PINTAIL NORTH-SOUTH FLIGHT PATHS IN THE GRASSLAND ECOLOGICAL AREA

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ABSTRACT: I determined the highway zone over which 42 radiotagged female northern pintails (*Anas acuta*) flew on their way from daytime roost sites in the north to nocturnal feeding sites in the south part of the Grassland Ecological Area (EA), California, during 4 and 11 November and 9 December, 1992. My objectives were to identify important pintail flight corridors along a highway where increased urbanization is projected, gather baseline flight path information so that impacts of future urbanization and other landscape changes can be evaluated, and provide insight into how urbanization and wetland habitat impact pintail flight paths. Most pintails flew fairly direct routes from their roost to feeding sites but some apparently followed routes over wetlands they encountered early in their trip and ended up taking indirect routes. No pintails flew over and 1 pintail diverted around the most heavily urbanized zone, providing weak evidence that urbanization may have acted as a partial barrier to pintail flight. Urban expansion eastward from the City of Los Banos into the path used by most pintails should be avoided to maintain direct waterfowl flight paths between habitats in the north and south Grassland EA. Open-space corridors should be incorporated into conservation planning in urban-wetland landscapes to facilitate direct flight paths between wetlands, which may be important to daily energetics of wintering pintails during hunting season, when they must fly considerable distances between sanctuaries and some feeding areas.

Key words: *Anas acuta*, California, Central Valley, corridor, flight, movements, Grassland Ecological Area, northern pintail.

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The concept of conservation corridors to reduce negative impacts of habitat fragmentation by facilitating movements of wildlife among habitat remnants is well established (Beier and Noss 1998, Earn et al. 2000). However, landscape features that act as movement barriers or funnels (Dover and Fry 2001) depend upon the mobility and ecology of the species. Impacts of landscape features on waterfowl flight paths have received little study. Although waterfowl are highly mobile and capable of flying around or over most obstacles, flight is the most energetically expensive activity of birds (Norberg 1996), costing as much as 15 times basal metabolic rate (King 1974, Prince 1979). Thus, changes in flight paths may greatly increase time and energy required for daily movements (Cox and Afton 1996) and could reduce use of habitats that are more difficult to visit. Thus, an understanding of waterfowl daily movements relative to landscape features is necessary for informed conservation planning (Marzluff and Ewing 2001).

The Grassland Ecological Area (EA) is the largest contiguous block of wetland habitat remaining in the Central Valley of California and provides critical habitat for many wetland-dependent species, including northern pintails (*Anas acuta*), during winter (United States Fish and Wildlife Service 1978, Shuford et al. 1998). Similar to other Central Valley areas, rapid expansion of human populations in the region is projected (State of California 2001) and will likely result in expansion of Los Banos, the main urban area in the Grassland EA. The city of Los Banos is situated along Highway 152, which runs east-west and separates the north (NGL) and east (EGL) from the south (SGL) parts of the Grassland EA (Fig. 1). All National Wildlife Refuges (NWRs) and all but one (all in 1992) California State Wildlife Area (WA) with areas closed to waterfowl hunting (i.e., sanctuaries) are located in the NGL and EGL. Thus, a continuous urban zone could develop between the main hunting-season waterfowl roost areas in the NGL and EGL and important feeding areas on privately-owned duck club wetlands in the SGL (Fleskes 1999) if urban expansion continued east from the city of Los Banos.

Most Grassland EA wetlands are privately owned and managed with funds derived largely from waterfowl hunters (Gilmer et al. 1982). Changes in movements and habitat use by pintails and other waterfowl important to hunters in the area (Gilmer et al. 1989) that impact hunter success could impact management of many Grassland EA wetlands (Heitmeyer et al. 1989, Baldassarre and Bolen 1994). Grassland EA is a focal point for waterbird habitat conservation efforts (United States Fish and Wildlife Service and Canadian Wildlife Service 1986, Central Valley Habitat Joint Venture Implementation Board 1990) and knowledge of important pintail flight corridors is needed to guide these programs.

The goals of this study were to identify important pintail flight corridors in the Grassland EA along High-

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way 152 where increased urbanization is projected (Weissman and Strong 2001), provide baseline flight path information necessary to evaluate impacts of future urbanization and other landscape changes (Swetnam et al. 1998), and provide insight into whether urbanization and wetland habitat impact pintail flight paths.

STUDY AREA

The Grassland EA was comprised of the NGL, EGL, and SGL (Fleskes 1999). In 1992, the NGL were comprised of public areas with some wetlands closed to hunting (San Luis NWR [1,069 ha wetlands with 579 ha in sanctuary], Kesterson NWR [383 ha wetlands with 105 ha in sanctuary], Los Banos WA [1,035 ha wetlands with 217 ha in sanctuary), public areas without sanctuaries (Volta, Salt Slough and China Island WAs, 1,024 ha wetlands total) and privately owned waterfowl hunting clubs (North Clubs; 9,691 ha wetlands). The Grassland State Park in the NGL was closed to hunting but had no flooded areas. The EGL were composed of Merced (332 ha wetlands with 233 ha in sanctuary) and Arena Plains NWRs (23 ha wetlands, all sanctuary) and waterfowl hunting clubs (East Clubs; 1,142 ha wetlands). The SGL were entirely private (South Clubs; 7,286 ha wetlands) and separated from the NGL and EGL by Highway 152 which runs east-west through the city of Los Banos (Fig. 1).

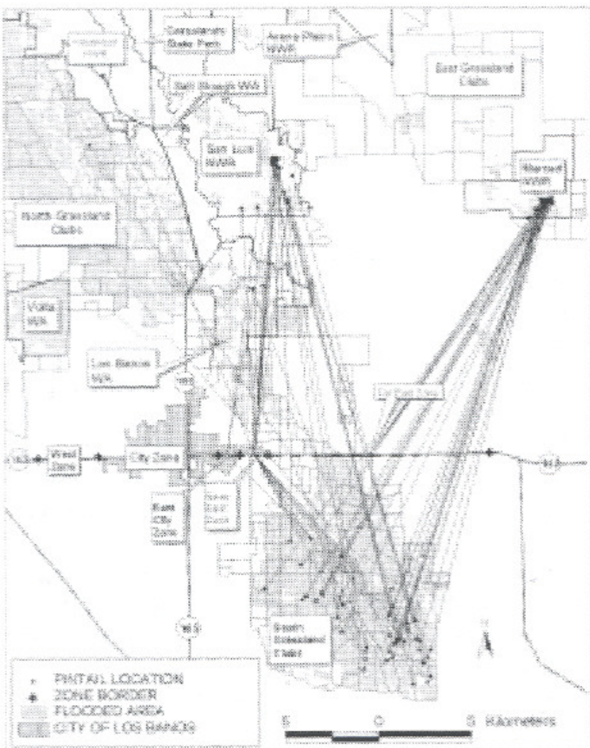

Figure 1. Approximate evening flight paths (n = 53) on 4 November, 11 November, and 9 December, 1992 for 42 different radiotagged female pintails (22 Hatch-Year and 20 After-Hatch-Year) from daytime roost sites on National Wildlife Refuges (NWRs), State Wildlife Areas (WAs), and a private duck club in the north and east part of the Grassland Ecological Area (EA) to nocturnal feeding sites on private duck clubs in the south part of the Grassland EA. Other important pintail flight corridors (e.g., east-west across Highway 165 north of Los Banos, Fleskes 1999) are not shown.

METHODS

Highway 152 Zones

I delineated 5 Highway 152 zones, using road intersections or waterways to mark the boundary between adjacent zones that contained different levels of urbanization. Listed from west-to-east, the zones were: 1) WEST, a 2.7-km zone from Volta Road to Los Banos Creek on the west border of Los Banos; 2) CITY, the 5.3-km Los Banos zone; 3) EASTCITY, a 1-km zone from Ward Road on the east border of Los Banos to San Luis Canal; 4) NEAREAST, a 1.3-km zone from San Luis Canal to Sante Fe Grade; 5) FAREAST, a 9.7-km zone from Sante Fe Grade to San Juan Road (Fig. 1). I used photographs that I took during October 1992 flights and a Geographic Information System to estimate urbanization, measured as the percent of each zone that had buildings within 100 m of Highway 152, and to estimate the distance from Highway 152 in each zone to the nearest flooded area.

Pintail Flight Paths

As part of a 3-year study of northern pintail wintering ecology, 58 Hatch-Year (HY) and 65 After-Hatch-Year (AHY) female pintails were captured, radiotagged, and released in the San Joaquin Valley, California during August and September, 1992 (Fleskes 1999). On 4 November, 11 November, and 9 December, 1992 (all hunting days with clear evenings and days, dates selected because work schedules permitted and numerous radiotagged pintails were flying daily to the SGL), I used truck-mounted directional antennae to determine (Fleskes 1999) the afternoon location of all radiotagged pintails that were present in the NGL and EGL. Technicians stationed in tracking vehicles at the borders of the 5 Highway 152 zones scanned for all radiotagged pintails until an hour after sunset and determined the zone over which each pintail that went to the SGL flew. I continued monitoring all birds, and when signal strength decreased and movement stopped for more than 1-2 minutes, I triangulated the initial landing location for those that landed in the SGL. I used the ARC/INFO (Environmental Systems Research Institute, Incorporated, Redlands, California, USA) computer program and a Geographic Information System with digitized maps to plot the NGL or EGL starting location and the SGL ending location. If the line connecting the starting and ending location crossed in the Highway 152 zone where I observed the pintail crossing, I assumed and plotted a direct flight line. If the line connecting the starting and ending location crossed outside the Highway 152 zone where I observed that the pintail crossed, I plotted a Highway 152 crossing point as the midpoint of the known crossing zone (except in one instance where I was able to determine the actual crossing location).

RESULTS

Urbanization and Nearest Wetland Habitat in Highway 152 Zones

The CITY zone was entirely urbanized (100% of zone with buildings within 100 m of Highway 152), the EASTCITY partially (61%) urbanized, and the WEST (7%), NEAREAST (6%), and FAREAST (2%) zones were almost entirely non-urbanized open space. The nearest flooded area was 3.5 km from Highway 152 in the WEST zone, 2.4 km for CITY, 1.9 km for EASTCITY, 0.9 km for NEAREAST, and <0.1 km for FAREAST.

Pintail Evening Flights Over Highway 152 Zones

A total of 42 different radiotagged female pintails (22 HY and 20 AHY) from the NGL and EGL flew over Highway 152 a total of 59 times during the 3 evening monitoring periods. Almost all flights occurred within 15 minutes after sunset, and fly-over zones for 6 crossings were not determined because of the difficulty of tracking numerous birds simultaneously. In addition, direct flight paths between roost and SGL feeding sites could not be determined for 9 pintails that crossed over Highway 152 zones because they did not land in the SGL.

The fly-over zone for 32 of the 44 pintail flights that ended in SGL included the direct flight path (Fig. 1). The only pintail that started from a NGL duck club, and for which a direct route would have been over the EASTCITY Zone, flew farther east and crossed in the FAREAST Zone. The other pintails (8 from San Luis NWR, 1 from Kesterson NWR, 2 from Los Banos WA) that deviated from direct flight paths flew farther west and crossed in the NEAREAST ($n = 10$) or EASTCITY ($n = 1$) zone.

No pintails were detected flying over the WEST or CITY zones, 2 of 53 flights were over the EASTCITY, 11 were over the NEAREAST, and 40 were over FAREAST zone (Fig. 1). All 27 flights starting at Merced NWR crossed Highway 152 over the FAREAST zone. Flights starting at San Luis NWR crossed over the FAREAST ($n = 11$), NEAREAST ($n = 8$), or EASTCITY ($n = 2$) zones. Flights from Los Banos WA crossed over the NEAREAST ($n = 2$) or FAREAST ($n = 1$) zones. The only pintail starting at Kesterson NWR crossed over the NEAREAST zone and the only pintail from the NGL duck club crossed in the FAREAST zone.

Of the 8 HY and 3 AHY pintails tracked on >1 evening, 3 HY and 3 AHY crossed the same zone after leaving from the same roost site, 3 HY crossed the same zone each time even from different roosting sites, 1 HY crossed different zones from the same roost site, and 1 changed both roost and crossing zone.

DISCUSSION

Most pintails flew fairly direct routes from their roost to feeding sites but some apparently followed routes over wetlands they encountered early in their trip and ended up taking indirect routes (Fig. 1). Pintails from Merced NWR had little option on their way to the SGL but to fly over a mostly unflooded, non-urbanized landscape and all apparently chose fairly direct routes. In contrast, pintails from San Luis NWR and Los Banos WA encountered wetlands early during their trip and some apparently followed them, resulting in them crossing Highway 152 in the NEAREAST or EASTCITY zone before diverting back southeast towards their SGL feeding site. St. Clair et al. (1998) reported that black-capped chickadees (*Poecile atricapillus*) preferred to fly over forested corridors when available but made direct flights over large habitat gaps when no corridor existed. Likewise, pintails flew long distances over dry landscapes but wetlands encountered apparently did funnel some of them.

There was weak evidence that urbanization acted as a partial barrier to pintail flight. I observed no pintails flying over the heavily urbanized CITY zone, and the only pintail who's direct flight path would have taken it over an urbanized zone diverted eastward to a rural zone. However, this indirect flight path may have resulted from the bird following wetlands it encountered rather than to avoid urbanization. Two pintails did fly over the EASTCITY zone, indicating that moderate urbanization is not a complete barrier to pintail flight. Also, no pintails flew over the rural WEST zone, so the high percentage of pintails that flew over the rural zones east of Los Banos may have been simply fortuitous because those zones were in the direct flight path of most pintails.

Pintail flight paths on cloudy or foggy evenings may be different than during the clear evenings that I studied. Shimada (2001) reported that greater white-fronted geese (*Anser albifrons*) sometimes took indirect flight routes to avoid crossing over visible power lines but readily crossed over power lines hidden by trees. Spaans et al. (1998) reported that local wintering diving ducks avoided wind turbines by flying between them when visibility was good but flew around entire rows of turbines rather than between individual turbines on moonless nights. Thus, impacts of urbanization on pintail flight routes may vary with visibility conditions. Flight paths of pintails from the SGL returning in the early morning to day-roost sites in the NGL may differ from the evening flight paths that I studied.

Based upon lack of pintails overflying and diversion by one pintail around the most heavily urbanized zone, eastward expansion of Los Banos along Highway 152, especially if accompanied by loss of wetlands, would likely cause at least some pintails whose direct flight paths would include urbanized areas to divert farther east. This could have 2 negative impacts on pintails. First, non-direct flight paths would require additional energy. Flight is energetically costly relative to other activities (Wooley and Owen 1978) and can be a major component of daily energy expenditure (Cox and Afton 1996). Second, some wetlands in the west and northwest part of the SGL would require indirect flight paths for some pintails to reach. Pintail use of these habitats would probably be delayed or reduced because distant habitats are generally used last (Frederick et al. 1987). This delay or decline could be even greater for species less mobile than pintails and result in reduced hunter success and eventually reduce incentive to manage wetlands on those hunting clubs. The increased energy requirements of indirect flight paths (Austin and Humburg 1992), combined with reduced accessibility or amount of habitat could result in reduced carrying capacity of the Grassland EA and earlier exodus of waterfowl to other Central California regions (Frederick et al. 1987, Fleskes et al. 2002).

MANAGEMENT IMPLICATIONS

Although I observed only weak evidence that urbanization was a barrier to pintail flight, the potential negative impacts of eliminating direct connectivity between wetland habitat blocks in the Grassland EA should be considered to ensure that waterfowl populations in the region are maintained (Beier and Noss 1998). Conservation programs for waterfowl should strive to facilitate direct flights between roosting and feeding sites (Fox and Madsen 1997). A continuous wetland corridor would help guide waterfowl between NGL and SGL habitats. City of Los Banos urban expansion eastward along Highway 152 or northward along Highway 165 (Fleskes 1999) should be avoided to maintain open space and wetlands in these important pintail flight routes. In addition, new direct flight paths over existing open space could be created by establishing new roosting areas near existing feeding sites (e.g., new refuge in the SGL), or new feeding sites near existing roosting areas (e.g., new wetlands in EGL). State wildlife areas have been established and wetlands restored in the northwest part of the SGL and north of Highway 152 in the FAREAST zone since this study was conducted. A comparison of pintail flight paths in the current and 1992 landscape would provide information on how these new wetlands and any increased urbanization have impacted pintail flight paths.

Most studies have found that habitat corridors facilitate movements and help maintain connectivity among habitats for a wide variety of species (Debinski and Holt 2000). Maintaining open space between habitat blocks to facilitate direct flight paths is especially important to wintering pintails during hunting season, when they must fly considerable distances between their day-roost sanctuaries and some feeding areas. Although probably more critical for less mobile species, conservation corridors may be important to the daily energetics of wintering waterfowl and should be incorporated into conservation planning in urban-wetland landscapes.

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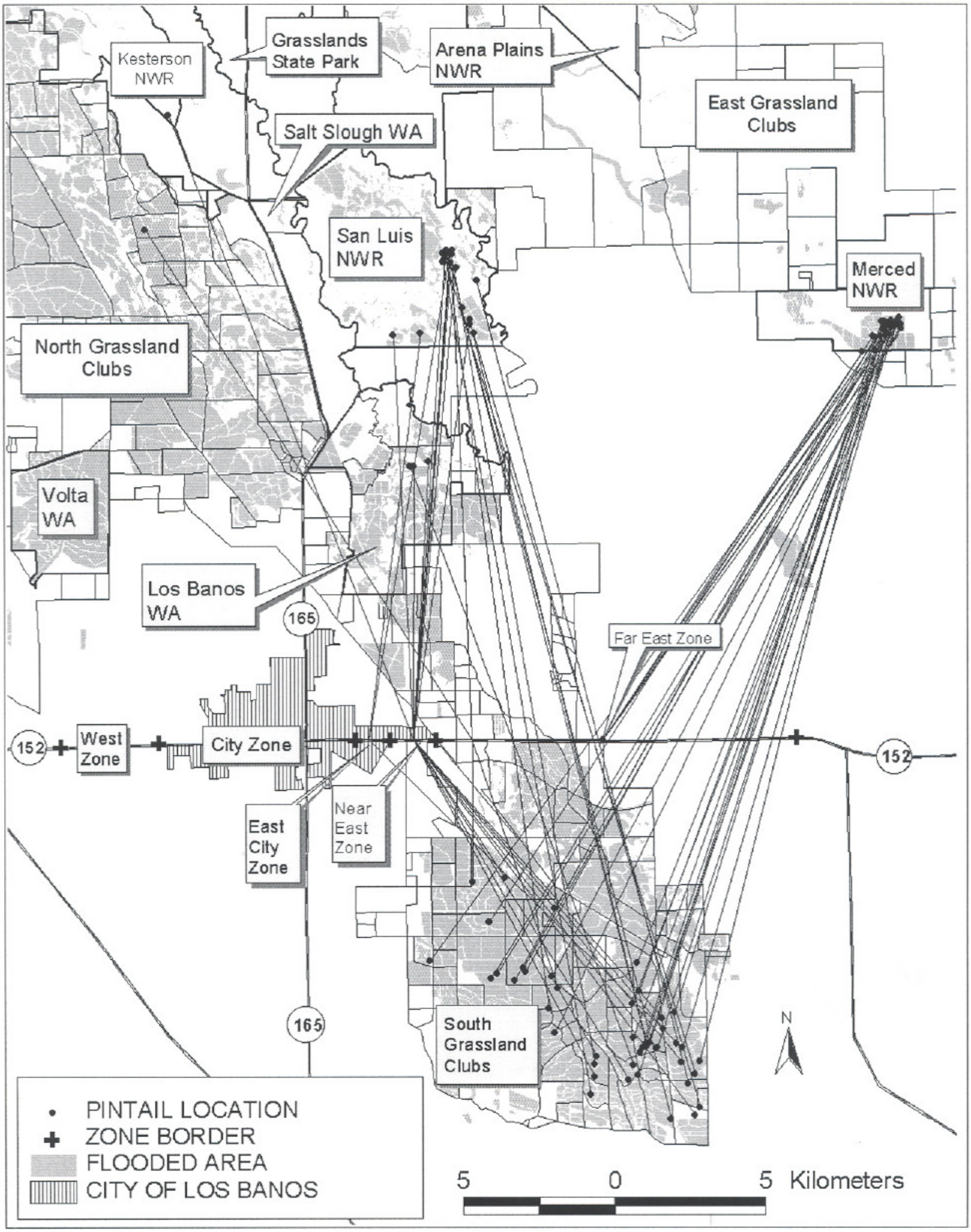

Kesterson NWR
Grasslands State Park
Arena Plains NWR
East Grassland Clubs
Salt Slough WA
San Luis NWR
Merced NWR
North Grassland Clubs
Volta WA
Los Banos WA
165
Far East Zone
152
West Zone
City Zone
152
East City Zone
Near East Zone
165
South Grassland Clubs
N
PINTAIL LOCATION
ZONE BORDER
FLOODED AREA
CITY OF LOS BANOS
5 0 5 Kilometers