I set alpha at 0.05 except I set alpha at 0.10 for survival tests because censoring resulted in small sample sizes for many tests and I wanted to reduce the probability of Type II errors.

I estimated survival with the Kaplan-Meier method to avoid difficulties associated with assumptions of constant survival distributions (Kaplan and Meier 1958, Cox and Oakes 1984:48-50) and because it allows for staggered entry and censoring of subjects (Pollock et al. 1989a). I estimated survival during 8 intervals; prehunting, first hunting season, second hunting season, hunting season (first and second season and the 12-27 day non-hunting split combined), posthunting, before 1 December, after 1 December, and for the entire winter. I estimated survival for pintails in the SJV, elsewhere in central California (i.e. the Delta, SACV, Suisun Marsh and SFB combined), and for the two areas combined (i.e. all of central California). I treated birds as censored when they left a region of interest and as captured when they entered a region of interest. To pool across years I used the date that the first pintail was radio-tagged each year (28-31 August) as day 1 of the 202-205 day winter interval.

I used the program code in White and Garrott (1990:236-239) to estimate Kaplan-Meier survival rates and compute log rank tests. I computed hunting and nonhunting mortality rates by considering natural or hunting mortalities, respectively, as censored observations (Conroy et al. 1989). I used a Z-score test which accounts for nonindependence of mortality rates estimated from the same sample (Scott and Seber 1983) to compare hunting and nonhunting mortality rates. I first computed an overall 3 df Chi-square test by summing each winter's Chi-square value. If the overall test was significant ($P \leq 0.10$) I then examined the 3 within winter 1 df Chi-squares.

I compared survival rates among the 3 winters, and among prehunting, hunting, and posthunting intervals (and interactions) in a 3 X 3 configuration following Sauer and Williams (1989) using PROC IML (SAS Inst. Inc. 1989b). I used a log-rank test (Pollock et al. 1989b) and Z-test to make pair-wise comparisons among the 3 winter survival distributions and rates, respectively. I conducted proportional hazards modeling using PROC PHREG that allows for staggered entry (SAS Inst. Inc. 1994, Allison 1995) to test the relationship between survival and capture date, capture location, body condition at capture and other variables. I modeled several possible measures for body condition and capture date individually (i.e., continuous and indicator variables) and used the covariate representative for each that was most closely related to survival. I followed Dobson (1990:98) and Milliken (1984:990-999) to assess importance of explanatory variables and their interactions on survival. For proportional hazards modeling, I report the probability of a greater 1df Wald's Chi-Square statistic.

I used the program code in White and Garrott (1990:31-35) to approximate the statistical power ($1 - \beta$) of detecting hypothetical 0.05, 0.10, 0.15, and 0.20 decreases in survival and other rates. I subtracted the above hypothetical values from the largest rate in each comparison and used the largest and smallest number of radio-tagged pintails in each group as sample sizes for the power tests. I set alpha at 0.10 for survival tests and 0.05 for all others.

RESULTS

Causes, location and timing of pintail mortalities

Of the 419 pintails that I successfully radio-tagged, 101 died during the winter in which they were radio-marked. However, 7 of those were censored because of failing radios before being reported shot (in the SJV) and 2 were censored when they left central California before being shot near Salton Sea. Thus, I estimated survival from 92 deaths among the 419 radio-tagged pintails.

Hunting was the major cause of death (76/92 = 83%); 7 were killed by avian predators, 1 died with several unmarked pintails from a collision with a power line during a late-December period of dense fog, and 8 died from other non-hunting causes (4 avian cholera, 1 aspergillosis [Aspergillus sp.], 3 undetermined disease or poison). Overall, hunting mortality rates were higher than non-hunting mortality rates for both HY (X^2 = 29.78, 3 df, $p < 0.001$) and AHY (X^2 = 21.16, 3 df, $p < 0.001$) pintails (Tables III.3 and III.4); within year differences were greater for HY ($p \leq 0.003$) than for AHY females ($p \leq 0.017$). Hunters retrieved 80.3% of the pintails they shot; crippling rates did not differ between private (10/58 = 17%) and public (5/18 = 28%) hunting areas (X^2 = 0.967, 1 df, p = 0.326) or between age classes (X^2 = 0.028, 1 df, p = 0.867). Of the 76 pintails shot in central California with functioning transmitters, 61 (80%) were shot in the SJV, 11 in the SACV, 2 in the Delta, and 1 each in the Suisun Marsh and San Francisco Bay. All predator kills occurred in the SJV, with all but 1 being killed during preseason and 4 of 7 on private lands. All disease deaths occurred after late December with 5 of 8 dying In the SACV and all but 1 on private lands.

Factors related to pintail survival in Central California

Winter survival of female pintails in central California differed between age classes (X^2 = 3.19, 1 df, p = 0.07) with no year by age class interaction (X^2 = 1.30, 2 df, p = 0.52). Overall, the pooled winter survival estimate for HY females (0.67, Table III.3) was lower (z = 1.65, p = 0.10) than for AHY females (0.76, Table III.4). However, the timing of HY and AHY mortalities was similar and the shape of survival curves for the two age classes (Figure III.2) did not differ (log rank test, X^2 = 0.049, 1 df, p = 0.82).

Table III.3. Kaplan-Meier survival and mortality estimates for Hatch-Year female northern pintails radio-tagged during August-October, 1991-93 in San Joaquin Valley and wintering in central California.

Wintering period	Intervals[a]	Days[a]	n[b]	Deaths	Survival	SE	Hunting[c] mortality	Nonhunting[c] mortality
1991-92	Preseason	58	43	1	0.975	0.025	0.000	0.025
	Hunting season	72	37	12	0.640	0.085	0.328	0.032
	Postseason	75	15	0	1.000	0.000	0.000	0.000
	Overall	205	43	13	0.624	0.084	0.328	0.048
1992-93	Preseason	54	58	1	0.982	0.017	0.000	0.018
	Hunting season	79	55	14	0.734	0.061	0.266	0.000
	Postseason	69	35	2	0.943	0.039	0.000	0.057
	Overall	202	58	17	0.680	0.065	0.266	0.054
1993-94	Preseason	56	90	0	1.000	0.000	0.000	0.000
	Hunting season	86	83	18	0.734	0.056	0.250	0.016
	Postseason	63	34	2	0.931	0.047	0.000	0.069
	Overall	205	90	20	0.683	0.063	0.250	0.067
Overall	Preseason	54-58	191	2	0.989	0.008	0.000	0.011
	Hunting season	72-86	175	44	0.717	0.037	0.270	0.012
	Postseason	63-75	84	4	0.951	0.024	0.000	0.049
	Overall	202-205	191	50	0.676	0.039	0.269	0.055

[a]Based on "Balance of State" hunting zone regulations where > 95% of the radio-tagged pintails in central California were present during most of the hunting season. Hunting season includes a 22-day first season, a 13-day (1991), 20-day (1992), or 27-day (1993) split with no hunting and a 37-day second season.
[b]Max. no. of pintails monitored during interval.
[c]Obtained by censoring mortalities from other sources.

Table III.4. Kaplan-Meier survival and mortality estimates for After-Hatch-Year female northern pintails radio-tagged during August-October, 1991-93 in San Joaquin Valley and wintering in central California.

Wintering period	Intervals[a]	Days[a]	n[b]	Deaths	Survival	SE	Hunting[c] mortality	Nonhunting[c] mortality
1991-92	Preseason	58	72	2	0.966	0.024	0.000	0.034
	Hunting season	72	57	10	0.820	0.052	0.180	0.000
	Postseason	75	35	0	1.000	0.000	0.000	0.000
	Overall	205	72	12	0.792	0.054	0.180	0.028
1992-93	Preseason	54	65	1	0.973	0.027	0.000	0.027
	Hunting season	79	62	16	0.715	0.061	0.235	0.050
	Postseason	69	36	0	1.000	0.000	0.000	0.000
	Overall	202	65	17	0.696	0.062	0.235	0.069
1993-94	Preseason	56	91	0	1.000	0.000	0.000	0.000
	Hunting season	86	82	11	0.836	0.047	0.164	0.000
	Postseason	63	38	2	0.937	0.044	0.000	0.063
	Overall	205	91	13	0.783	0.057	0.165	0.052
Overall	Preseason	54-58	228	3	0.977	0.015	0.000	0.023
	Hunting season	72-86	201	37	0.793	0.031	0.190	0.011
	Postseason	63-75	109	2	0.981	0.013	0.000	0.019
	Overall	202-205	228	42	0.760	0.033	0.189	0.050

[a]Based on "Balance of State" hunting zone regulations where > 95% of the radio-tagged pintails in central California were present during most of the hunting season. Hunting season includes a 22-day first season, a 13-day (1991), 20-day (1992), or 27-day (1993) split with no hunting and a 37-day second season.
[b]Max. no. of pintails monitored during interval.
[c]Obtained by censoring mortalities from other sources.

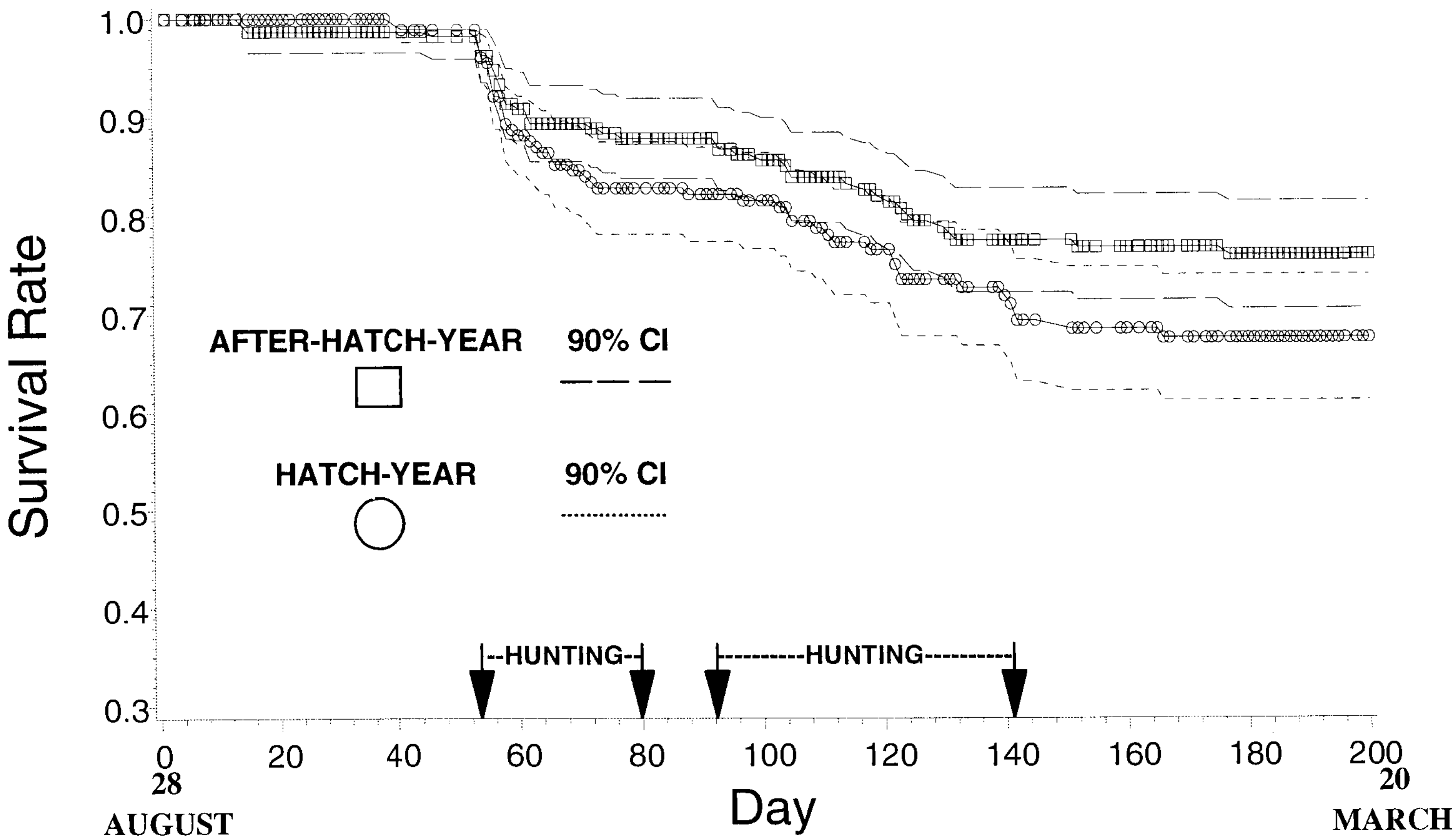


Figure III.2. Kaplan-Meier survival distributions (years pooled) of after-hatch-year and hatch-year female northern pintails radio-tagged during late August - early October in the San Joaquin Valley and monitored in central California, 28 August - 20 March, 1991-94.

Survival rate endpoints did not differ among years for either HY ($X^2 = 0.21$, 2 df, $p = 0.899$) or AHY ($X^2 = 1.38$, 2 df, $p = 0.502$) female pintails (Tables III.3 and III.4); test power was < 0.7 for differences ≤ 0.15 (Table III.5). However, more HY females died earlier and fewer later during the 1991 hunting season compared to other winters (Figure III.3). Thus, the shape of the 1991 HY survival curve differed from other years (1991 vs 1992 log-rank test, $X^2 = 5.23$, $p = 0.02$; 1991 vs. 1993 log-rank test, $X^2 = 16.34$, $p < 0.001$).

Survival during each winter varied by interval (Tables III.3 and III.4) for both age classes ($X^2 \geq 30.69$, 2 df, $p < 0.001$) with survival during the hunting interval being lower than during the preseason and postseason intervals for both age classes ($z \geq 5.30$, $p < 0.001$). There was no interaction between year and interval for either age class ($X^2 \leq 3.83$, 4 df, $p \geq 0.43$); most HY (88%) and AHY (88%) mortalities occurred during the hunting interval. Pre- and post-season survival were similar (Table III.3 and III.4); test power was > 0.7 even for differences as small as 0.05 (Table III.5).

Within the hunting interval, survival during the first and second hunting season (Table III.6) did not vary for AHY females ($X^2 = 0.34$, 1 df, $p = 0.56$) but the year by hunting season interaction was significant for HY pintails ($X^2 = 5.98$, 2 df, $p = 0.05$). HY survival during the first hunting season (0.711) was lower ($z = 2.46$, $p = 0.0138$) than HY survival during the second season (0.944) in 1991 but did not differ during other years ($z \leq 0.66$, $p \geq 0.5092$); test power was > 0.7 for differences as small as 0.05 for HY but only for differences > 0.10 for AHY (Table III.5).

Table III.5. Power (1 -β) analysis for tests not finding significant differences. Alpha = 0.10 for survival tests (i.e., the first 9) and 0.05 for the last 5 tests.

Test for difference(s) in:	Age	Highest value	Power to detect a decrease from the highest value of: 0.05	0.10	0.15	0.20	Sample size (n) range for tests: Largest	Smallest
Survival among years	AHY	1991-92, 0.79	0.19	0.42	0.67	0.86	91	65
	HY	1993-94, 0.68	0.16	0.33	0.55	0.76	90	43
Survival among intervals	AHY	Postseason, 0.98	0.72	0.98	0.99	0.99	228	109
	HY	Preseason, 0.99	0.72	0.97	0.99	0.99	191	84
Survival during first vs. second hunting season	AHY	2nd 1991, 0.94	0.26	0.55	0.79	0.92	82	47
	HY	2nd 1991, 0.94	0.71	0.87	0.95	0.98	83	19
Survival at end of first hunt season by type of radio-tag	AHY	Spear, 0.97	0.29	0.56	0.76	0.89	51	40
	HY	Harness, 0.88	0.18	0.36	0.57	0.75	50	42
Survival at end of second hunt season by type of radio-tag	AHY	Harness, 0.84	0.16	0.32	0.51	0.70	51	40
	HY	Spear, 0.74	0.15	0.28	0.45	0.64	50	42
Survival at end of winter by type of radio-tag	AHY	Harness, 0.81	0.16	0.30	0.49	0.68	51	40
	HY	Harness, 0.69	0.14	0.26	0.44	0.62	50	42
Preseason survival in SJV vs. elsewhere in central California	AHY	Elsewhere, 1.00	0.80	0.97	0.99	0.99	228	12
	HY	Elsewhere, 1.00	0.72	0.94	0.99	0.99	191	4
Postseason survival in SJV vs. elsewhere in central California	AHY	Elsewhere, 0.99	0.49	0.81	0.94	0.99	106	36
	HY	Elsewhere, 0.99	0.28	0.57	0.78	0.91	68	39
Winter survival in SJV vs. elsewhere in central California	AHY	Elsewhere, 0.81	0.32	0.73	0.95	0.99	228	139
	HY	Elsewhere, 0.77	0.25	0.58	0.86	0.97	191	87
AHY vs. HY crippling freq.	------	AHY, 0.21	0.15	0.33	0.62	0.88	42	34
Public vs. private crippling freq.	Both	Public, 0.28	0.14	0.28	0.49	0.74	58	18

Table III.5. (cont.)

Test for difference(s) in:	Age	Highest value	Power to detect a decrease from the highest value of: 0.05	0.10	0.15	0.20	Sample size (n) range for tests: Largest	Smallest
Frequency of being alone when harvested during Oct. - Nov. for radio-tagged vs nonradio-tagged female northern pintails	AHY	Unmarked 0.71	0.11	0.15	0.20	0.28	14	12
	HY	Radioed 0.83	0.15	0.27	0.43	0.60	53	18
	Both	Radioed 0.70	0.08	0.18	0.33	0.52	67	30
Frequency of being alone when harvested during Dec. - Jan. for radio-tagged vs. nonradio-tagged female northern pintails	AHY	Radioed 0.38	0.06	0.07	0.10	0.14	8	8
	HY	Radioed 0.58	0.06	0.09	0.14	0.22	23	12
	Both	Radioed 0.50	0.06	0.11	0.19	0.31	31	20
Frequency of being alone when harvested during Oct. - Jan. for radio-tagged vs. nonradio-tagged female northern pintails	AHY	Unmarked 0.45	0.06	0.10	0.17	0.27	22	20
	HY	Radioed 0.73	0.09	0.20	0.37	0.57	76	30
	Both	Radioed 0.62	0.10	0.23	0.45	0.68	98	50

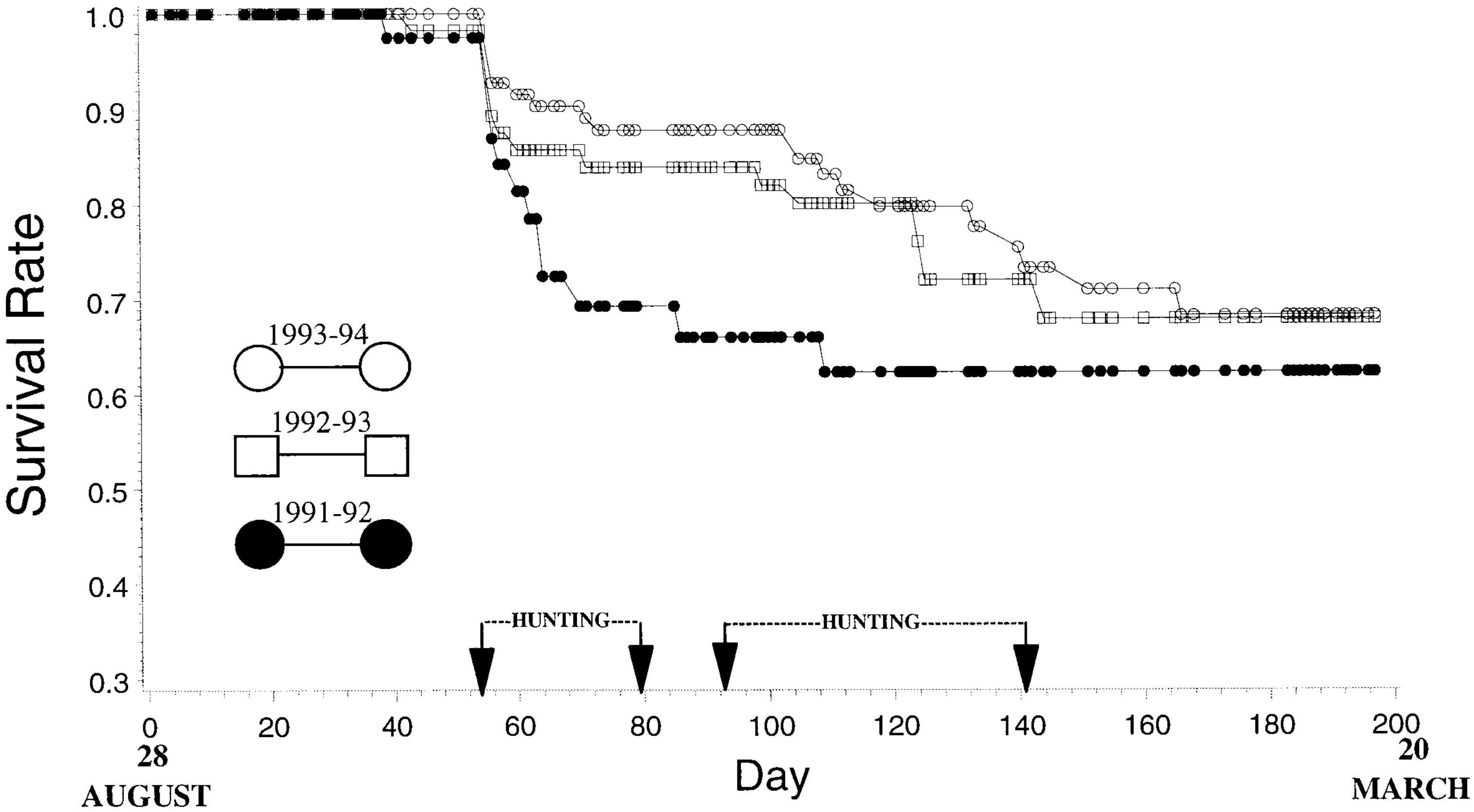


Figure III. 3. Kaplan-Meier survival distributions of hatch-year female northern pintails radio-tagged during late August - early October in the San Joaquin Valley and monitored in central California, 28 August - 20 March, 1991-94.

Table III.6. Kaplan-Meier survival and mortality estimates during the first and second hunting intervals for Hatch-Year (HY) and After-Hatch-Year (AHY) female northern pintails radio-tagged during August-October, 1991-93 in the San Joaquin Valley and wintering in central California.

		Hatch-Year					After-Hatch-Year				
Winter Period	Hunting Season[a]	n[b]	Deaths	Survival	SE	Hunting[c] Mortality	n[b]	Deaths	Survival	SE	Hunting[c] Mortality
1991-92	First	37	11	0.711	0.078	0.289	57	7	0.877	0.044	0.123
	Second	19	1	0.944	0.054	0.056	47	3	0.935	0.036	0.065
1992-93	First	55	8	0.854	0.048	0.146	62	7	0.903	0.037	0.097
	Second	44	6	0.859	0.053	0.141	50	9	0.807	0.058	0.153
1993-94	First	83	10	0.878	0.036	0.122	82	6	0.925	0.029	0.075
	Second	58	8	0.835	0.054	0.146	57	5	0.903	0.041	0.097
Overall	First	175	29	0.837	0.028	0.163	201	20	0.905	0.021	0.095
	Second	121	15	0.862	0.033	0.129	154	17	0.881	0.027	0.105

[a]Based on "Balance of State" hunting zone regulations where > 95% of the radito-tagged pintails in central California were present during the hunting season. The first season opened the fourth Saturday of October and lasted 22 days. The second season opened after 13 (1991), 20 (1992) or 27 (1993) days of no hunting and lasted 37 days.

[b]Max. no. of pintails monitored during interval.

[c]Obtained by censoring nonhunting mortalities. HY nonhunting mortality was 0.019 in the second 1993-94 season, 0.009 overall for the second season and 0.0 otherwise. AHYnonhunting mortality was 0.040 for the second 1992-93 season, 0.014 overall for the second season and 0.0 otherwise.

Radio type was related to the timing but not overall magnitude of mortalities. Compared to birds equipped with spear-suture radios, more pintails of both ages equipped with harness radios died early but fewer died later (only for 1993-94, when both spear suture and harness radios were used). Thus, the shapes of survival curves differed between radio-types for both AHY (log-rank test, $X^2 = 4.74$, $p = 0.03$) and HY (log-rank test, $X^2 = 3.91$, $p = 0.05$) females (Figures. III.4 and III.5) but the estimated survival rate for birds equipped with harness and spear-suture radios did not differ at the end of the first hunting season ($z \leq 1.59$, $p \geq 0.11$), second hunting season ($z \leq 0.44$, $p \geq 0.66$) or winter ($z \leq 0.22$, $p \geq 0.83$). Test power comparing radio-type point estimates was < 0.7 for differences as large as 0.15 for HY and 0.10 for AHY at the end of the first hunting season and for differences as large as 0.20 for AHY and HY late in winter after many females had shed spear-suture radios and sample size was small (Table III.5). However, proportional hazards modeling also indicated no relation between survival and radio type alone ($p = 0.76$) or after accounting for age-class and body condition ($p = 0.80$). Other results of proportional hazards modeling also agreed with the preceding analysis, with age class ($p = 0.058$) but not year ($p \geq 0.43$) being related to survival. Capture location (i.e., Tulare Lake Basin, Mendota Wildlife Area or Grasslands) was not related to survival ($P \geq 0.68$). Body mass (g) at capture was more closely related to survival than other representations of body condition (fat index, protein index [Miller 1989], heavy half vs light half, light 2/3 vs heavy 1/3, light 1/3 vs mid 1/3 vs heavy 1/3) that I tested. Likewise, the number of days that a bird was captured before hunting began was more closely related to survival than other representations of capture date (early vs late half,

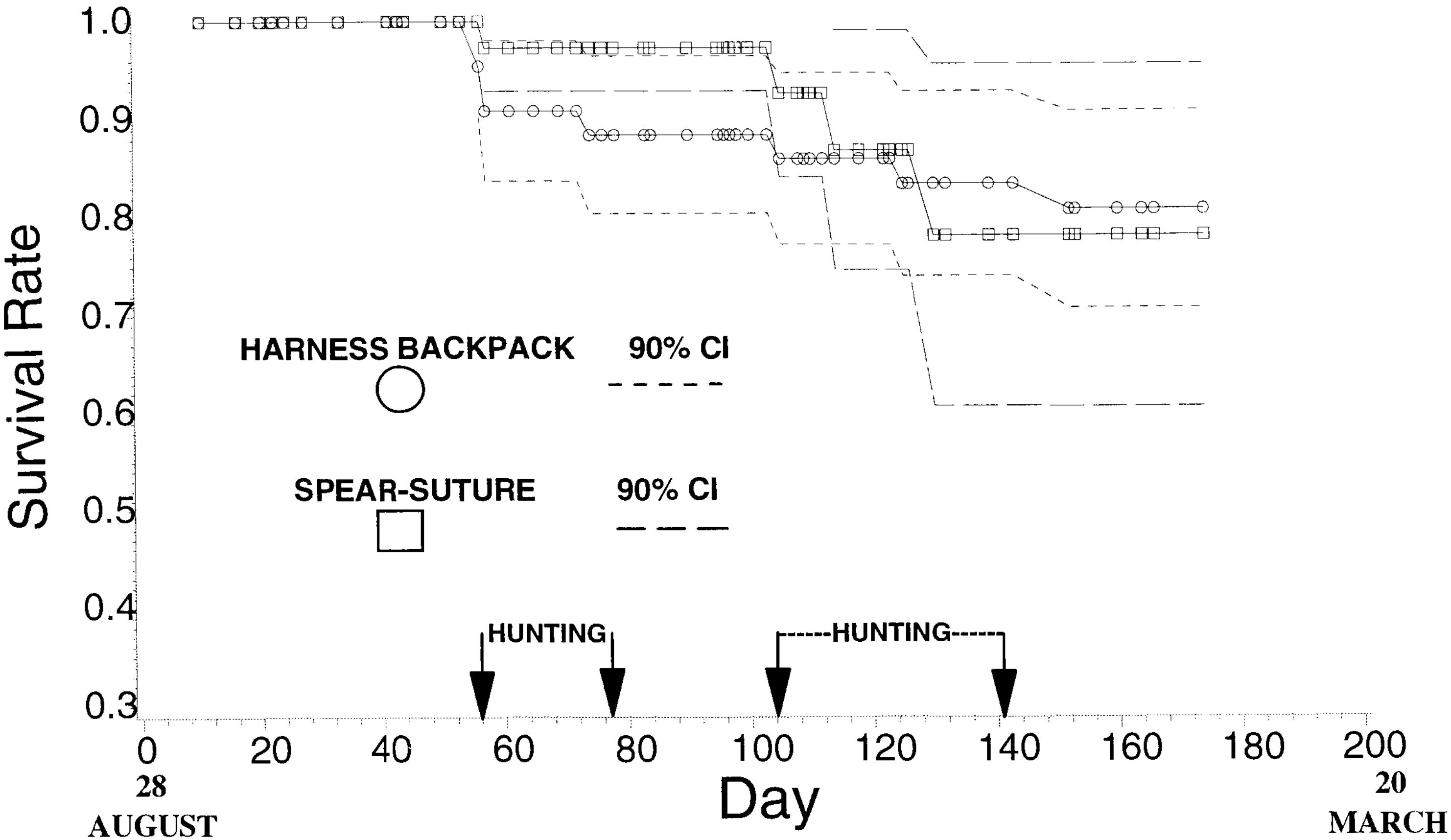


Figure III.4. Kaplan-Meier survival distributions of after-hatch-year female northern pintails by the type of radio-tag that was attached during late August - late September in the San Joaquin Valley and monitored in central California, 28 August - 15 February, 1993-94.

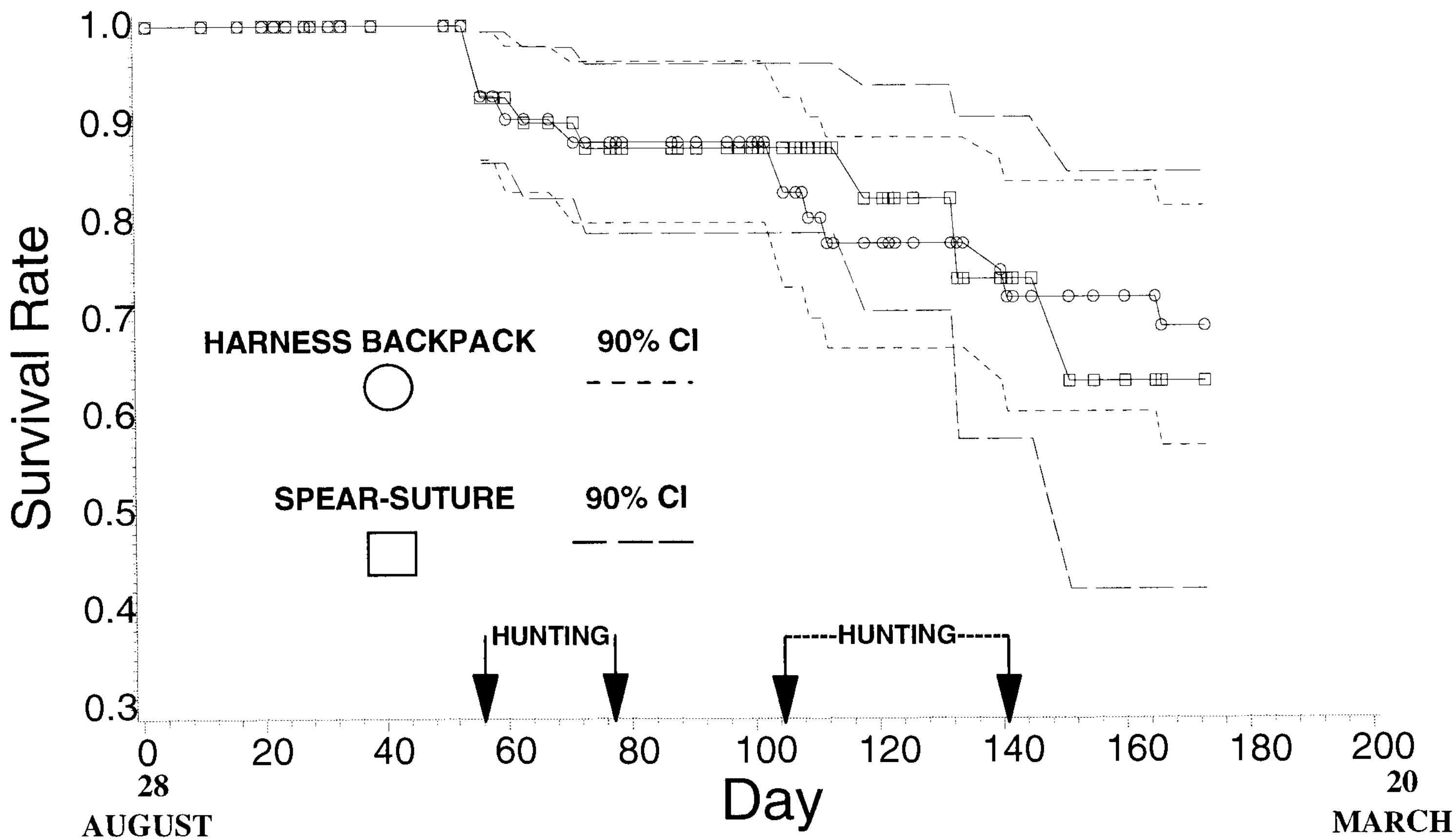


Figure III. 5. Kaplan-Meier survival distributions of hatch-year female northern pintails by the type of radio-tag that was attached during late August-late September in the San Joaquin Valley and monitored in central California, 28 August - 15 February, 1993-94.

early 1/3 vs mid 1/3 vs late 1/3) that I tested. Individually, body mass (g) was related to survival for HY ($p = 0.0487$) but not AHY ($p = 0.1807$) female pintails. Capture location ($p \geq 0.4757$) and capture date ($p \geq 0.5654$) were not related to survival. After accounting for radio-type, capture date, capture location and year, body mass at capture was related to survival for HY female pintails ($p = 0.0548$) but not AHY ($p = 0.1575$) females. For HY female pintails, each 10 g increase in their capture weight reduced the hazard of dying during winter by an estimated 3%.

Survival in the SJV vs elsewhere in central California

Many of the pintails that I radio-tagged in the SJV spent much of the winter, especially December - March, elsewhere in central California (most in SACV and Delta). Survival distributions (Figure III.6) differed greatly for female pintails in the SJV and elsewhere in central California (log rank test, $X^2 \geq 69.5$, $p < 0.001$), mainly because survival during the hunting interval in the SJV for both HY (0.795, S.E. = 0.035) and AHY (0.847, S.E. = 0.029) female pintails was lower (log rank test, $X^2 \geq 7.53$, $p \leq 0.006$, $z \geq 2.48$, $p \leq 0.01$) than elsewhere in central California during the same interval (HY = 0.919, S.E. = 0.028, AHY = 0.935, S.E. = 0.020). During the pre- and posthunting intervals, female pintail survival in the SJV (0.951 - 0.989) and elsewhere in central California (0.965-1.00) was similar (logrank test, $X^2 \leq 1.26$, $p \geq 0.26$, $z \leq 0.62$, $p \geq 0.54$); test power was > 0.7 for differences as small as 0.05 during preseason and 0.10 during postseason (Table III.5). Overall, the pooled winter survival rates of pintails in the SJV (HY = 0.65, AHY = 0.72) did not differ significantly ($z \leq 1.20$, $p \geq 0.23$) from survival

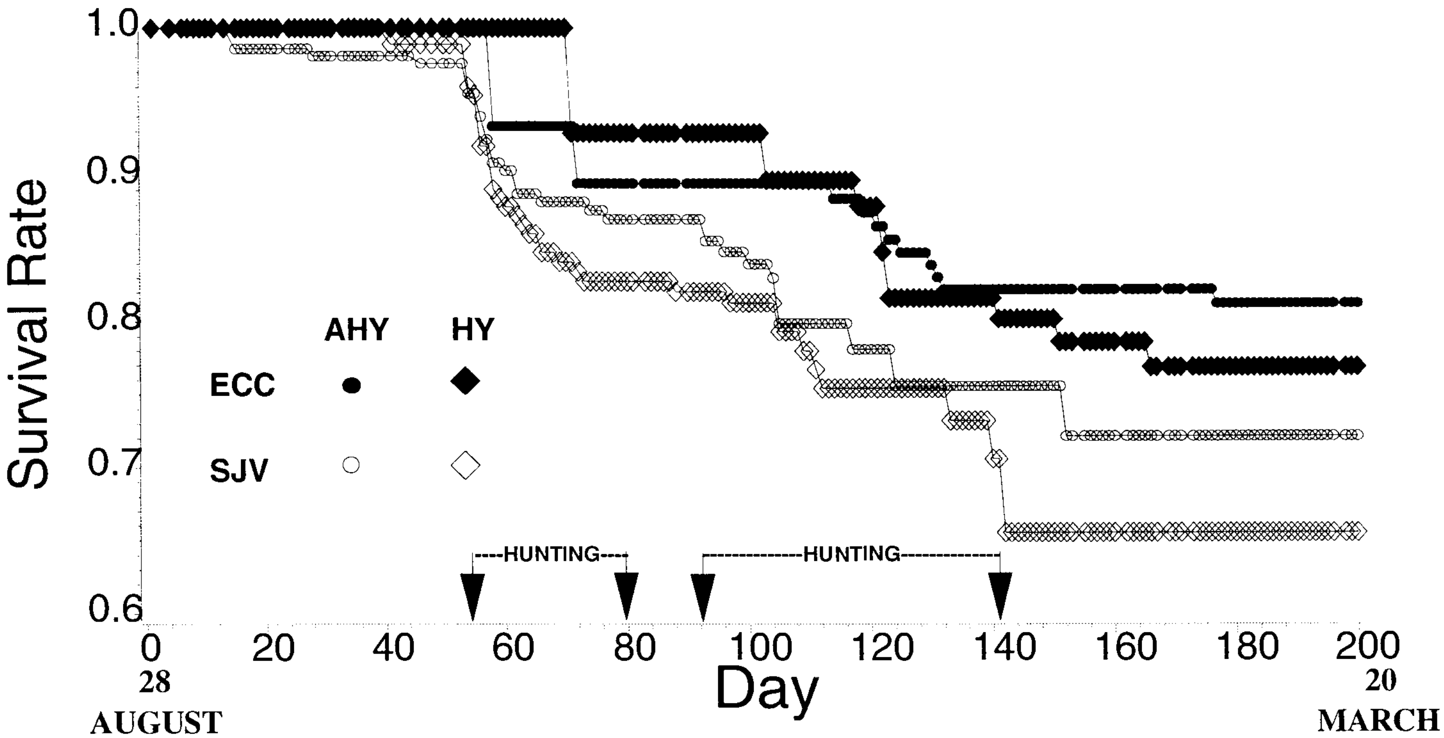


Figure III.6. Kaplan-Meier survival distributions of after-hatch-year (AHY) and hatch-year (HY) female northern pintails wintering in the San Joaquin Valley (SJV) versus elsewhere in central California (ECC), 1991-94. Pintails were radio-tagged in the San Joaquin Valley during late August-early October.

elsewhere in central California (HY = 0.81, AHY = 0.77); test power was < 0.7 for differences smaller than 0.10 for AHY and 0.12 for HY pintails (Table III.5). Survival after December 1, when large numbers of pintails began to leave the SJV for the Delta and SACV, was almost identical in the SJV (HY = 0.87, AHY = 0.90) and elsewhere in central California (HY = 0.89, AHY = 0.93).

Impact of radio-tagging

Radio-tagging affected the mass but not the general behavior of pintails. Most (16/26) radio-tagged pintails were of greater (>30 g) or similar (± 30 g) mass when harvested as when captured but the mean mass of radio-tagged pintails that were harvested was significantly less than other pintails of the same age class that were harvested during the same interval (Table III.7). Change in mass of radio-tagged pintails between when they were captured for radio-tagging and when they were harvested (mean change = -26g, S.E. = 18g, n = 26) was related to mass at time of capture ($F = 31.84$, $p < 0.0001$) but not radio type ($F = 0.87$, $p = 0.36$) or number of days between capture and harvest ($F = 0.07$, $p = 0.79$). There was weak evidence ($F = 3.68$, $p = 0.0687$) that change in mass was related to age class (Least square mean change = -59g for HY and -14g for AHY). Female pintails heavier than 728g at the time they were radio-tagged tended to lose weight whereas lighter birds tended to gain weight between capture and harvest (Change[g] = 647 - 0.89 x capture mass[g], $R^2 = 0.61$).

The likelihood of being alone when harvested was similar for radio-tagged and other pintails (Table III.8) and nearly all (60/63) hunters described the behavior of the

Table III.7. Mass (g) of radio-tagged versus unmarked female northern pintails when shot in California, 1991-94.

	Hatch-Year			After-Hatch-Year		
Harvest interval	Radio-tagged Mean (SE, n)	Two-tailed t-test	Unmarked Mean (SE, n)	Radio-tagged Mean (SE, n)	Two-tailed t-test	Unmarked Mean (SE, n)
Oct. - Nov.	719 (18.9, 8)	$t = 4.14$ $p < 0.001$	847 (9.1, 88)	768 (25.8, 8)	$t=4.41$ $p < 0.001$	905 (15.8, 24)
Dec. - Jan.	725 (23.4, 7)	$t = 2.19$ $p < 0.05$	821 (22.5, 24)	752 (23.5, 3)	$t=1.69$ $p > 0.10$	905 (53.3, 8)
Combined	722 (14.3, 15)	$t = 4.93$ $p < 0.001$	841 (8.6, 112)	763 (19.4,11)	$t=4.47$ $p < 0.001$	905 (17.3, 32)

Table III.8. Frequency of being alone when harvested for radio-tagged vs. unmarked female northern pintails shot by hunters in California, 1991-94[a].

	Hatch-year		After-Hatch-Year		Age Classes Combined	
Period shot	Radio-tagged	Unmarked	Radio-tagged	Unmarked	Radio-tagged	Unmarked
Oct. - Nov.	15/18 = 83%	36/53 = 68%	6/12 = 50%	10/14 = 71%	21/30 = 70%	46/67 = 69%
Dec. - Jan.	7/12 = 58%	13/23 = 57%	3/8 = 38%	0/ 8 = 0%	10/20 = 50%	13/31 = 42%
Combined	22/30 = 73%	49/76 = 64%	9/20 = 45%	10/22 = 45%	31/50 = 62%	59/98 = 60%

[a]Frequency did not differ ($\chi^2 \leq 3.69$, 1 df, $p > 0.05$) between radio-tagged and unmarked northern pintails for any age class during any period.

radio-tagged pintail they harvested as "normal"; two said the radio-tagged pintail was lowest in the flock and one said "it wasn't flying right". Two hunters saw the transmitter before they shot the bird. The power to detect age- (esp. AHY) and interval-specific (esp. Dec. - Jan) differences in the likelihood of being alone when harvested was < 0.7 even for differences greater than 0.2 (Table III.5).

DISCUSSION

Regional differences in hunting mortality

Pintails that I radio-tagged in the SJV survived winter at a rate (HY = 0.68, AHY = 0.76) similar to pintails radio-tagged in Louisiana (HY = 0.63, AHY = 0.80) (R. Cox, pers. comm.) and the Suisun Marsh (HY = 0.62, AHY = 0.76) (M. R. Miller, pers. comm.) but lower than pintails radio-tagged in the SACV (AHY = 0.88) (Miller et al. 1995b) and Sinaloa, Mexico (HY = 0.93, AHY = 0.91) (Migoya and Baldasarre 1995). Survival varied among studies mainly because hunting mortality rates differed; nonhunting mortality rates in all studies were low.

My observation of higher hunting mortality in the SJV than elsewhere in central California is consistent with other available data. Rienecker's (1987b) banding data shows higher ($p \leq 0.007$) direct recovery rates for HY and AHY female pintails banded during 1950-61 in the Grasslands than for those banded during 1949-63 in the SACV. Also, comparisons of regional abundance and harvest of pintails (Table III.1) shows that the portion of the central California pintail harvest occurring in the SJV is greater than the portion of the central California pintail population that occurs there. These differences in relative abundance and harvest, which indicate higher harvest rates in the SJV than elsewhere in central California, were likely even greater than shown in Table III.1 because surveys of central California areas outside the SJV were often incomplete, resulting in an over-estimation of percentage of central California pintails occurring in the SJV. Hestbeck (1993a) found no variation in annual survival rates among more broad geographic regions (e.g. Central California vs. Imperial Valley) for female pintails banded post-season.

I speculate that differences in pintail hunting mortality among studies were due to regional differences in habitat, hunter densities, waterfowl populations and other environmental factors and not simply differences in study methodology. For instance, pintail habitat in the Grasslands during much of the hunting season is almost exclusively provided by private duck clubs or public wildlife areas managed specifically for waterfowl and hunting. In contrast, crop fields that are flooded mainly to promote straw decomposition or weed control are available in the SACV and Delta. Also, about 25% of wetland habitat on WAs and NWRs in the SACV is closed to waterfowl hunting compared to only about 6% of wetland habitat on WAs and NWRs in the northern SJV (CVHJV Technical Committee 1996). The type of habitats available to pintails may also influence their vulnerability to hunting. For instance, pintails may have an easier time fulfilling their energetic requirements and avoiding hunters in regions such as the SACV, where they can feed on flooded agricultural crops such as rice, than in regions such as the northern SJV where only wetlands are available. Invertebrates make up a larger portion of the diet of pintails during winter in the SJV (Beam and Gruenhagen 1980, Connelly and Chesmore 1980, Euliss 1984) than in the SACV (Miller 1987) and although invertebrates have similar metabolizable energy per gram as rice (see Miller 1987), the time and effort required to gather the same amount of energy is probably much greater for invertebrates than rice (Miller 1985, Paulus 1988). Other waterfowl, especially preferred species such as mallards, are less abundant in the SJV than in the SACV (Pacific Flyway Waterfowl Reports and USFWS, Portland, OR, unpubl. data) which may also increase the relative vulnerability of SJV pintails to harvest. Migoya and Baldasarre (1995) theorized that the large habitat area and low numbers of hunters in Sinaloa resulted in light hunter pressure relative to California and Louisiana. My data suggest hunting pressure also varies within California resulting in higher pintail harvest rates in the SJV than elsewhere in central California.

There is little evidence that differences in survival among studies are simply artifacts resulting from different study methodologies. Most methods appear identical among all the pintail survival studies, although slight differences in how radios were fitted or how birds were handled may have impacted survival. Perhaps AHY pintails marked in the SACV (Miller et al. 1995b) survived at a higher rate than AHY pintails I marked because Miller et al. (1995b) captured almost all their pintails > 52 days before hunting whereas I captured pintails up to 20 days before hunting. However, I found that the number of days between capture and start of hunting was not significantly related to survival. Further, when my pintails went to the SACV they survived the hunting season at a rate similar to those marked by Miller et al. (1995b) in the SACV and at a rate higher than my pintails that remained in the SJV. Although the study in Mexico (Migoya and

Baldasarre 1995) was shorter (106 days) than mine and Miller et al. (1995b) (157 to 205 days), survival rates should be unaffected by study duration unless significant intervals of mortality are omitted; there is no information to suggest that occurred during the Mexico study. Thus, although it should be recognized that differences in weather, harvest regulations or other conditions that vary over time may have influenced pintail survival during each study, most information indicate that survival of female pintails does vary geographically.

Survival covariates

I found two characteristics, age class and body condition, that were related to survival and hunting mortality of female pintails. HY females that I studied had a hunting mortality rate 1.42 times greater than adult female pintails. Most researchers also report that immature ducks are harvested at a higher rate than adults (Bellrose 1980, Hochbaum and Walters 1984, Reinecke et al. 1987, Krementz et al. 1988, Haramis et al. 1993, R. R. Cox pers. comm., M.R. Miller, pers. comm.). For instance, recent mallard harvest strategies were based upon estimates that immature females were 1.59 times more vulnerable to hunting than adult females in the midcontinent region during 1979-95 (USFWS 1997). Anderson's (1975:18) data indicate that the mean recovery rate of immature female mallards was 1.55 times that of adult females. Immature female pintails banded preseason 1970-90 in areas where most of California's wintering pintails originate had an unweighted area mean recovery rate 2.23 times greater than that of adults (F. Johnson, pers. comm). However, where hunting pressure is light (Bergan and Smith

1993, Migoya and Baldasarre 1995) or hunting of the species is prohibited (Hohman et al. 1993) hunting mortality may be equally low regardless of age (but see Haramis et al. 1993). Conroy et al. (1989) found that winter survival of immature female black ducks was lower than for adults but most of the difference was because of higher non-hunting mortality for immatures.

Fall body condition was related to hunting mortality for HY but not AHY pintails that I studied. Miller et al. (1995b) also did not detect a relation between condition and mortality for AHY female pintails, but few died from any cause and test power was low. In contrast, Conroy et al. (1989) reported a negative relation between condition and hunting mortality for adult female black ducks but not for immature females. However, immatures in their study were lighter and had lower survival than adults. I theorize that HY pintails have less ability than AHY pintails to gain weight between when they arrive on the wintering grounds and when hunting begins. Inexperienced juveniles, especially those in poor condition, may be less adept at finding or competing for resources then adults, especially when drought conditions exist and habitat is very limited. HY females arrive on the wintering grounds later than AHY females and have less time to improve their condition before being exposed to hunters. These differences between HY and AHY pintails may explain what occurred in 1991; HY females arrived late on the wintering grounds, were faced with poor habitat conditions due to continued drought, had poor early-season body condition and poor early survival that improved later in the year.

Numerous investigators have found a negative relation between body condition of ducks (i.e. lipid or protein reserves, or index, [e.g., mass with or without a size correction]) and their likelihood of being shot (Greenwood et al. 1986, Hepp et al. 1986, Reinecker and Shaiffer 1988, Conroy et al. 1989, Dufour et al. 1993, Heitmeyer et al. 1993, Hohman et al. 1995) or dieing during winter (Haramis et al. 1986, Longcore et al. 1991). Those finding no relation worked in areas where hunting of their study species was closed (Haramis et al. 1993, Hohman et al. 1993, Dugger et al. 1994) or hunting pressure was light (Migoya and Baldassarre 1995). Jeske et al. (1994) found no condition effect on survival but reported that avian cholera, known to kill birds regardless of condition (Mclandress 1983), was a major source of mortality and likely masked any relation between fate and condition. Krementz et al. (1989) and Sheeley and Smith (1989) also did not detect any effect of condition on survival but their test power was low (Dufour et al. 1993, Jeske et al. 1994). Reinecke et al. (1987) initially reported finding no consistent relation between condition and survival but later with a different analytical method on part of the same data set, detected a negative relation (Reinecke and Shaiffer 1988). Apparently, weather, habitat, predators, and other factors that affect survival were favorable enough at most sites that even if a duck was in poor condition its chances of dieing were not greatly impacted unless hunting pressure was high.

Crippling rates

The proportion of the total kill of radio-tagged pintails that was unretrieved (19.7%) was slightly greater but surprisingly similar to the proportion of ducks that hunters reported knocking down in sight but were unable to retrieve during the 1991-92, 1992-93 and 1993-94 hunting seasons (17.4%, 16.6%, and 16.3%, respectively, USFWS

1993, 1994). I expected my estimate for female pintails would be greater than one based upon hunter reports because my estimate includes birds falling out of sight of the hunter and excludes the bias that would result if, as suggested by several studies, hunters underestimate or understate crippling losses (Hopper et al. 1975, Nieman et al. 1987, Parker 1991, but see Martin and Carney 1977:33). However, the similarity between my crippling rate estimate for female pintails and one for all Pacific Flyway ducks may be coincidental because retrieval rates probably vary among species and sexes. Factors that likely minimized crippling rates of female pintails in central California relative to other ducks in the flyway include the highly desirable nature of pintails in California that should maximize retrieval effort (Gilmer et al. 1989, Miller et al. 1995a) and the tendency for most to be shot over shallow, open ponds where downed birds are easy to retrieve. Additionally, 76% of my shot birds were on private duck clubs where crippling rates tend to be lower (Bellerose [Bellrose] 1953, Martin and Carney 1977), possibly because hunters on private lands tend to be more experienced and well-equipped, and more likely to be accompanied by dogs and allow birds to work closer (Bellerose [Bellrose] 1953, Hochbaum and Walters 1984, Nieman et al. 1987, but see Boyd 1971). Factors that possibly increased crippling rates of female pintails in central California relative to other ducks in the flyway is that drab females are less likely to be retrieved than males (Hopper et al. 1975, Martin and Carney 1977:48) and pintails are notoriously wary (Miller et al. 1995a) which may increase shot distance and crippling rates (Hochbaum and Walters 1984). The crippling rate for female pintails that I observed under the one pintail per day regulation during this study may be higher than when more liberal pintail bag limits are in place because severe bag restrictions on commonly encountered birds reportedly reduce retrieval rates (Martin and Carney 1977:48).

My estimate of crippling rates for female pintails is fairly unbiased. My estimate includes all birds crippled, not just those seen and reported by the hunter. Hunter descriptions of the behavior of radio-tagged pintails indicated that the likelihood of crippling a radio-tagged and unmarked pintail were similar. My extensive aerial searches of California, including urban areas, found all missing birds and eliminated the upwards bias in the crippling rate estimate that would have resulted from misclassifying birds that were retrieved but unreported as unknown or emigrated. Likewise, encounters with hunters indicated public notices and curiosity about the radio-tag successfully eliminated fear of reporting a radio-tagged bird for most hunters and minimized any upwards bias in the crippling rate estimate that would have resulted from hunters leaving downed birds because of the radio-tag. I did find one shot bird that appeared to be hidden in vegetation near a road and I found two discarded radios. I classified the hidden bird as unretrieved because it could have crawled there or been discarded for other reasons (i.e., over limit, Mikula et al. 1972). I classified the two with cut-off radios as retrieved because they were obviously bagged (Conroy et al. 1989).

Nonhunting mortality

Nonhunting mortality was the source of 17% of the mortalities of female pintail mortalities I observed during winter. Nonhunting mortality reportedly accounts for about half of the annual mortality of North American waterfowl (Bellrose 1980). Thus, most nonhunting mortality apparently occurs outside the late-August to mid-March interval that I studied.

Avian predators were a major source of nonhunting mortality, accounting for 7.6% of the deaths I observed and killing 1.7% of the pintails I successfully radio-tagged. Others studying female pintails in central California reported 2.1% - 3.6% of their radio-tagged samples killed by predators (Miller et al. 1993, 1995b). I suspect that northern harriers (Circus cyaneus), red-tailed hawks (Buteo jamaicensis) or great horned owls (Bubo virginianus) were the main predators in the SJV because they were abundant and are known to kill pintails and other ducks (Luttich et al. 1970:196, Collopy and Bildstein 1987, Palmer 1988:300). I repeatedly observed northern harriers flush pintails and other waterfowl from islands and levees and saw one harrier kill a green-winged teal (Anas crecca). Most depredations occurred in late summer. Miller et al. (1995b) theorized that depredation rates were highest in late summer because of increasing pintail abundance on limited wetlands. Possibly, I misclassified some depredations during the hunting season as unretrieved hunter kills. However, I doubt this error was significant because all birds that I possibly misclassified died in ponds that were being hunted and each bird's movements included and, in most cases, narrowed the time of death to when hunters were afield. Further, other researchers working in central California also report that most (Miller et al. 1993) or all (Miller et al. 1995b) depredations occurred in late summer. In the Miller et al. (1995b) study, misclassification of deaths during the hunting season was impossible because all deaths during that interval were confirmed hunter kills.

Avian cholera was another major source of nonhunting mortality during this study, accounting for 4.3% (6.5% if unspecified disease losses were due to cholera) of the deaths and killing 1.0% (1.4% if unspecified disease losses were due to cholera) of the female pintails I radio-tagged; 1% of the female pintails radio-tagged in the SACV (Miller et al. 1995b) and Suisun Marsh (Miller et al. 1993) died of avian cholera. Estimates of avian cholera losses calculated by extrapolating numbers of carcasses picked up, ranged from 0.2% to 2.0% of the wintering duck population in California (see Botzler 1991) and 4.5% for midcontinent mallards (Samuel 1992). Avian cholera was unknown in California until 1944, but since then epizootics have occurred almost annually during winter (Botzler 1991) and the Central Valley is now one of four North American focal points for the disease (Friend 1987).

This and other recent telemetry studies and disease reports indicate that avian botulism kills fewer pintails than avian cholera in central California most years during September - March but that botulism may be extremely important at other times of the year and in other areas. Neither I or Miller et al. (1993) attributed deaths of any radio-tagged female pintails to botulism during 1991-94 and Miller et al. (1995b) lost only one radio-tagged pintail to botulism during 1987-91. Reported botulism losses in central California during the 1991-94 winters were low compared to cholera losses (Natl. Wildl. Health Research Center, Madison, Wisc., unpubl. reports). However, botulism is prominent during July - September (Parrish and Hunter 1969, Hunter 1970, Locke and Friend 1987) when most pintails, especially female and young, are still north of Central California (USFWS and CDFG unpubl. data)); recent losses have been massive (i.e.,

>500,000 ducks on one Saskatchewan lake in 1997, U.S. Geological Survey, Reston, VA, unpubl. reports). Also, botulism has historically been prominent in central California, with die-offs being recorded in the Tulare Basin as early as 1909 (Clarke 1913), as large as 250,000 waterfowl (Locke and Friend 1987) and continuing throughout the winter (Parrish and Hunter 1969). Thus, botulism is probably a more important factor in pintail population dynamics than my data show. Samuel (1992) estimated daily mortality rates of midcontinent mallards due to cholera to be greater than from botulism but cautioned that more reliable estimates are needed.

The one duck that died of aspergillosis in late winter frequented dairy farms and corn fields (J.P. Fleskes, unpubl. data) which are likely sites of the causative fungi Aspergillus sp. (Locke 1987).

One radio-tagged pintail died after striking a power line. Power line collisions are thought to be a relatively minor source of waterfowl mortality (Stout and Cornwell 1976). However, waterfowl casualties tend to be isolated events (Tordoff and Mengel 1956) and the magnitude and significance of collision losses to waterfowl is poorly understood (Krapu 1974a). Fog and power lines in the vicinity of waterfowl concentrations are common conditions in central California and probably leads to a high likelihood of strikes (Quotrup and Shillinger 1941, Harrison 1963, Anderson 1978) relative to other areas.

Are my survival estimates unbiased?

The winter survival rates that I estimated for female northern pintails may be biased low because they are based upon a radio-tagged sample. Although flight and social behavior were normal, body mass dynamics (Miller 1986) of some pintails appears to have been altered by radio-tagging. Abnormal weight loss due to radio-tagging with harness transmitters has been reported by others (Greenwood and Sargeant 1973, see Conroy et al. 1989) although some report no effect (Gilmer et al. 1974, Bowman and Longcore 1989, Houston and Greenwood 1993). The cause(s) of this weight loss may include increased preening around the transmitter (Greenwood and Sargeant 1973, Pietz et al. 1993), at least temporarily (Gilmer et al. 1974), which reduces feeding rates, and increased energetic demands due to transmitter weight, transmitter drag (Caccamise and Hedin 1985, Gessaman and Nagy 1988) or loss of insulating feathers (Greenwood and Sargeant 1973). Some weight loss may also occur simply from capturing and handling birds (G. Yarris, Calif. Waterfowl Assoc., Sacramento, unpubl. data). Regardless of the cause, because HY female pintail body condition in September - October was related to their winter survival, it is possible that survival rates presented here, for HY pintails at least, are negatively biased.

The magnitude of this possible bias is unknown but I can derive one estimate by using the relation between mass of pintails at capture in the fall and survival of HY females (3% increase in hazard for each 10 g mass reduction) and the difference in mean mass of harvested radio-tagged and unmarked HY females (119 g, Table III.7) that I observed. These calculations result in an adjusted HY female pintail survival rate of 0.79 (i.e., 0.79 = 0.67 + [[0.03 x [119/10] x [1 - 0.67]]), an 18% increase from the unadjusted HY survival rate of 0.67. Capture mass was not a significant covariate for AHY female pintail survival but hunting mortality is usually lower for AHY than HY ducks (Bellrose 1980, Hochbaum and Walters 1984, Reinecke et al. 1987, Krementz et al. 1988, Haramis et al. 1993) so actual AHY survival may also be greater than the 0.76 rate reported here.

It is possible that even if radio-tagging altered mass dynamics, adjustments to my survival estimates are unnecessary. For instance, birds may adapt to radio-tags by adjusting body mass without any effect on survival. My finding that heavy birds lost more weight than light birds is consistent with this possibility. Also, calculations dividing mean annual survival estimates by my winter survival estimates produce biologically reasonable estimates of female pintail survival during the non-wintering period (20 March - 29 August) which indicates my winter survival estimates are not severely biased. For instance, a mean spring-summer survival estimate of 0.80 for both HY (range = 0.63 - 0.98) and AHY (range = 0.67 - 0.86) female pintails results from using annual survival estimates from 1950-61 preseason banding in the SJV (Rienecker 1987b), 1970-90 preseason banding in northern Alberta/Northwest Territories, southwestern Alberta, southwestern Saskatchewan, northern California, High Plains and Missouri River Basin (i.e., unweighted mean of breeding areas 2, 3, 4, 10, 12, and 13, F.A. Johnson, pers. comm.), 1952-56 postseason banding in the SJV (Rienecker 1987b), and 1957-78 postseason banding in central California (Hestbeck 1993a). My estimate is similar to the spring-summer survival estimate of 0.75 that Miller et al. (1993) generated for AHY female pintails wintering in the SACV. Other estimates of spring-summer survival for female pintails are lacking (Carlson et al. 1993), but most spring-summer survival estimates for female mallards are similar to my estimates for pintails and also range widely (0.574 to 0.914, Johnson and Sargeant 1977, Cowardin et al. 1985, Kirby and Cowardin 1986, Reynolds et al. 1995).

Like this study, most researchers that used harness transmitters to study dabbling ducks during the nonbreeding season report that radio-tagged ducks flew, moved, and intermingled normally with other ducks (Conroy et al. 1989, Parker 1991, Bergan and Smith 1993). Based on this evidence, most have discounted the likelihood of a significant negative bias or, after acknowledging its possible existence, have not attempted to estimate it. For instance, Conroy et al. (1989) reported that G. R. Constanzo (unpubl. data) found losses of 16 - 18% of body mass from December to March for radio-tagged female black ducks compared to 5 - 7% for female black ducks without radios but theorized that because all evidence indicated normal behavior of radio-tagged ducks, any lowering of survival was probably small. However, Reinecke et al. (1992) reported that although movements were normal, harness-equipped mallards were less likely to be in large flocks and more likely to be alone when harvested than non-radioed mallards. They theorized that this possibly resulted in higher hunting mortality (Olson 1965) and explained why their calculated band reporting rates were lower than expected.

The possible reduction in survival that may have resulted from radio-tagging does not preclude the validity of this study's results or the relevance of comparisons with studies using similar techniques. For instance, comparisons among years and intervals would still be valid. Also, comparisons with female pintail survival in Mexico (Migoya and Baldassarre 1995) and the SACV (Miller et al. 1995b), that indicate higher survival in those areas than in the SJV because of differences in hunting mortality, would still be valid. These conclusions are further supported by the higher survival of SJV pintails elsewhere in central California, banding data (Rienecker 1987b), and comparisons of population and harvest survey data.

Impact of radio type

My data were inconclusive on whether survival differed for spear-suture and harness-equipped pintails. Point estimate (e.g., at end of first hunt season) comparisons and proportional hazards modeling did not indicate a significant difference but data were available from only one year and test power was low. Survival distributions suggested that early survival was better for females equipped with spear-suture than harness-type radio-tags. Pietz et al. (1995) studied survival of adult ducks equipped with spear-suture radio-tags and found that, unlike reports for harness-equipped females, spear-suture radio-tags did not appear to affect survival of breeding dabblers or ducklings under their care. However, Mauser (1991) attached harness radio-tags to 77 female mallards in late incubation and recorded no mortalities during 5,279 exposure days of tracking. The impact of radio-tagging seems to vary by individual, season and environmental conditions (Burger et al. 1991), and may not be apparent during extremely favorable or unfavorable conditions when most succeed/live or fail/die regardless of whether or not they have been radio-tagged (Pietz et al. 1993). Radio-tagging seems to have its most apparent impact during the breeding season. Several studies found lower reproductive effort and capacity for female dabbling ducks equipped just prior to nesting with harness radio-tags than for unmarked females or those equipped with implants or suture-glue radio-tags (Chabaylo

1990, Pietz et al. 1993, Rotella et al. 1993), although Cowardin et al. (1985) and Houston and Greenwood (1993) report no apparent differences. The impact on brood-rearing success does not seem as great (Ball et al. 1975, Bergmann et al. 1994, Gammonley and Kelley 1994) although Wheeler (1991) reported higher predation rates for females with harness transmitters than for those with suture-glue transmitters. Additional studies, specifically designed to measure the impact of different types of radio-tags on the winter survival and hunting mortality of free-ranging dabbling ducks, are needed.

CONCLUSIONS

The decline in abundance of pintails wintering in the SJV is obviously related to poor habitat conditions there relative to other wintering areas in the Central Valley. About 90% of the estimated four to five million acres of wetlands originally present in the Central Valley have been lost (USFWS 1978, Gilmer et al. 1982); this loss has been especially detrimental to waterfowl in the SJV. SJV wetlands have been primarily converted into cotton fields or other crops that have little value to waterfowl. In contrast, the rice and corn fields that have replaced many SACV and Delta wetlands are of high value to waterfowl. Recent water-conserving preirrigation practices in the Tulare Basin have further lowered the value of SJV agricultural lands to waterfowl (Houghten et al. 1985, Barnum and Euliss 1991) and agricultural drain water contaminated with trace elements and heavy metals (e.g. selenium) have degraded some SJV wetlands (Ohlendorf et al. 1986, Barnum and Gilmer 1988). The high loss and degradation of SJV habitat appears to have altered pintail distribution and reduced winter survival below that of pintails elsewhere in the Central Valley. Because female pintails exhibit high fidelity to wintering grounds (Rienecker 1987a, Hestbeck 1993b) habitat improvements in the SJV that increase the carrying capacity and winter survival of pintails would likely increase SJV pintail populations.

To promote high survival of HY females pintails in the SJV, fall water deliveries need to be adequate, especially in drought years. I found that HY female pintails in poor condition were especially vulnerable to hunting. Poor condition of HY females and high early season mortality occurred during a year when drought delayed nesting on the breeding grounds (USFWS and CWS 1991) and delayed and reduced water deliveries on the wintering grounds (Grassland Water District, Los Banos, CA, unpubl. data). This implies that if the late nesting index is high or drought conditions prevail on the breeding or wintering grounds, special efforts should be made to improve habitat conditions during August - October in order to promote weight gain. Delaying the opening date of hunting may also reduce hunting mortality by allowing more time for birds to improve their condition, but not if poor habitat conditions prevent weight gain. Also, overall survival would be increased only if compensatory factors are not prevalent and this is unlikely if habitat conditions remain poor.

Pintail survival would likely be enhanced by increasing the amount of flooded agricultural lands in the SJV. Female pintail survival during winter was lower in the SJV than in Mexico or the SACV. The main difference among these regions is the amount of habitat available to pintails. The most economical way to increase habitat would probably be to provide incentives to flood rice and other grain lands in the SJV that are currently being plowed and left dry. Some of these lands may be unhunted or lightly hunted. Conversely, conversion of rice fields to cotton fields that is occurring in the SACV will likely reduce survival of pintails wintering there and should be discouraged.

Late-season habitat improvements in the SJV may cause pintails to remain longer but probably would not have a large impact on survival. Most pintails now leave during early December. Increasing the quantity or quality of late-season habitat may reduce or delay this exodus but December-March survival of pintails was high in the SJV and elsewhere, so little gain can be expected. However, the cross-seasonal benefit of improved late-season habitat may justify the effort.

Caution should be taken when creating new habitat so as not to redistribute waterfowl away from existing private wetlands. This could lower hunting success and discourage habitat management that could cause failure of some duck clubs and conversion of their wetland habitats into less beneficial uses that may ultimately lower survival and productivity of a wide array of wetland-dependent wildlife, including pintails.

CONCLUSION

This study shows that numerous, inter-related dynamic factors influence the ecology of female northern pintails during winter in California. However, the importance of abundant, productive habitat is evident in all aspects of pintail wintering ecology.

Changing habitat availability affected pintail distribution and movements. Early winter drought conditions in 1991 increased the exodus of pintails from the SJV to both Mexico and the Sacramento Valley. Loss of Tulare Basin wetlands and the more recent reduction in agricultural flooding there, at the same time flooding of Sacramento Valley rice fields increased, has altered movements and distribution of pintails throughout California. Establishment of new sanctuaries in the Grassland EA has changed pintail movement patterns in that area. Pintail distribution and movement patterns are not static and will continue to change as habitat conditions change.

Availability of water to flood habitats obviously affected habitat use by pintails. Low availability of water was a major impediment to post-harvest flooding of SJV rice fields and nearly eliminated that preferred habitat for use by pintails in the SJV. Improved water supplies could allow increased winter flooding of SJV rice fields but it could also lead to conversion of some swamp timothy wetlands to watergrass wetlands and increase growth of emergent vegetation. Although increased habitat diversity is generally positive and some watergrass wetlands and wetlands with significant emergent cover received high use by pintails, pintails generally selected swamp timothy wetlands and other open habitats. Additional research is needed to understand why certain watergrass wetlands received little use by pintails and how loss of open wetlands would affect the carrying capacity of the SJV for all fauna, especially many shorebirds, that are associated with open wetland habitats.

Survival of female pintails was related to habitat conditions. Pintail survival was higher in a landscape that included an abundance of winter-flooded rice fields than in a landscape dominated by cotton agriculture. The expansion of cotton agriculture into the Sacramento Valley will be detrimental to pintails if it reduces rice agriculture. Survival of HY females was lowest in the drought year of 1991. Poor HY survival that year was likely the result of poor early-season habitat that reduced the ability of HY pintails to gain weight and increased their vulnerability to harvest. Increased HY vulnerability in drought years could bias productivity estimates based on age ratios of harvested birds.

One trait that pintails clearly displayed during this study was their ability to quickly detect and respond to changes in habitat availability. I documented several extended "excursion" flights where pintails flew throughout a local area before they settled into one pond or field. This explains how pintails with no previous use of East Grassland habitats were able to move there immediately after late-winter floodwaters inundated that area. Pintails also responded to changing habitat availability on a larger scale. On several occasions after heavy rains, I first discovered newly flooded habitats on the periphery of my study area (e.g., floodwaters near Huron, vernal pools east of Modesto) by tracking pintails. The need for managers to recognize that pintails range widely is important. Local habitat management decisions can be far-reaching and have potential to impact a larger portion of the pintail population than for less mobile species.

Thus, habitat management for pintails requires large scale planning, and coordination among managers is critical.

Inevitably, the question that faces all resource managers is "where should our limited resources be directed to provide the most benefit?". This question is especially relevant for pintails, which unlike most other waterfowl species, are still well below their long-term population average despite return of favorable water conditions on most nesting and wintering areas (Wilkins and Cooch 1999). Conversion of grasslands to croplands and changes in predator populations in major pintail nesting areas that has reduced the recruitment of young pintails into the population and increased mortality of nesting hens is obviously a large part of the problem (Miller and Duncan 1999). Thus, resources should undoubtedly be directed towards alleviating those problems. However, wintering areas should not be neglected. Pintails spend the majority of the year (e.g., 7-8 months in California) concentrated in large groups on the few remaining habitats on wintering areas. Thus, the potential for impacting significant portions of the population is large. Although, the mechanism is not fully understood, habitat conditions on wintering areas apparently impact productivity (Raveling and Heitmeyer 1989). In addition, pintails have evolved a strategy that relies on high survival when recruitment potential is poor and survival of females is especially important to pintail population dynamics (Flint and Rockwell 1997). Contaminants and disease problems on wintering areas could have dire consequences to pintail populations and effects of sub-lethal chronic exposure to contaminants are extremely difficult to access. With large increases in human populations in the Central Valley of California expected during the next decade (Palmer

1993), potential for problems will escalate. Thus, conservation efforts to improve habitat conditions on wintering areas, such as the Central Valley Habitat Joint Venture (CVHJV 1990), should continue.

Although pintail survival is lower in the SJV than SACV, conservation efforts should be continued throughout the Central Valley. The SJV provided a vast area of prime wintering habitat for pintails in the past (Johnson et. al. 1993) and still represents about half the wintering range of pintails in California. Continued management of the entire wintering range is important to maintain a healthy pintail population. Pintails are highly mobile and a significant proportion of the population could be exposed to hazardous elements if marginal habitats are neglected. Restriction of range increases crowding and probability of catastrophic disease losses. The Grassland EA and other SJV areas are recognized areas of global importance to shorebird and other migratory bird populations (Shuford et al. 1998, Grassland Water District 1999). Habitat conservation efforts aimed at pintails will also benefit these species directly by restoring and improving habitats and indirectly by increasing the likelihood that waterfowl hunting clubs, which provide the majority of wetland habitat in the SJV, will survive and continue to manage their habitats. Thus, special attention on this critical area should be continued.

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