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HOME RANGE AND HABITAT USE OF BREEDING SWAINSON'S HAWKS IN THE SACRAMENTO VALLEY OF CALIFORNIA

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ABSTRACT.—Four adult Swainson's hawks (*Buteo swainsoni*) were radiotagged along the Sacramento River in 1992. The mean home range (minimum convex polygon) was 4038.4 ha (40.4 km²). Core areas of intensive use (adaptive kernal) by nesting Swainson's hawks ranged from 25.9–82.2 ha. Individual hawks foraged as far as 22.5 km from the nest. In the Sacramento Valley, foraging ranges and total home range area were strongly influenced by agricultural patterns and cover types. Ruderal and fallow fields, grain crops, and safflower were the vegetative cover types that ranked highest in foraging use. The predominance of less suitable cover types within the study area may explain the relatively large home ranges exhibited by the Swainson's hawks in this study.

KEY WORDS: Buteo swainsoni; *foraging ecology*; *habitat use*; *home range*; *Swainson's hawk.*

Rango de hogar y uso del hábitat de *Buteo swainsoni* reproductivos en el Valle Sacramento de California

RESUMEN.—En 1992, cuatro individuos adultos de la especie *Buteo swainsoni* fueron radio-marcados a lo largo del Río Sacramento, California. La media de rango de hogar (polígono convexo mínimo) fue de 4038.4 ha (40.4 km²). Areas núcleo de uso intensivo por parte de *B. swainsoni* se encontraban dentro de un rango de 25.9 a 82.2 ha. Los individuos de *B. swainsoni* se alimentaban en sitios distantes hasta 22.5 km del nido. En el Valle Sacramento, los rangos de forrajeo y el área total de rango de hogar, fueron fuertemente influenciados por patrones agrícolas y tipos de cubierta vegetacional. Campos ruderales y abandonados, cosechas de granos y cártamo fueron los tipos de cubiertas vegetativa de mayor uso como sitios alimentarios. La predominancia de cubiertas vegetales menos utilizadas en el sitio de estudio pueden explicar el rango de hogar relativamente grande exhibido por esta especie.

[Traducción de Ivan Lazo]

The Swainson's hawk (*Buteo swainsoni*) was common historically throughout most of the lowland grassland and riparian communities that once occupied the Central Valley of California (Grinnell and Miller 1944). However, an estimated 90% decline of the breeding population of this species in recent years (Bloom 1980) resulted in the listing of the Swainson's hawk in California as a threatened species. The current breeding range of the Swainson's hawk in California is generally comprised of two populations, one located in the Great Basin area in the northeastern corner of the state, and the other, larger population located primarily in the middle portion of the Central Valley (the Sacramento Valley) near Sacramento (Bloom 1980).

Very little is known about the breeding home range and foraging habitat requirements of the Swainson's hawk in the Sacramento Valley. And yet, this region is home to the highest concentration of Swainson's hawks in the state (Bloom 1980). Previous studies suggest that home-range sizes can vary significantly in response to agriculture, changes in prey availability, and various farming practices (Bechard 1982, Estep 1989, Woodbridge 1991). Using radiotelemetry, I determined home-range sizes, core-use areas, and habitat use of a small population of nesting Swainson's hawks in the Sacramento Valley.

STUDY AREA

This study was conducted in an open rural area within the city of West Sacramento, bordered on the east by the Sacramento River and the city of Sacramento. Agricultural cropland, pastureland, and areas of non-native grassland comprised the majority of the open space areas in the region. Common crop types included wheat, corn, tomatoes, alfalfa, onions, sugar beets, and safflower. Dense urban areas associated with West Sacramento and Sacramento occured to the north and east of the study area. Narrow riparian areas dominated by Frémont cottonwood (*Populus fremontii*), valley oak (*Quercus lobata*), walnut (*Juglans* sp.), willow (*Salix* sp.), and box elder (*Acer negundo*) occur along the Sacramento River to the east and along Putah Creek to the west. Isolated oak woodlands occur sporadically throughout the residential and agricultural areas.

METHODS

Swainson's hawks were trapped using dho-gazas (Hamerstrom 1963). A bal-chatri trap (Berger and Mueller 1959) and a noose carpet (Collister 1967) were used for a pair of Swainson's hawks that avoided the dho-gaza. All captured Swainson's hawks were weighed, sexed (determined by the presence or absence of a brood patch and by overall size and weight), and fitted with backpack transmitters weighing from 19.2–19.8 g. Radio signals were received using ICOM IC-03AT transceivers and three-element Yagi antennas. Each trapped hawk was also fitted with a numbered, colored plastic leg band and a standard U.S. Fish and Wildlife Service aluminum leg band.

Tracking began after each bird was fitted with a transmitter and released. In the Sacramento Valley, Swainson's hawks often congregate in large groups and begin migrating southward in September (Bloom 1980, Estep 1989). Tracking was discontinued on 31 August since home range and foraging information obtained after this period was not expected to be strongly correlated with nest territories. Each bird was followed from dawn until dusk at least 2 d/wk during the study period (1 June to 31 August).

Because of the very active and aerial nature of Swainson's hawks, these birds are regularly lost to view during periods of high-altitude soaring and straight flight. Data were recorded in 5-min intervals and only when the bird was visually observed. Behavioral information was recorded in terms of foraging or nonforaging. Foraging behavior included circling, hovering, stooping, and feeding. Nonforaging behavior included straight flight, perching (unless, because of location and habitat, it was considered foraging from a perch), incubating, and preening. Location points were plotted on aerial photographs containing field numbers for each cover type.

A geographic information system (GIS) was used to map land uses and observational points within the study area. Information associated with each observation (time, date, hawk number, vegetation type, behavior) were also incorporated into the database. Home range calculations for each radio-marked Swainson's hawk were later imported into the GIS database in order to create home-range polygons. These polygons were then overlain onto the study area map to enable analysis of hawk foraging habitat and to compare individual home ranges.

To avoid autocorrelation of data, only observations separated by at least 0.5-hr intervals were used to determine home ranges and habitat use. Lair (1987) suggested that observation points may be considered biologically independent if sufficient time has passed for the animal to have moved to a new location or, for the purposes of this study, to cross its home range. For this study it was estimated that it would take a Swainson's hawk no more than 0.5 hr to cross its home range.

Home ranges were calculated using the CALHOME program developed by J. Kie (unpubl.), and were based on field observations and locations plotted over the entire duration of the study. The home range of each hawk was determined using the minimum convex polygon (MCP) method. Because use of this method includes outlier location points (occasional or isolated movements to locations outside the normal use area) which tend to overestimate home-range sizes, a 95% contour level was used in order to exclude these points. A 50% contour level using the adaptive kernal (AK; Worton 1987) method was used for delineating core-habitat-use areas (those land areas that are used most extensively by nesting hawks as foraging habitat) within the home range. Core-use areas at the 50% MCP level were also determined for comparison.

To evaluate habitat use, information on the vegetative cover type or crop type at each Swainson's hawk observation point was also recorded. A chi-square analysis was used to compare Swainson's hawk habitat use with habitat availability.

RESULTS

Four adult Swainson's hawks, three males and one female (which was mated to one of the males), were trapped and radiotagged (Table 1). Attempts were made to trap all adults from the six pairs in the study area. The first hawk was trapped on 2 June 1992, and the last was trapped on 10 July 1992. Each radio-tagged hawk was tracked for an average of 138 hr over the duration of the study. The number of biologically independent points for each hawk ranged from 73–122.

Home Range and Core-Use Areas. Home ranges of the four radio-tagged hawks were relatively large (Table 1). At the 95% MCP contour level, home ranges varied from 723.6–7658.8 ha ($\bar{x}$ = 4038.4 ha, SD = 5348.4 ha, N = 4) and were linear in nature (Fig. 1). Home ranges of the three males were larger than that of the female, and averaged 5143.3 ha. The furthest any individual hawk foraged from the nest was 22.5 km.

The size (50% AK) of the core-habitat-use areas ranged from 25.9–82.2 ha ($\bar{x}$ = 48.2 ha, SD = 21.8 ha, N = 4) (Table 1). These core areas were generally located in the immediate vicinity of each nest. For comparison, mean core-use areas using the MCP technique was 86.5 ha (Table 1).

Habitat Use. Dominant cover types within the home ranges (100% MCP) of the radio-tagged Swainson's hawks were grain crops (17.4% of the total undeveloped land potentially available as Swainson's hawk foraging habitat), ruderal/fallow fields (16.3%), row crops (corn/milo/sudan grass; 10.9%), tomatoes (10.6%), and safflower (10.2%). When observed habitat use by the radio-tagged Swainson's hawks was compared to habitat availability, Swainson's hawks did not forage in a habitat in proportion to its availability, but were observed most often foraging over ruderal/fallow fields, alfalfa, and pastureland (χ^2 = 31.3, df = 11, P < 0.001).

Foraging Behavior. Both sexes of the radio-tagged

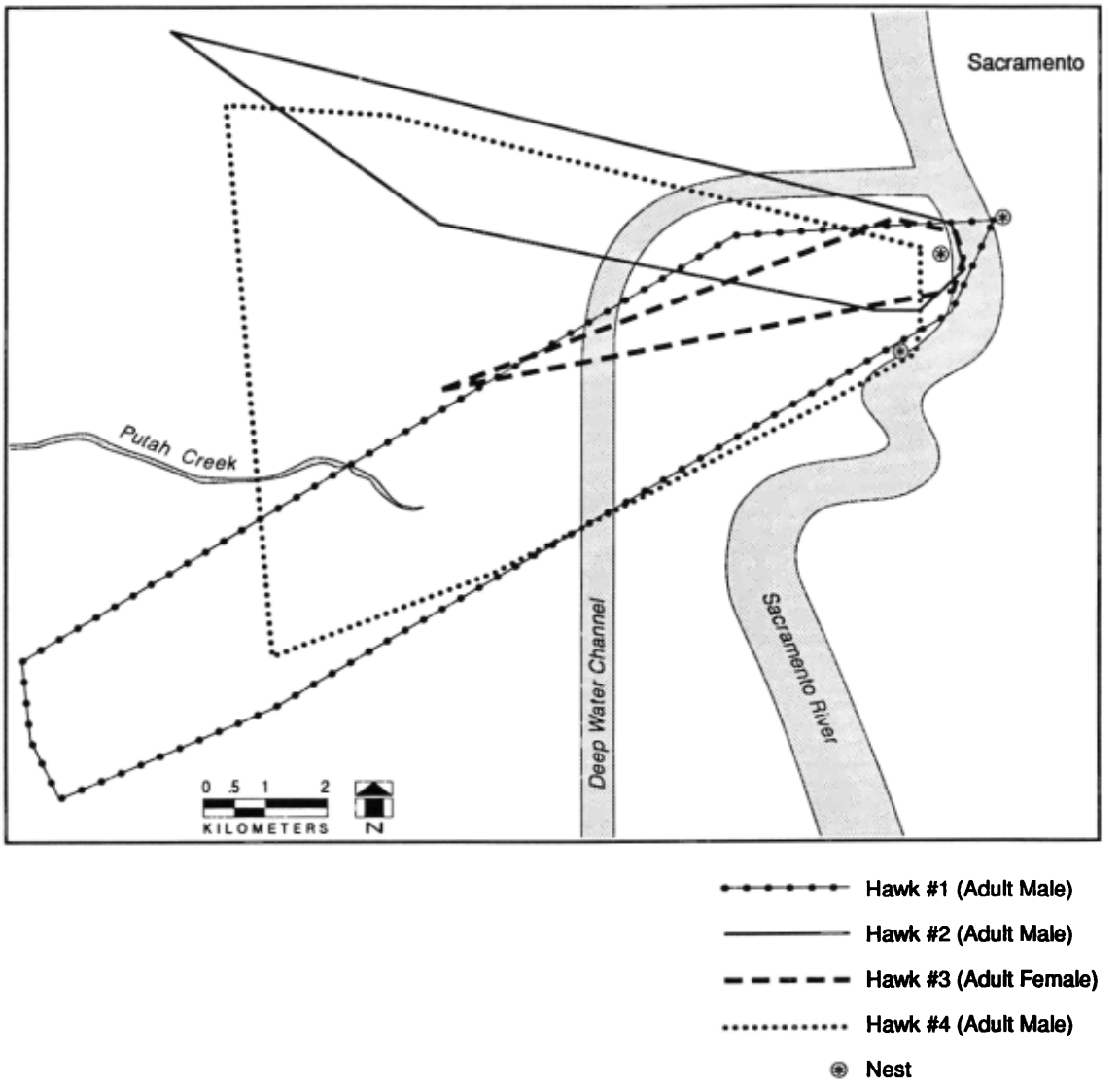

Figure 1. Nest locations and home range sizes (95% MCP) of four radio-tagged Swainson's hawks in the Sacramento Valley of California. Hawks #2 and #3 were mates.

Swainson's hawks were observed foraging almost exclusively from the air. The hawks were highly active and never spent much time over a particular field unless attracted by cutting or harvesting activities. In some instances, particularly in late July and August, large groups of Swainson's hawks, including one that contained approximately 130 individuals, were observed foraging over several adjacent fields that were undergoing some form of cutting or harvesting. Many of these birds appeared to be making shallow aerial stoops, apparently chasing and capturing flying insects.

After fields were cut, or in the case of some fields that were recently irrigated, radio-tagged hawks were often observed foraging from the ground. These birds would wait for a small rodent or insect to pass by,

Table 1. Home range information from radio-tagged Swainson's hawks in Yolo County, California, 1992.

HAWK SEX	CAPTURE DATE[a]	TOTAL HOURS TRACKED	TOTAL OBSERVATION POINTS	TOTAL FORAGING POINTS	TOTAL BIOLOGICALLY INDEPENDENT POINTS[b]	HOME RANGE (HA)[c]		
						95% MCP[d]	50% MCP	50% AK[e]
M	2 June	132	445	277	122	5339.0	21.0	32.7
M	10 July	120	380	268	80	2432.2	223.9	25.9
F	21 June	120	347	216	73	723.6	12.0	52.2
M	4 June	180	453	258	91	7658.8	88.9	82.2
Mean		138	406	255	92	4038.4	86.5	48.2

[a] Tracking ended 31 August.
[b] Total number of foraging points collected at a time interval (0.5 hr) sufficient to allow a radio-tagged Swainson's hawk to cross its home range.
[c] Based on biologically independent observation data.
[d] MCP = minimum convex polygon.
[e] AK = adaptive kernal.

and would then quickly pounce upon the particular prey item. Usually, the prey would be consumed on the ground where it was caught, especially if it was an insect (no attempt was made to identify prey items to taxonomic species). Fields containing 15–20 Swainson's hawks foraging from the ground were observed on two occasions in July and on three occasions in August.

DISCUSSION

Foraging ranges and total home range area of raptors are known to be influenced by prey abundance and prey accessibility (usually a function of vegetation cover and density), nest location, the total amount of available suitable foraging habitat within the home range, and type of vegetation (Wakeley 1978, Baker and Brooks 1981, Bechard 1982, Schmutz 1987, Estep 1989, Woodbridge 1991). Bechard (1982) reported a strong correlation between home range size of Swainson's hawks and the amount of suitable foraging habitat that was available. Preston (1990) found that red-tailed hawks (*Buteo jamaicensis*) and northern harriers (*Circus cyaneus*) responded to changes in prey abundance and cover density; patches of vegetation containing high prey populations but with dense vegetative cover were used by both species less frequently than predicted. In agricultural areas, the abundance and accessibility of prey such as small rodents and insects may change in response to growth, maturity, and harvest of certain crops. In the Sacramento Valley where agriculture is the dominant land use, Estep (1989) found that as crops matured and vegetative cover increased, Swainson's hawks enlarged their foraging ranges in order to find more accessible prey; as crops and fields nearer the nest area were cut or harvested, the foraging range was reduced, sometimes even to a single field. Although no statistical analysis was conducted in this study to determine the correlation of home-range size with agricultural activities (crop cutting or harvesting), I suspect that foraging ranges of the radio-tagged Swainson's hawks increased in size as preferred crop types matured and prey become less accessible, and decreased during periods of harvesting and mowing when prey suddenly become more available.

In the Sacramento Valley, where changing agricultural markets and the juxtaposition of agriculture areas with urban development has resulted in a wide variety of agricultural cover types dispersed over very large areas, Swainson's hawk home ranges tend to be somewhat large. Estep (1989) reported a mean home range of 2760.4 ha for Swainson's hawks in the Central Valley, which compares to the large home ranges found in this study (despite the relatively small sample size in this study). However, in areas where the land use includes a predominance of cover types with a continually available prey base and abundant prey populations, Swainson's hawks may require substantially smaller home ranges in which to breed. Woodbridge (1991) found Swainson's hawks in northeastern California that nested

in areas surrounded by cover types that were high in prey density and prey accessibility and low in vegetative cover were associated with very small, circular home ranges (mean equal to 405.0 ha).

Grain crops, ruderal/fallow fields, row crops, tomatoes, and safflower were the dominant cover types in the study area. Estep (1989) found that crop patterns in the Central Valley that included a predominance of cover types with less overall vegetative cover and greater prey availability (i.e., alfalfa, fallow fields, dryland pasture) were preferred by Swainson's hawks and ranked highest in foraging use; grain crops and late-harvested row crops that had relatively small prey populations, and that were high in vegetative cover were less suitable as foraging habitat. The predominance of grain crops and row crops in my study area, combined with the large distances Swainson's hawks had to travel from nest sites to reach more compatible cover types, may explain the relatively large home ranges exhibited by the Swainson's hawks in this study. The presence of urban and residential areas to the north and east likely account for the somewhat linear nature of the home ranges in this study.

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