

## NEST-SITE SELECTION AND REPRODUCTIVE PERFORMANCE OF URBAN-NESTING SWAINSON'S HAWKS IN THE CENTRAL VALLEY OF CALIFORNIA

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**ABSTRACT.**—From 1990–94, we studied Swainson's hawks (*Buteo swainsoni*) nesting in the cities of Davis and Stockton and in adjacent rural habitats in California's Central Valley. We documented 31 urban nesting attempts at 16 sites in Davis and 34 nesting attempts at 24 sites in Stockton. Most were located in residential neighborhoods (Davis 81%, Stockton 71%) with the remainder in park-like landscapes or commercial/industrial settings. Nests were found more frequently in neighborhoods >20 yr old, with areas >45 yr old preferred due to the availability of mature landscaping. Three nests were found in neighborhoods <20 yr old, all in trees that predated urbanization. Nest trees were significantly taller than a random sample in 20–45-yr-old neighborhoods, but not in areas >45 yr old. Conifers were preferred over other trees in Davis (79%) and Stockton (94%) regardless of neighborhood age; conifers may provide better visual screening from below than other tree types. Fewer young fledged from nests in urban than in rural settings ( $P < 0.05$ ). The proportion of nesting attempts resulting in at least one fledgling, and the number of young fledged per nesting attempt and per successful nest for urban nests were among the lowest reported for this species. Swainson's hawk nests have not been found in apparently suitable urban areas in the Central Valley where foraging habitat is unavailable for 5–8 km (e.g., Lodi and Sacramento), thus requiring long-distance transport of prey throughout the entire nesting cycle. Rapid urbanization or crop changes near cities could cause the long-term decline of Swainson's hawks in existing urban neighborhoods.

**KEY WORDS:** *Buteo swainsoni*; California; nest-site selection; reproductive success; Swainson's hawk; urban-nesting.

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Selección del sitio de nidificación y características reproductivas de *Buteo swainsoni* urbano-nidificantes en el Valle Central de California

**RESUMEN.**—Desde 1990 a 1994, estudiamos individuos de *Buteo swainsoni* nidificantes en las ciudades de Davis y Stockton, además de hábitat rurales adyacentes en el Valle Central de California. Documentamos 31 nidos urbanos en 16 sitios localizados en Davis y 34 nidos en 24 sitios de Stockton. La mayoría de los nidos fueron localizados en vecindarios residenciales (81% en Davis y 71% en Stockton), el remanente se ubicó en paisajes parecidos a parques o en sitios comerciales e industriales. Los nidos fueron encontrados más frecuentemente en vecindarios de más de 20 años de antigüedad, con áreas mayores a 45 años de antigüedad, preferidas debido a la disponibilidad de paisajes maduros. Tres nidos fueron encontrados en vecindarios con menos de 20 años de antigüedad y todos ubicados en árboles. Los árboles con nidos fueron significativamente más delgados que los obtenidos en una muestra azarosa en un vecindario de 20 a 45 años de antigüedad, pero no en áreas mayores a 45 años de edad. Las coníferas fueron preferidas sobre otros tipos de árboles en Davis (79%) y Stockton (94%) independientemente de la edad del vecindario; las coníferas proveen un mejor campo visual que otros tipos de árboles. El número de juveniles producidos en nidos urbanos era menor a los producidos en asentamientos rurales ( $P < 0.05$ ). La proporción de nidificaciones resultantes en al menos un volantón y el número de juveniles por nidificación y por nido

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exitoso para nidos urbanos, se encuentra entre los más bajos reportados para esta especie. Nidos de *B. swainsoni* no han sido encontrados en áreas urbanas aparentemente apetecibles en el Valle Central, donde los hábitat de forrajeo no están disponibles en 5 a 8 km (e.g., Lodi y Sacramento) así necesitan transportar grandes distancias sus presas. La rápida urbanización o cambios en las cosechas cerca de las ciudades podría causar una declinación a largo plazo de *B. swainsoni* en los vecindarios urbanos existentes.

[Traducción de Ivan Lazo]

In their reviews of the biology of the Swainson's hawk (*Buteo swainsoni*), neither Bent (1937) nor Palmer (1988) reported nesting in an urban setting. The first documented record of urban-nesting Swainson's hawks was in a Fremont cottonwood (*Populus fremontii*) in Davis, California in 1979 (Peter H. Bloom pers. comm.). Subsequently, James (1992) reported five successful urban nests found between 1988 and 1991 in Regina, Saskatchewan.

The California Department of Fish and Game (CDFG) classifies the Swainson's hawk as a threatened species. To understand why this species has declined in California, considerable research has been focused on its population, nesting, and foraging ecology in the Central Valley (Bloom 1980, Schlorff and Bloom 1984, Estep 1989, Risebrough et al. 1989, and Babcock 1995). Recent surveys in the Central Valley have revealed that Swainson's hawks regularly nest in certain urban settings in Sacramento, San Joaquin, Solano, and Yolo counties. They are not known to nest regularly in urban settings in either the more northern or southern portions of the Central Valley.

From 1990 through 1994, we studied urban-nesting Swainson's hawks in two cities in the Central Valley—Davis (Yolo County) and Stockton (San Joaquin County)—and in the surrounding agricultural landscape. We wanted to answer three primary questions: (1) What nest-site characteristics are the hawks selecting by tree type, tree height, and age of the surrounding urban neighborhood? (2) Do they fledge as many young as hawks that select nest sites in agricultural habitats? and (3) Why do Swainson's hawks nest in some Central Valley communities and not in others?

#### STUDY AREAS AND METHODS

We monitored the reproductive performance of nesting Swainson's hawks on two study areas in the Central Valley of California from 1990 through 1994 (Fig. 1). The Yolo County area covered approximately 346 km<sup>2</sup>, and more than 90% of it was in irrigated agriculture. The diverse mixture of crops was dominated by annual species including tomatoes, beets, grains, alfalfa, sunflower, and safflower. Orchards, vineyards and other perennial crops and also dry and irrigated pastures were <2% of the

landscape. Native habitats were restricted almost exclusively to narrow bands of riparian vegetation along water courses, and small, isolated stands of valley oak (*Quercus lobata*). Two urban areas, Davis and Woodland, constituted approximately 5% of the study area and were surrounded by agricultural landscape.

The San Joaquin County study area covered approximately 390 km<sup>2</sup>. Approximately 37% was urbanized land within Stockton, and the remainder was agricultural land (Fig. 1). The composition and diversity of crops were similar to the Yolo County study area. Native habitats also were limited to small, isolated stands of valley oak and riparian vegetation confined by flood control levees along stream courses.

Nest surveys were conducted each year from early April through June by inspecting all potential nesting habitat including nest sites occupied in previous years. Occupied nests were revisited at least once between mid-July and late August to count young fledged. Chicks reaching fledgling size were presumed to have fledged successfully (Steenhof and Kochert 1982). Nest sites were defined as urban if the nest was immediately adjacent to urban land uses and <250 ha of agricultural or undeveloped land was found within 1.5 km of the nest. The ages of neighborhoods in Davis were determined from 1952, 1975, and 1993 street maps and in Stockton from 1934, 1975, and 1993 street maps.

In 1994, we characterized existing trees in Davis at 198 points stratified by neighborhood age and spaced a minimum of 0.25 km apart. At each point, we recorded whether the nearest tree and the tallest tree within 50 m were conifers, and the height of the tallest tree within 50 m. The same data were recorded for all urban nest trees in Davis.

Nest productivity data were not distributed normally and could not be transformed for analysis with parametric statistical procedures. A one-tailed Wilcoxon matched-pairs signed-ranks test was used to compare nest productivity between rural and urban nests (Daniel 1990). The results of this nonparametric test were conservative because considerable information was lost by reducing the data to ranks of the annual differences in nesting success.

#### RESULTS AND DISCUSSION

The 31 urban-nesting attempts recorded from 1990–94 in Davis occurred at 16 different sites (Table 1). Similarly, the 34 urban-nesting attempts in Stockton occurred at 24 different sites. The most common setting (81% in Davis and 71% in Stockton) was in the yards of homes in residential neighborhoods (Fig. 2). In both cities, nests were also found

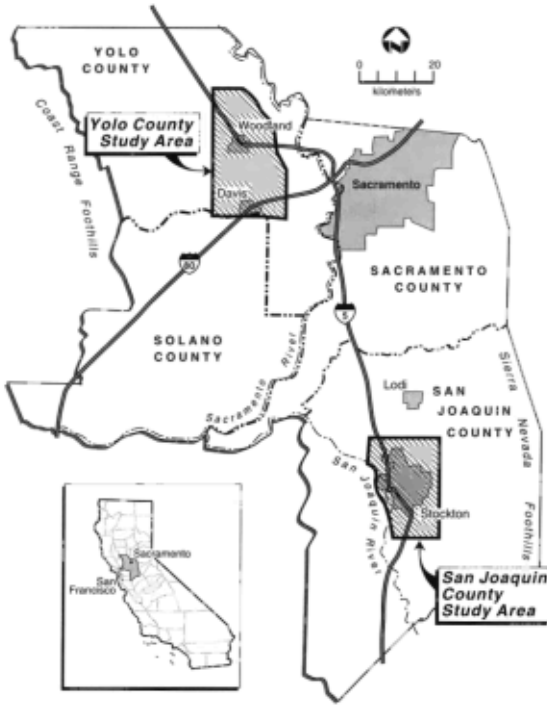


Figure 1. Location of the Yolo and San Joaquin study areas and urban centers in the Central Valley of California.

in park-like landscapes (19% in Davis and 17% in Stockton) such as golf courses, cemeteries, and on the central campus at the University of California, Davis. However, nests were notably absent from all urban parks. Three nests in Stockton were in commercial and industrial settings—two next to major intersections in commercial areas (Fig. 2), and one between State Highway 99 and the on- and off-ramps to the freeway. The settings for urban nest sites in the Central Valley were similar to those described by James (1992) in Regina, Saskatchewan. The level of human activity varied considerably between the sites, but was ongoing and highly predictable throughout the nesting season including during courtship and nest-site selection. Thus, urban-nesting Swainson's hawks selected sites with adjacent human activities and habituated to the setting from the beginning of the nesting cycle.

**Nest-site Selection.** Swainson's hawk nests in trees that postdated urbanization were found more frequently in neighborhoods >20 yr old than expected by chance in Davis (Fisher Exact Test,  $P = 0.041$ ) and nearly so in Stockton (Fisher Exact Test,  $P = 0.051$ ; Table 2). Neighborhoods >45 yr old were preferred, and nesting did not occur in neighborhoods <20 yr old except at three locations in Stockton where large, old trees that predated urbanization were used (Table 2). In Davis and Stockton, the

Table 1. Reproductive performance of urban- and rural-nesting Swainson's hawks in the Yolo and San Joaquin County study areas.

STUDY AREA/ YEAR	URBAN			RURAL		
	NESTING ATTEMPTS	SUCCESSFUL NESTS	YOUNG FLEDGED	NESTING ATTEMPTS	SUCCESSFUL NESTS	YOUNG FLEDGED
Yolo County (Davis urban nests)						
1990	6	5	9	68	64	109
1991	8	6	9	86	74	116
1992	5	2	3	116	94	143
1993	4	2	4	94	66	105
1994	8	7	11	128	106	190
Total	31	22	36	492	404	663
San Joaquin County (Stockton urban nests)						
1990	3	1	2	13	11	24
1991	5	3	3	12	9	11
1992	5	5	9	10	7	12
1993	9	5	8	9	7	14
1994	12	8	14	16	14	22
Total	34	22	36	60	48	83



Figure 2. Typical settings for urban Swainson's hawk nests: (A) Deodar cedar (*Cedrus deodara*) in a commercial/industrial neighborhood, Stockton, Calif.; (B) introduced pine (*Pinus* sp.) in a residential neighborhood, Davis, Calif.

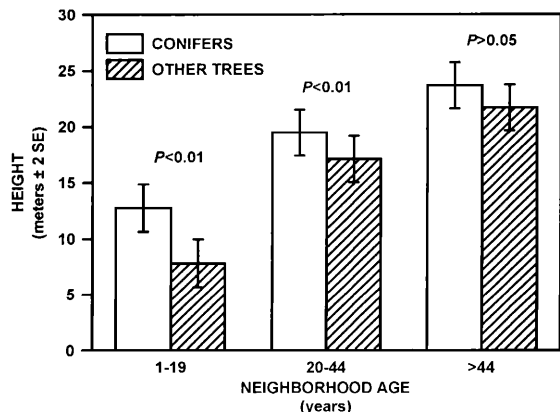


Figure 3. Height comparison from a random sample of the tallest trees stratified by tree type and neighborhood age in Davis, California. Significant effects were due to tree type, neighborhood age, and the interaction between these two variables (ANOVA,  $F = 83.2$ ,  $P < 0.001$ ).

proportion of nest trees that predated urbanization was inversely related to neighborhood age, with no preexisting trees used in neighborhoods >45 yr old. This pattern of nest tree selection is presumed to be related to the absence of potential nest trees of suitable size in younger neighborhoods. In 20–45-yr-old Davis neighborhoods, the mean height of nest trees (22.4 m) differed from a random sample of the

Table 2. Distribution of nest trees used by urban-nesting Swainson's hawks in Davis and Stockton, California, compared with age and size of neighborhoods.

CITY/ NEIGHBORHOOD AGE	AREA (ha)	NEST TREES	PRE-EXISTING NEST TREES <sup>a</sup>
Davis			
≤1951	300 (9.9%) <sup>b</sup>	5 (31.3%) <sup>b</sup>	0%
1952–75	1585 (52.3%)	11 (68.8%)	18%
1976–94	1143 (37.8%)	0 (0.0%)	—
Total	3028	16	
Stockton			
≤1934	3494 (24.4%)	11 (45.8%)	0%
1935–75	7464 (52.1%)	10 (41.7%)	40%
1976–94	3364 (23.5%)	3 (12.5%)	100%
Total	14 322	24	

<sup>a</sup> Percentage of nest trees older than the age of the neighborhood.  
<sup>b</sup> Percent of the total area.

Table 3. Proportion of urban nests placed in conifers compared to random samples drawn from all trees and the tallest trees in different age neighborhoods in Davis, California.

NEIGHBORHOOD AGE	PROPORTION IN CONIFERS		
	NEST TREES	ALL TREES <sup>a</sup>	TALLEST TREES <sup>a</sup>
<1950	1.00	0.03 <sup>c</sup>	0.37 <sup>c</sup>
1951–75 <sup>b</sup>	0.67	0.27 <sup>d</sup>	0.56 <sup>c</sup>
1976–94	—	0.20	0.38

<sup>a</sup> Binomial test comparison to proportion of nest trees.  
<sup>b</sup> Excludes two nests in trees that predated development.  
<sup>c</sup>  $P < 0.01$ .  
<sup>d</sup>  $P < 0.05$ .  
<sup>e</sup>  $P > 0.05$ .

tallest (18.7 m;  $t = 2.77$ ,  $P < 0.01$ ), indicating that Swainson's hawks selected the tallest trees in intermediate age neighborhoods. In neighborhoods >45 yr old, this comparison was 24.1 m versus 22.4 m ( $t = 0.75$ ,  $P > 0.46$ ), indicating no significant difference between the height of trees that were selected by Swainson's hawks and a random sample of the tallest trees.

Outside urban areas in the Central Valley, most Swainson's hawk nests have been reported in Fremont cottonwood or valley oak (Schlorff and Bloom 1984, Estep 1989). Urban nests that postdated urbanization were primarily in conifers in Davis (79%) and Stockton (94%). In Davis, conifers were selected more frequently than expected based on their relative abundance in the urban landscape (Table 3). Conifers were taller than other trees in neighborhoods <45 yr old (Fig. 3) suggesting the preference may be for the tallest trees and not specifically for conifers. However, in neighborhoods >45 yr old, conifers were not significantly taller than other tree types (Fig. 3), but Swainson's hawks' nests were found in conifers more frequently than expected based on conifer abundance (Table 3).

James (1992) noted that three of four nest trees in Regina, Saskatchewan, were in conifers. He stated this pattern was opposite of that found in more typical habitats (Schmutz et al. 1980 and Bechard et al. 1990). However, Swainson's hawks will nest in conifers if present. Bechard et al. (1990) provided an unranked list of nest trees that included ponderosa pine (*Pinus ponderosa*) and western juniper (*Juniperus occidentalis*). Bloom (1980) reported that most

Swainson's hawk nests were found in junipers (*Juniperus* sp.) in the Great Basin portion of north-eastern California. In the Central Valley, conifers were present only in urban settings and around some farmhouses. We speculate that Swainson's hawks prefer conifers in urban settings because the dense foliage and radial branching pattern provide more complete visual screening from human activities below the nest than trees with leaves only near branch tips and a dendritic branching pattern.

**Reproductive Performance.** Urban-nesting Swainson's hawks in the Yolo County study area fledged fewer young per nesting attempt each year than rural-nesting hawks (Fig. 4). The same relationship was observed in 4 of 5 yr in the San Joaquin County study area (Fig. 4). Analysis of these patterns using a one-tailed Wilcoxon matched-pairs signed-ranks test showed a significant difference in Yolo County ( $T_- = 0, P < 0.05$ ) but not in San Joaquin County ( $T_- = 3, P = 0.16$ ). However, five was the minimum sample size required for this non-parametric test, and the number of young fledged needed to be lower for urban nests in all 5 yr to yield a significant difference. The inability to confirm statistical significance for Stockton was likely a result of small sample size. Pooling the results from the two study sites also showed that fewer young were fledged from nests in urban settings ( $T_- = 7, P < 0.05$ ).

The proportions of successful nests (those that fledged at least one young) in both Davis and Stockton were lower than on adjacent rural lands, and among the lowest when compared to other reported

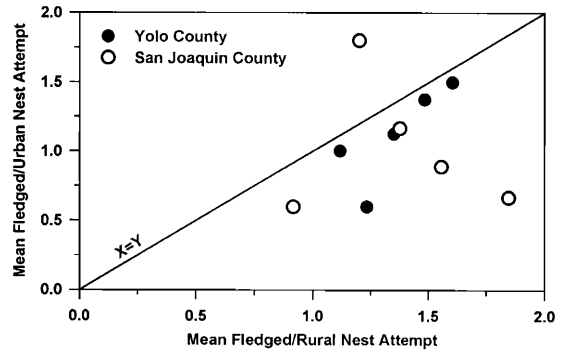


Figure 4. Mean number of young fledged, 1990 through 1994, from urban and rural nests in the San Joaquin and Yolo County study areas. Diagonal line indicates equal reproductive success at urban and rural nest sites.

multi-year studies (Table 4). The number of young fledged per nesting attempt and per successful nest for urban nests were also among the lowest reported values. Rural nests in Yolo and San Joaquin counties had similar success rates and number of young fledged per nesting attempt compared with other studies. However, the number of young per successful rural nest was similar to urban nests and lower than values reported at other locations.

**Nesting in Other Central Valley Towns.** Swainson's hawks also nest in the older neighborhoods of several major urban areas in the Central Valley portions of Sacramento, San Joaquin, Solano, and Yolo counties (Table 5). They are conspicuously absent, however, from the City of Lodi and the Sac-

Table 4. Reproductive performance of Swainson's hawks outside California compared to reproductive performance of Swainson's hawks in the Yolo and San Joaquin County study areas. All studies conducted for at least 3 yr.

LOCATION	YEARS	NEST ATTEMPTS	SUCCESSFUL NESTS (%)	FLEDGED/ ATTEMPT	FLEDGED/ SUCCESSFUL	SOURCE
SE Washington	3	48	81.3	1.50	1.85	Fitzner (1978)
NE Colorado	3	119	54.6	1.19	2.18	Olendorff (1978)
SE Alberta	3	153	71.2	1.41	1.98	Schmutz et al. (1980)
SE Washington	5	96	—	1.11	—	Bechard (1983)
SE New Mexico	3	36	81.0	1.67	1.94	Bednarz (1988)
Yolo County <sup>a</sup>	5	492	82.1	1.35	1.64	This study
San Joaquin Co. <sup>a</sup>	5	60	80.0	1.38	1.73	This study
City of Davis <sup>b</sup>	5	31	70.9	1.16	1.64	This study
City of Stockton <sup>b</sup>	5	34	64.7	1.06	1.64	This study

<sup>a</sup> Rural nest sites.  
<sup>b</sup> Urban nest sites.

Table 5. Breeding status of urban-nesting Swainson's hawks in major urban areas in the Central Valley portion of Sacramento, San Joaquin, Solano, and Yolo Counties, California.

CITY	1993 POPULATION <sup>a</sup>	URBAN-NESTING SWAINSON'S HAWKS?
Woodland	41 850	Yes
Davis	50 100	Yes
Lodi	53 700	No
Stockton	226 300	Yes
Sacramento <sup>b</sup>	1 068 900	Urban edge only

<sup>a</sup> California Department of Finance 1993.

<sup>b</sup> Sacramento metropolitan area.

ramento metropolitan area. Numerous field surveys ranging from CDFG-sponsored efforts to environmental assessments have failed to detect urban-nesting Swainson's hawks in either of these locations. Both communities were established before the turn of the century and have old neighborhoods with apparently suitable habitat for urban nests.

Besides providing suitable nesting habitats, the cities that support urban-nesting Swainson's hawks are surrounded by crops that are suitable Swainson's hawk foraging habitat. However, Lodi is nearly surrounded by vineyards for 8–10 km, a crop type not used for foraging by Swainson's hawks (Estep 1989). The older neighborhoods of Sacramento are similarly encompassed by at least 5–8 km of urban development. Swainson's hawks do nest in Sacramento, but are limited to a narrow band of riparian vegetation along the Sacramento River. Along most of its course through the city, the Sacramento River is at the interface between urban development and agricultural lands, and these nests are adjacent to suitable foraging habitat.

Estep (1989) and Babcock (1995) have shown that Swainson's hawks in the Central Valley of California will forage more than 15 km from a nest site. While these distant sites may be critical at times, long-distance foraging bouts are generally limited to periods when suitable foraging habitat is not available nearby due to crop phenology. Babcock (1995) observed prey caught at long distances from nest sites frequently was consumed by adult birds near the point of capture. Prey brought back to the nest to provision young or a mate was generally caught near the nest. Presumably this pattern is due to the energetic inefficiency of transporting prey long dis-

tances. Similarly, Swainson's hawks are extremely rare in the northern and southern portions of the Central Valley where potential nest sites in urban and rural settings are surrounded by vineyards, orchards, rice, and cotton, all unsuitable Swainson's hawk foraging habitat (Estep 1989). The energetic cost of transporting prey these distances throughout the nesting cycle apparently is too great.

**Land Use Changes and Urban Nesting.** As urbanization continues in the Central Valley, the availability of Swainson's hawk foraging habitat will decline and the remaining foraging habitat will be at greater distances from older neighborhoods with suitable nest sites. These two trends will typically increase the distance between foraging areas and urban nest trees. Thus, the energetic costs of nesting will increase and reproductive success may decline. The only foreseeable change counteracting these trends is that newer neighborhoods will mature and may become nesting habitat. If urban expansion occurs too quickly, urban-nesting birds may be lost as the distance from nest sites to foraging habitat becomes too great, typically >5–8 km in the study area. If the mixture of agricultural crops next to cities such as Davis or Stockton becomes less suitable for foraging, urban-nesting birds could be expected to decline if the distance to foraging habitat becomes too great. Agricultural land uses are typically dictated by market conditions and are not as easily predictable as future urbanization.

**Why Urban Nesting?** Why do Swainson's hawks nest in urban settings where reproductive success is lower? Two alternative hypotheses could explain this paradox. First, rural nesting habitat may be saturated. Competition for nest sites could force some birds into the less productive, urban habitat. This hypothesis is consistent with the observation that the highest concentrations of Swainson's hawks in the Central Valley are in Sacramento, San Joaquin, Solano, and Yolo counties (Bloom 1980, Estep 1989). However, a portion of rural nest sites are unoccupied each year. In neither study area was the number of urban nesting attempts correlated with the number of rural nesting attempts. This relationship might be expected if birds were forced into urban settings when the number of rural nest attempts was high. Second, reproductive success might be comparable or better in urban than in rural settings if parameters such as lifetime reproductive success or post-fledging survival are considered. For example, if the mortality of adults in urban settings is lower due to decreased

predation or a lower likelihood of being shot, then the expected lifetime reproductive success would be higher.

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