

RECENT AND HISTORICAL RAPTOR POPULATIONS IN FRESNO, MADERA, AND MERCED COUNTIES, CALIFORNIA

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ABSTRACT: Roadside raptor surveys have historically been used to establish indices of relative abundance of wintering raptors. This research establishes baseline data for migratory wintering raptors in the central San Joaquin Valley and compares these findings with surveys conducted after 1970. Survey routes of 62-, 82-, and 86-km were chosen that traveled across Fresno, Madera, and Merced counties. All raptors within 0.5 km of each side of the road were identified using binoculars and a 20X spotting scope. Data collected was used to estimate population size and relative abundance of each raptor species. Land use patterns since 1970 throughout the study area were determined using aerial photographs and land use maps. A significant increase in total acreage of orchards and vineyards and a significant decrease in total acreage of alfalfa and irrigated pasture occurred from 1970 to 1994. Changes in raptor abundance that may have been due to the changes in vegetation were observed. Red-tailed hawk (*Buteo jamaicensis*) populations showed a significant increase in relative abundance from 28 % to 48 % ($P < 0.05$) while the indices for American kestrels (*Falco sparverius*) (48 % to 40 %) and northern harriers (*Circus cyaneus*) (23 % to 9 %) declined significantly ($P < 0.05$). The populations of ferruginous hawks (*Buteo regalis*) and Swainson's hawks (*Buteo swainsoni*) showed no significant change in abundance.

Key words: raptor, survey, population, Fresno, Madera, Merced.

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INTRODUCTION

Roadside raptor surveys have historically been used to establish indices of relative abundance of wintering raptors between areas and time periods (Leopold 1942, Johnson and Enderson 1972), and to estimate total populations of raptors (Woffinden and Murphy 1977). Knowledge of the raptor density of an area may be useful as an indicator of the integrity of the ecosystem (Odum 1971). Roadside raptor surveys are most reliable when conducted in areas of open vegetation (Millsap and LeFranc 1988).

The focus of our present research was to survey wintering raptors in the central San Joaquin Valley. Information about the current status of the red-tailed hawk, American kestrel, northern harrier, ferruginous hawk, and Swainson's hawk in an area where the major land use is agricultural, is necessary to establish trends on the effect changing land use patterns may have on migratory wintering raptor populations; although other factors may cause changes in raptor populations including food availability and weather.

The purpose of our survey was to establish a set of long-term baseline data during the period that migratory raptors use the San Joaquin Valley (Woffinden and Murphy 1977). Secondly, it was to establish an index of relative abundance, and to estimate the total popula-

tion of wintering raptors throughout the study area. Data exists on wintering raptors in the central region of the San Joaquin Valley in an intensely cultivated area of Madera County (Porteous 1991, Yancey 1991). However, a similar set of data covering what is essentially an east to west transect through Fresno, Madera, and Merced counties does not exist. The data obtained during our research may prove useful for establishing trends on agricultural land use and its relation to wintering raptor populations in the San Joaquin Valley.

STUDY AREA

The eastern route of this survey (which passed primarily through the foothills of the Sierra Nevada) was known as the Madera 1 route and began at the junction of Highways 41 and 145. The majority of this route consisted of native or undisturbed vegetation that has remained relatively unchanged since the California Department of Fish and Game began surveying the area in 1971. The route still consists of native grassland, oak woodland and foothill pine forest (*Pinus sabiniana*), and extensive rangeland. Most of the rangeland is used as grazing pasture while the remaining portion includes the San Joaquin Experimental Range where limited grazing occurs. Construction of houses and other structures has occurred along the route, primarily on the outskirts

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of the city of Madera near the end of the route. During the period of this study a graded dirt road was also made through oak woodland in the foothills along Road 406 between Highway 41 and Road 400. Total distance for this route was 62 km. Data from the surveys of this route were analyzed separately from the other routes which passed through areas where the primary land use was agricultural.

The central route of this survey (the Madera 2 route) began in the Bonadelle Ranchos at Avenue 17 and Road 38, 4.8 km west of the starting point of the Madera 1 route. This route proceeded west to Highway 99 passing through areas of agricultural, industrial, and residential land uses. Once west of Highway 99 the land use was primarily agricultural, consisting of alfalfa or irrigated pasture-land, fallow cropland, orchards, or vineyards. Approximately 43.5 km west of the starting point the land use was rangeland for 16 km. The route then turned southeast and proceeded along Drive 7 to the San Joaquin River, 6.5 km northeast of the city of Mendota. Total distance for this route was 82 km.

The western route of this survey (the Los Banos route) began at San Diego Road, 1.6 km north of Belmont Avenue and 5 km west of the city of Mendota. The route then proceeded southwest for 27.4 km primarily through fallow cropland, crossed the California Aqueduct once, then proceeded northwest for 57 km through alfalfa or irrigated pasture-land, fallow cropland, orchards, vineyards, vegetable crops, and some riparian habitat along Panoche Creek. The route crossed the California Aqueduct once again near the end of the route, 4.8 km from the junction of Interstate 5 and Mercy Hot Springs Road. High voltage towers positioned parallel to the California Aqueduct and Interstate 5 provided perch sites with suitable habitat for foraging raptors. Total distance for this route was 86 km.

METHODS

This research was modeled after roadside raptor surveys conducted annually by the California Department of Fish and Game from 1970 to 1986. A total of 18 surveys were made along 3 routes by automobile, 6 surveys per route, and 3 times beginning at opposite ends of each route.

Prior to and upon completion of each survey, the temperature, wind speed, wind direction, percent cloud cover, and foot-candle light measurements were taken and recorded. Each survey was conducted by 2 observers using 10 x 50 binoculars and a 20X spotting scope whenever positive identification was not possible with binoculars. All raptors within 0.5 km of each side of the road were counted and identified to species. Vehicle speed on all surveys averaged between 8 and 16 kmph. Field guides were used as a reference for identification of some

raptors (Scott 1987, Peterson 1990). The land use directly beneath each raptor whether perched or in flight was recorded (Craighead and Craighead 1956).

A chi-square analysis was performed to determine if a significant change in species abundance had occurred in the study area since the time period 1970 to 1972 (Sokal and Rohlf 1973). Differences in the survey sample size between the 2 time periods required that chi-square analysis be done on the average number of raptors observed per period. An estimate of the population size for each species was calculated using the bounded count method (Overton 1971). An index of relative abundance (IRA) that is useful when compared to similar areas and time periods (Anderson et al. 1985) was calculated using the equation employed by Woffinden and Murphy (1977):

$$IRA = \frac{\text{Total number of a species observed}}{(\text{Total kilometers traveled}) \times (\text{Total number of replicated surveys})} \times 1000$$

Land use patterns since 1970 throughout the study area were determined using aerial photographs from the Farm Service Agency, and land use maps from the California Department of Water Resources. A chi-square analysis was performed to determine if a significant change in land use acreage had occurred in the study area since 1970.

RESULTS

The vegetation along the Madera 1 route was essentially the same as it was when the California Department of Fish and Game surveys began in 1970: there was no significant change in the vegetation along this route from 1970 to 1994. Chi-square analysis of the vegetation along this route showed no significant change in rangeland ($X^2 = 0.38$; $df = 1$; $P < 0.05$), orchard ($X^2 = 2.67$; $df = 1$; $P < 0.05$), or irrigated pasture-land ($X^2 = 0.29$; $df = 1$; $P < 0.05$). There was no measurable change in the total acreage of foothill pine and riparian vegetation along this route.

Chi-square analysis of the raptors observed along the Madera 1 route in each of these time periods showed a significant increase in the number of red-tailed hawks ($X^2 = 26.74$; $df = 1$; $P < 0.05$), American kestrels ($X^2 = 6.69$; $df = 1$; $P < 0.05$), and northern harriers ($X^2 = 3.92$; $df = 1$; $P < 0.05$). The IRA calculated for each raptor species along this route was: red-tailed hawk, 771.5; American kestrel, 209.7; northern harrier, 2.7; ferruginous hawk, 5.4; and Swainson's hawk, 2.7 (Table 1). The heavy use of foothill pine as territorial perches by red-tailed hawks, and territorial behavior such as circling and screaming, in the vicinity of the San Joaquin

Experimental Range, was similar to observations made by Fitch et al. (1946).

The vegetation along the Madera 2 route in 1970 consisted of 25.1 % alfalfa or irrigated pasture-land, 33 % fallow cropland, 2.5 % orchard, 30.8 % rangeland, 0.4 % riparian, and 8.2 % vineyard. The vegetation along this route in 1994 consisted of 11.7 % alfalfa or irrigated pasture-land, 41 % fallow cropland, 8.1 % orchard, 11.2 % rangeland, 0.4 % riparian, 18.3 % vineyard, and 9.3 % industrial or residential. The IRA calculated for each raptor species observed along this route was: red-tailed hawk, 392.3; American kestrel, 327.2; northern harrier, 77.2; ferruginous hawk, 14.2; and Swainson's hawk, 12.2.

The vegetation along the Los Banos route in 1970 consisted of 16.4 % alfalfa or irrigated pasture-land, 75 % fallow cropland, 3.7 % orchard, 3.7 % rangeland, 0.5 % riparian, and 0.7 % vineyard. By 1994 the vegetation along this route consisted of 7.5 % alfalfa or irrigated

pasture-land, 72.7 % fallow cropland, 6.6 % orchard, 3.7 % rangeland, 0.5 % riparian, 4.5 % vineyard, and 4.5 % vegetable crops. The IRA calculated for each raptor species observed along this route in 1994 was: red-tailed hawk, 420.5; American kestrel, 315.9; northern harrier, 34.9; ferruginous hawk, 9.7; and Swainson's hawk, 5.8.

The raptors observed along the Madera 2 and Los Banos routes from 1970 - 1972 and 1994 showed a significant increase in the number of red-tailed hawks ($X^2 = 14.17$; $df = 1$; $P < 0.05$), a significant decrease in the number of American kestrels ($X^2 = 5.5$; $df = 1$; $P < 0.05$), and a significant decrease in the number of northern harriers ($X^2 = 5.67$; $df = 1$; $P < 0.05$). No significant change in ferruginous hawk ($X^2 = 0.22$; $df = 1$; $P < 0.05$) or Swainson's hawk ($X^2 = 0.57$; $df = 1$; $P < 0.05$) populations was observed along these routes. The vegetation along the Madera 2 and Los Banos routes showed significantly more orchard ($X^2 = 7.3$; $df = 1$; $P < 0.05$) and

Table 1. Indices of relative abundance and population estimates of raptors observed during the winter of 1993-94 along 3 survey routes in Fresno, Madera, and Merced counties, California.

Species of raptor	Number of raptors observed	Index of relative abundance ^a	Population size (bounded) ^b	Confidence ^c interval
Madera 1 Route (62 km)				
Red-tail	287	771.5	(73 - 529)	36.9 - 58.8
Kestrel	78	209.7	(23 - 175)	7.8 - 18.2
Harrier	1	2.7	(1 - 20)	0 - 1.4
Ferruginous	2	5.4	(1 - 20)	0 - 0.7
Swainson's	1	2.7	(1 - 20)	0 - 0.4
Madera 2 Route (82 km)				
Red-tail	193	392.3	(41 - 136)	26.8 - 37.6
Kestrel	161	327.2	(32 - 127)	22.9 - 30.7
Harrier	38	77.2	(13 - 127)	3.5 - 9.2
Ferruginous	7	14.2	(3 - 22)	0.2 - 2.1
Swainson's	6	12.2	(2 - 21)	0.3 - 1.7
Los Banos Route (86 km)				
Red-tail	217	420.5	(58 - 457)	26.5 - 45.9
Kestrel	163	315.9	(35 - 149)	19.2 - 28.5
Harrier	18	34.9	(6 - 25)	1.1 - 4.9
Ferruginous	5	9.7	(2 - 21)	0.1 - 1.6
Swainson's	3	5.8	(3 - 60)	0 - 1.5

^a See text for calculation of index

^b Calculation based on Overton 1971.

^c alpha = 0.05

vineyard ($X^2 = 7.4$; $df = 1$; $P < 0.05$); and significantly less alfalfa or irrigated pasture-land ($X^2 = 3.7$; $df = 1$; $P < 0.05$).

DISCUSSION

The changes observed in the number of red-tailed hawks, American kestrels, and northern harriers between 1970 - 1972 and 1994 along the Madera 2 and Los Banos routes may be a consequence of changes in land use patterns. Change from rangeland and heavily irrigated crops like alfalfa or pasture-land to long-term land uses such as orchards and vineyards may reduce some raptors' foraging efficiency. Also, fewer prey may be available due to more intense farming techniques and reduced availability from better concealment due to the cover of foliage (Bechard 1982).

Another explanation for the differences observed may be using a small set of data collected by the California Department of Fish and Game to make comparisons between time periods. As a result, any conclusions should be made with caution.

Fourteen ferruginous hawks were observed along all 3 routes (Table 2). The majority of these sightings occurred along the Madera 2 and Los Banos routes. The number of sightings per survey in 1994 was similar to those observed per survey from 1970 to 1986. However, the decline in available foraging and nesting habitat for this species due to the conversion of rangeland and native grassland began before Fish and Game surveys and our research was conducted, but may pose a continuing threat to the long-term status of this raptor in California.

Ferruginous hawk populations may be declining in many areas of the state of California but showed no significant decline throughout our study area.

The Swainson's hawk is believed to winter primarily in South America (Scott 1987). However, during 1994 surveys Swainson's hawks were observed along all 3 routes. Swainson's hawk sightings were reported along the Madera 2 and Los Banos routes beginning in 1970. These raptors may represent a portion of a larger population of Swainson's hawks observed intermittently by other researchers during the winter since 1990 on the Sacramento River delta, possibly moving south in response to climactic conditions, or they may represent an entirely different population of Swainson's hawks (Sebastian Herzog and Waldo Holt, pers. comm.). Further research is needed to determine this species status. One Swainson's hawk was observed along the Madera 1 route near the Fresno River in 1994. The majority of sightings were made within 25 km of the San Joaquin River which represented the only lengthy stretch of continuous riparian habitat in this part of the San Joaquin Valley considered typical nesting habitat for the Swainson's hawk (Estep 1989).

MANAGEMENT IMPLICATIONS

Changes in land use patterns over previous decades may have played a role in the red-tailed hawk becoming the dominant Buteo of the region (Houston and Bechard 1984), and very likely influences the current distribution and abundance of ferruginous and Swainson's hawks in California.

Table 2. Raptors observed during the winter of 1993-94 along 3 survey routes in Fresno, Madera, and Merced counties, California.

Species	Routes			
	Madera 1	Madera 2	Los Banos	Total
Red-tailed hawk	287	193	217	697
American kestrel	78	161	163	402
Northern harrier	1	38	18	57
Ferruginous hawk	2	7	5	14
Swainson's hawk	1	6	3	10
Prairie falcon (<i>Falco mexicanus</i>)	3	2	0	5
White-tailed kite (<i>Elanus caeruleus</i>)	0	1	4	5
Golden eagle (<i>Aquila chrysaetos</i>)	3	1	0	4
Bald eagle (<i>Haliaeetus leucocephalus</i>)	1	2	0	3
Peregrine falcon (<i>Falco peregrinus</i>)	0	0	1	1
Sharp-shinned hawk (<i>Accipiter striatus</i>)	1	0	0	1
Merlin (<i>Falco columbarius</i>)	0	0	1	1
Unidentified raptor	40	32	27	99
Total	417	443	439	1299

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