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ROOST CHARACTERISTICS AND BEHAVIORAL THERMOREGULATION IN THE SPOTTED OWL

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Previous studies on the Spotted Owl *(Strix occidentalis)* have established important parameters in habitat preference of this species. Old growth, multi-layered forests; water availability; and the presence of suitable nest sites are consistent characteristics of the habitats occupied (Gould 1974, 1977; Forsman 1976). These authors postulated heat intolerance as a possible factor in habitat selection. To further examine this hypothesis, we analyzed aspects of Spotted Owl habitat in preferred use areas, particularly at major roost sites, and related this information to behavioral adaptations of the owls.

This preliminary investigation was aimed specifically at understanding features of the forest environment which determine roost site selection. Relating to these features, possible limitations imposed on the Spotted Owl by physiological tolerances to environmental extremes were also considered.

STUDY AREA AND METHODS

The bulk of this study was conducted on The Nature Conservancy's 20,000 ha Northern California Coast Range Preserve (NCCRP) in Mendocino County; three locations in Marin County were also examined. The study spanned the period from 20 June to 31 August 1977. NCCRP encompasses a variety of vegetational communities of which the Mixed Evergreen Forest (Sawyer, Thornburgh, Griffen 1977) is a major component. The South Fork of the Eel River runs north through the Preserve. The watersheds of several tributaries to the Eel are included within the boundaries of NCCRP. Two of these tributaries, Fox Creek and Skunk Creek, were centers of Spotted Owl activity during the study period.

The habitat analysis phase of this study dealt with ten major roost sites. Seven of these were located at NCCRP; sites 2 and 6 were within the territory of pair 1, at Skunk Creek, and sites 1, 3, 4, 5, and 7 were in the territory of pair 2, at Fox Creek. Pair 1 fledged two young this season; pair 2 did not produce offspring. The last three sites were located in Marin County, representing two pairs of owls. Sites 8 and 9 were in a steep sided creek drainage near Palomarin. This pair of Spotted Owls fledged two young this year. Site 10 was at San Geronimo, where one immature owl was observed roosting.

Daytime roosts were located by walking through the areas where Spotted Owls had been seen or heard. Owl roosts are distinguished by a large accumulation of white fecal matter and pellets. Major roosts were identified on the basis of the presence of Spotted Owl pellets ranging in age from a week to several months old, indicating a long period of use. Secondary or minor roosts were noted as having only insignificant fecal accumulations with few or no pellets.

A 50 m transect was marked in four compass directions (N, S, E, W) from major roosts to establish a 10,000 m^2 plot. Vegetation along the transect was evaluated by a count of the number and age class (adult/sapling) of each species encountered in a 5 m wide swath. We measured relative humidity, using a sling psychrometer, and ambient temperature at ground level, using a centigrade thermometer, hourly at major roost sites both when observing the owls and when the owls were absent. Temperature was also recorded in open canopy situations adjacent (within 50 m) to the major roosts. Humidity values were recorded as percentage of 100% saturation and were then converted to ambient vapor pressure, in torr (Weast 1972-73).

We observed heat stressed owls on seven separate occasions for a total of 25 hours. Direct observation of the owls was made at distances ranging from 2 to 5 m. Signs of disturbance due to our presence (such as watchfulness or evasive behavior), which could add to their stress, were never noted in the owls during observations.

RESULTS

Roost Selection

The canopy at major roosts was typically of two heights, with Douglas-fir *(Pseudotsuga menziesii)* forming an irregular upper stratum as tall as 65 m. Tanoak *(Lithocarpus densiflora)* formed a major component of a more continuous lower stratified canopy of heights to 35 m. Douglas-fir was not the sole component of the primary canopy. Coast Redwood *(Sequoia sempervirens)* was a frequent, though less abundant, coniferous companion to the Douglas-fir. At the more hydric sites 8 and 9 at Palomarin there was a shift in the hardwood understory from Tanoak,

Table 1. Percent occurrence of coniferous and hardwood trees in 10,000 m^2 plots surrounding each major roost site. Standard deviation from the mean of both vegetation types was 10.3.

Vegetation Type	Roost Site No.									
	1	2	3	4	5	6	7	8	9	10
Coniferous (Mean: 19.1)	42.1	25.1	21.6	8.5	20.2	17.2	5.5	8.9	14.6	27.3
Hardwood (Mean: 80.9)	57.9	74.9	78.4	91.5	79.8	82.8	94.5	91.1	85.4	72.7

typical at NCCRP, to a combined secondary canopy of California Bay *(Umbellularia californica)*, Buckeye *(Aesculus californica)* and Coast Live Oak *(Quercus agrifolia)*. At San Geronimo, Coast Redwood was the sole component of the primary canopy. Tanoak formed a secondary canopy with minor representation by California Bay. The basic floral components of each of these areas may best be represented as percentage of coniferous and hardwood trees (Table 1). The more continuous hardwood understory is particularly important to the owls; out of the 156 major and minor roost sites sampled, 151 were in hardwood trees. All major roosts were located in hardwoods.

The physical characteristics of each major roost (Table 2) were strikingly similar, particularly in view of the diverse habitat types available to the owls. In contrast to the habitat described above, the study area at NCCRP also encompassed more xeric stands of pure Madrone *(Arbutus menziesii)* or Interior Live Oak *(Quercus wislizenii)*, along with mature stands of Douglas-fir with no hardwood understory. No owl roosts were found in these additional areas. A deviation from the similarity in roosts was noted at sites 8 and 9 where the structure of the broadleaf understory trees provided comparable canopy cover, despite the lower tree density. Additionally, we could find no surface water within several kilometers of site 10.

Temperature data gathered at preferred roost sites suggest that these owls seek cool areas in the forest. There was a consistent tendency for the summer temperature to be 3° or 4° C cooler in these deeply shaded forest roosts than in open canopy situations (Figure 1). Immature owls of pair 1 selected waterside roost sites on "hot" days (open canopy temperatures of 28.4° to 35.2° C) on four of six occasions. In these areas, temperatures were as much as 7° or 8° C cooler than temperatures in the open canopy areas where direct sunlight reached the forest floor.

Table 2. Habitat analysis data for 10 major Spotted Owl roost sites at NCCRP (sites 1-7), Palomarin (sites 8, 9), and San Geronimo (site 10).

Roost Site No.	Height of Roost Above Ground (meters)	Distance from Year-Round Surface Water (meters)	Distance from Creek Drainage (meters)[1]	Slope Aspect	Surrounding Tree Density (trees/ 25 m^2 plot)[2]
1	7.5	150-200	0	NE	4.9
2	4.5	200-250	0	NNW	4.8
3	7.6	200-250	0	N	4.1
4	5.6	200-250	0	NNW	4.9
5	6.4	250-300	0	NNE	5.1
6	1.8	100-150	10	NNW	4.8
7	5.2	150-200	0	NE	4.4
8	5.0	20-30	–	ENE	2.2
9	4.0	20-30	–	WSW	3.2
10	5.0	–	0	NNW	4.2

1. A "0" denotes that the roost was located within the creek drainage; a dash denotes that no creek drainage was present near the roost (within 500 m). All creek drainages were seasonal with January to June flow.

2. This figure includes all age classes. The canopy cover at all roost siges varied between 80 and 90%, based on visual estimation.

At NCCRP, midday temperatures during the summer (June-August) average around 30.0° C. Summer temperature data for a ten year period (1966-1976) show that temperatures greater than 32.0°C and as high as 41.6° C were recorded on an average of 38 days per year from 6 May to 2 October. These temperatures were recorded in a large meadow within the boundaries of NCCRP. High temperatures during this study period ranged from 32.0° C to 37.8° C in this same open meadow. Long term temperature data for open canopy situations at Palomarin and San Geronimo were not available.

Postural Adjustments

As an initial response to increasing ambient temperatures (approaching 27.0° C), Spotted Owls displayed an unusual postural adjustment. While perching, the owls were balanced with the talons open rather than clenched on the limb of the tree (Figure 2). In this posture, the soft pads of the feet were exposed to the air; the bright pink color of these pads suggest that these areas are highly vascularized, and therefore effective surfaces for heat dissipation. This posture was observed in all stages of heat stress. The physiological mechanism for this pathway of heat loss has been previously described in pigeons (Bernstein 1974).

Exposure of the legs and feet is another possible means of heat dissipation, by convection and radiation from these structures to the air (Howell and Bartholomew 1961). This postural change was used as an early response to increasing heat load, and continued during gular flutter (see below). Spotted Owls usually perched in a squat position with the feet and legs covered by the contour feathers. When stressed by the heat, however, their posture was erect so that the legs and feet were well exposed.

As temperatures reached or exceeded 28.0° C and the need to dissipate heat was correspondingly increased, Spotted Owls erected the feathers on the breast and scapular area. In other species subjected to heat stress, elevation of the scapular feathers has been observed, notably in the Masked Booby, *Sula dactylatra* (Bartholomew 1966), and in the Brown Pelican, *Pelecanus occidentalis*, and the Double-crested Cormorant, *Pha-*

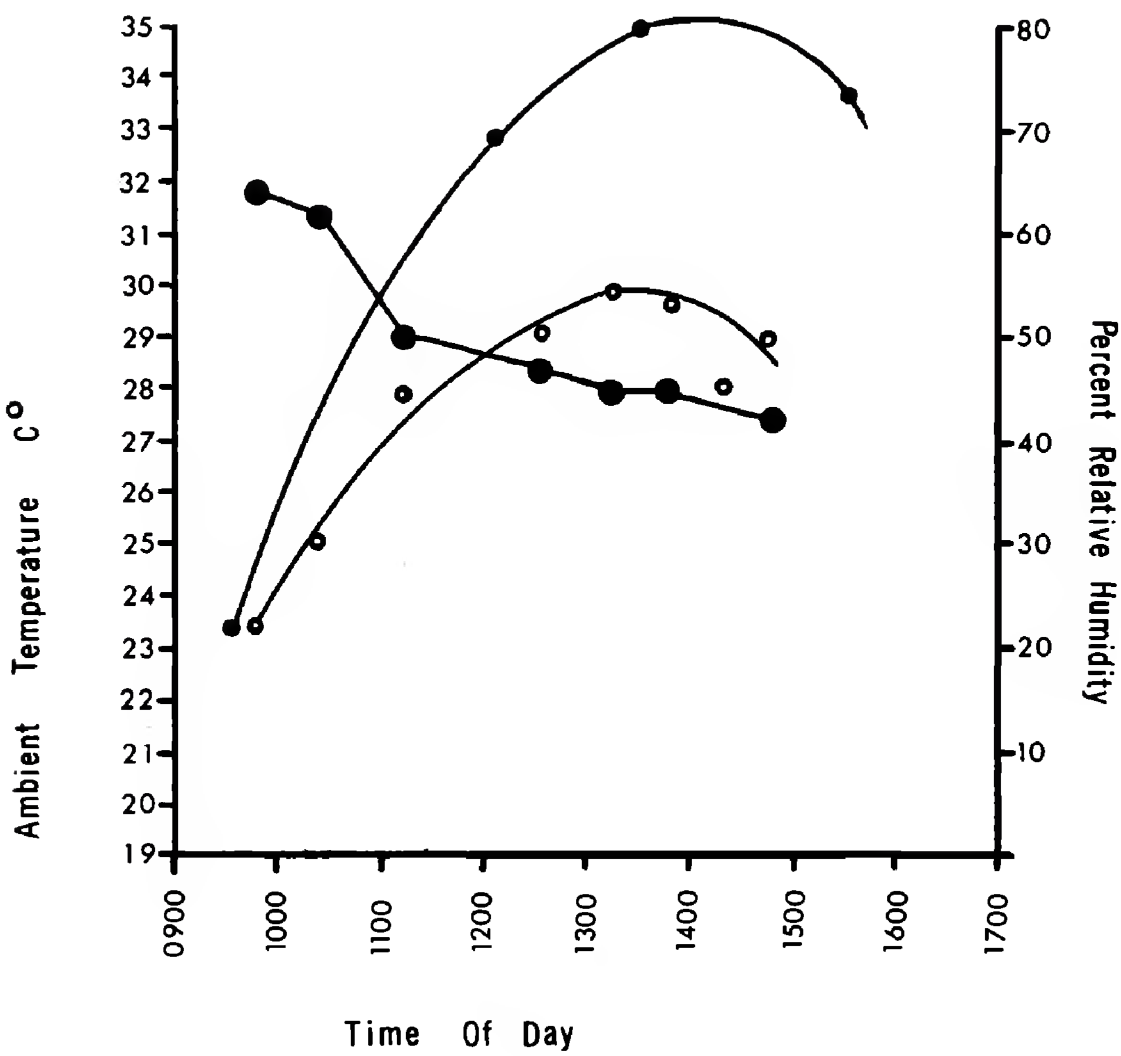

Figure 1. Temperature-humidity relationships at roost sites. Open circles represent trends in temperature at the roost sites; small dots represent temperature trends in adjacent open canopy areas; large dots represent the trend in relative humidity at the roost sites. Data points presented here are from measurements taken at site 3 but are representative of all 10 major roosts.

lacrocorax auritus (Bartholomew, Lasiewski and Crawford 1968). Feather erection permits movement of relatively cool air among the feathers, allowing heat loss by convection.

Gular Flutter

Of the climatic variables examined in the habitat analysis, temperature and humidity influence the effectiveness of gular flutter. The ability of the owls to dissipate heat through evaporation would be inhibited by high ambient temperature, when coupled with high ambient vapor pressure. In Oregon, Spotted Owls have been observed to initiate gular flutter at ambient temperatures as low as 29.0° C (Forsman 1976). At NCCRP, Spotted Owls were observed to initiate gular flutter at 28.0° C for fledgling young and 29.5° C for an adult male.

Observations of gular flutter by the owls, apparently indicative of greater degrees of heat stress, were rare. Gular flutter was observed on three occasions, once in an adult male owl and twice in the immature birds of pair 1. The owls gular fluttered intermittently; in each case the mandibles were held slightly open and the amplitude (gauged by the degree of distension of the gular region) was variable, increasing when flutter frequency was increased. The adult male was observed to initiate gular flutter at 29.5° C (humidity varied from 26%, or 9.3 torr, to 30%, or 8.6 torr) in contrast to the observed response of the owlets; they initiated gular flutter at 28.0° C (humidity varied from 43%, or 15.2 torr, to 50%, or 14.2 torr).

Differences in response to increasing ambient temperatures between the adult owl and the owlets may be due to physical differences between these age groups. Although not directly measured in this study,

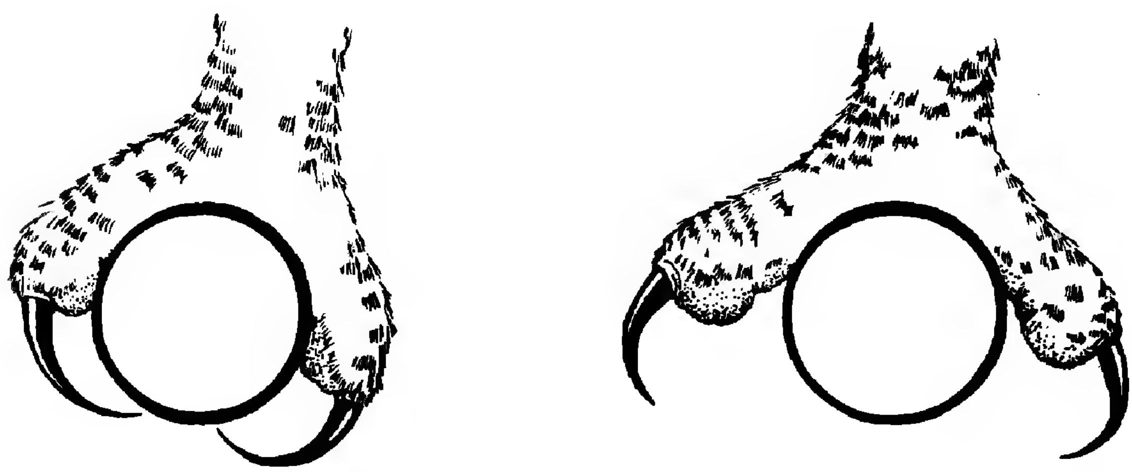

Figure 2. Spotted Owl foot postures, differing in response to varying temperature conditions. Foot on the right is characteristic of owls showing signs of heat stress, with temperatures greater than 27° C. Foot posture on left is characteristic when temperatures are less than 27° C.

differences in the insulative value of downy plumage and the feather cover of the adult may influence the efficiency of heat loss. The differences in humidity cited above could also play a role.

Spotted Owls that were actively gular fluttering, at temperatures in excess of 29.0° C, drooped the wings and held them away from the body. This behavior, documented in a number of species (Bartholomew, Lasiewski, and Crawford 1968) increases the surfaces for heat loss and exposes the more lightly feathered underwings and axillary surfaces (Calder and King 1974). Heat stressed Spotted Owls also raised the tail and fanned the rectrices out away from the body. In "typical" heat stress posture, the owl's head was tilted back to expose the throat; this movement presumably expands the surface area of the gular region for increased evaporative heat loss.

Additional Observations

Spotted Owls were observed bathing on several occasions. This behavior has been described previously for this species without reference to thermoregulation (Forsman 1976, Miller 1974). Bathing was observed by both the immature owls of pair 1 during a period of gular flutter. If, as postulated by Lasiewski and Dawson (1964), gular flutter is an efficient means of cooling, bathing should not be necessary to augment heat loss. In this instance the owlets ceased gular flutter for 2.25 hours after their baths. It could not be determined if the owls drank any water. Gular flutter was later resumed. The air temperature remained fairly constant (28.0° to 29.4° C) for the entire observation period. Possibly bathing is used as a means of feather care, and is not directly related to body cooling. Adequate interpretations of bathing behavior must, however, be reserved until more observations can be made.

DISCUSSION AND CONCLUSIONS

During the summer months Spotted Owl roosts were consistently chosen low to the ground, in understory trees which form an umbrella of leaves over the perch site. The structure of these roost sites provided a 3°-4° C depression in temperature from that of open canopy situations. Spotted Owls behaviorally facilitated heat loss at ambient temperatures above 27° C. With midday summer temperatures at NCCRP averaging near 30° C, the selection of daytime roosts could prove to be a fundamental means by which these owls avoid heat stress.

Depending on the degree of heat stress, the owls augment heat loss to the air by postural adjustments; these include exposing the pads of the feet, exposing the legs, erecting contour feathers, and drooping the wings. At temperatures ranging between 28° and 29° C Spotted Owls initiate gular flutter, a low energy means of increasing the rate of evaporative heat loss. During periods of climatic stress, the effectiveness of these behavioral mechanisms in regulating body temperatures may be intimately tied to the availability of sheltered roost sites. Our data suggest the value to the Spotted Owls of dense multi-layered forests. In regions where summer climate is unfavorable to thermoregulation, these sheltered roosts could well be essential to the owl's survival. Recognition and analysis of these problems is therefore fundamental to the interpretation of the ecology and distribution of the Spotted Owl.

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BREEDING BIRD DENSITIES, SPECIES COMPOSITION, AND BIRD SPECIES DIVERSITY OF THE ALGODONES DUNES

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The Algodones Dunes, also known as the Imperial Sand Dunes, in Imperial County are considered to be the largest sand dune system in California and one of the largest in the United States (California Division of Mines 1952, Miller 1957). Within the Algodones Dunes are several different habitat types which contribute to the biological uniqueness of the area. Few data are available on the avian community of these dunes. The purpose of this investigation was to determine avian species composition, breeding bird densities, bird species diversity, and plant species diversity in the various habitats associated with the Algodones Dunes.

STUDY AREA

The Algodones Dunes are located in the extreme southeastern portion of California with the southernmost 6.4 km extending into Mexico. The dunes are bordered on the west by East Mesa, on the north by Mammoth Wash, on the east by the Chocolate Mountains and the Cargo Muchacho Mountains, and on the south by the Colorado River Delta. The Coachella Canal lies along the western boundary of the dunes while the Southern Pacific Railroad borders the eastern fringe, eventually intersecting the Coachella Canal to form the northern border.

This dune system is approximately 64.4 km long, varying in width from 4.8 km to 9.7 km, and is oriented in a northwesterly direction. The dunes are long and narrow at the northern tip, extending to a wider, southern base. Dune crests may exceed 90 m although most range between 60-90 m (Westec Services Inc. 1977). Elevation ranges from 33-168 m.

Climate

The Algodones Dunes are located within the Cahuilla Basin, an area of both low rainfall and humidity, and extremely high summer temperatures. Rainfall results from occasional torrential late summer showers or from infrequent light winter rains. Average annual rainfall for Amos, a site on the eastern side of the dunes, is 71.9 mm (Norris and Norris 1961).

Vegetation

Several basic habitat types occur on the Algodones Dunes. A considerable portion of the dunes consists of barren, wind-blown sand forming, in places, steep troughs and peaks. However, much of the area is not devoid of vegetation but contains psammophytic ("sand-loving") species which occur throughout this dune system, some of which are endemic.

Fingers of partially stabilized sand invade the borders of the Algodones Dunes. Within these fingers of land and along much of the periphery of the dunes, Sonoran Creosote Bush scrub, characterized primarily by Creosote Bush, occurs. On the western side of the dunes, stands of almost pure Creosote Bush, some reaching enormous size, are found. Gigantism presumably results from continual water seepage from the unlined Coachella Canal. This vegetation type is referred to as "dense" Sonoran Creosote Bush scrub in this study. Although unusually large Creosote Bushes are also prevalent in the more mesic sites on the eastern dunes border, there are substantial areas of relatively sparsely distributed Creosote Bushes referred to as "open" Sonoran Creosote Bush scrub.

Particularly interesting is the desert microphyll woodland habitat which has a patchy distribution along the eastern dune edge. In these areas the vegetation is luxuriant by desert standards, probably as a result of temporary impounding of runoff water during infrequent rains (Norris and Norris 1961). As water drains from the Chocolate and Cargo Muchacho mountains down the alluvial fans east of the dunes, it is effectively impeded by the large sand mass. This serves as a barrier, thereby creating in some locations a sufficiently mesic environment to permit development of a very dense, lush, desert microphyll woodland. Consequently, this habitat is found on only one side of the dune system.

METHODS

Avian Densities

Avian species composition and breeding bird densities were determined for four habitats: desert microphyll woodland, desert psammophytic scrub, open Sonoran Creosote Bush scrub and dense Sonoran Creosote Bush scrub.

Birds were sampled using the spot-map method (Williams 1936), whereby one 20 ha grid pattern (11.4 ha in the microphyll forest due to habitat patchiness) was established in each of the four habitats, using plastic flagging and wooden stakes placed at 50 m intervals along 5 parallel lines, each 450 m in length and 112.5 m apart. Each flag or stake was labeled with a number corresponding to the transect line and a letter corresponding to the distance traveled from the beginning of the line. Each habitat was censused three to six times from 20 April to 6 May 1977. Censuses commenced one-half hour after sunrise and were completed by 0900. Density values are expressed in terms of number of breeding individuals per 40 ha (100 acres), a commonly used base for avian studies.

Vegetation Analysis

Vegetation in each plot was sampled using the line-intercept method described by Mueller-Dombois and Elenberg (1974). A 100 m transect was sampled in each habitat type, thus providing information on plant species dominance (an indication of cover), relative dominance, frequency and relative frequency.

The desert microphyll woodland habitat was located on the eastern edge of the dunes, approximately 4.8 km north of the intersection of Glamis and Highway 78 (T 13 S, R 17½ E, section unsurveyed). The psammophytic scrub plot was placed roughly 500 m south of Highway 78 and 200 m east of the Gecko Campground Road (T 13 S, R 17½ E, Sec. 36). The open Sonoran Creosote Bush scrub plot was established 4.5 km north of Glamis (T 13 S, R 17½ E, section unsurveyed), whereas the dense Creosote Bush plot was located approximately 50 m east of the Coachella Canal and 2.8 km south of Highway 78 (T 14 S, R 17 E, sections 1 and 12).

Diversity

Diversity values (to base e) were determined for the avian community in each habitat type using Shannon's (1948) formula. Plant species diversity indices were calculated from relative dominance values for each habitat.

RESULTS

Vegetation

Results of the vegetational analysis indicate that the desert microphyll woodland had the highest numerical dominance and frequency (Table 1). The latter value is an indication of plant density. The numerous Palo Verde trees were dense and tall, many reaching 8 m and above (Figure 1). Much of the understory within the plot was relatively thick and provided dense cover for species such as Gambel's Quail.

In contrast to the microphyll woodland habitat, the other plots contained much less cover. Vegetation in the psammophytic plot was unevenly distributed, low in stature, and relatively sparse (Figure 2).

Within the western corner of the open Creosote Bush plot were shallow, narrow washes containing Palo Verde which were utilized for nesting by several species such as Verdins and Black-tailed Gnatcatchers. The individual Creosote Bushes were fairly evenly spaced in the open Creosote Bush habitat (Figure 3), and were not inordinately large as they were in areas bordering the canal. Analysis of the dense Sonoran Creosote Bush scrub habitat yielded much larger dominance and frequency values than did the sparse creosote area. The dense Creosote Bush plot is shown in Figure 4.

Figure 1. Desert microphyll woodland, Algodones Dunes, California (for location see Methods), October 1977.

Figure 2. Desert psammophytic scrub, October 1977.

Figure 3. Open Sonoran Creosote Bush scrub, October 1977.

Figure 4. Dense Sonoran Creosote Bush scrub, October 1977.

A comparison of the plant species diversity (PSD) values for the various communities indicates that the microphyll woodland plot had the highest PSD (1.26), whereas the pure stand of dense creosote had a diversity value of zero. The psammophytic scrub and open Creosote Bush scrub had intermediate values (0.77 and 1.05 respectively) between these two extremes.

Table 1. Vegetation analysis of four Algodones Dunes habitats in Imperial County, California.

DESERT MICROPHYLL WOODLAND

SPECIES	Dominance[1]	Relative Dominance[2]	Frequency[3]	Relative Frequency[4]
Brandegea *Brandegea bigelovii*	22.3	16.4	28	43.1
Palo Verde *Cercidium floridum*	74.8	54.9	12	18.4
Galleta Grass *Hilaria rigida*	1.5	1.1	2	3.1
Creosote Bush *Larrea tridentata*	22.5	16.5	6	9.2
Hairy-pod Peppergrass *Lepidium lasiocarpum*	0.7	0.5	1	1.5
Tumble-mustard *Sisymbrium altissimum*	0.7	0.5	1	1.5
Globemallow *Spaeralcea emoryi*	13.7	10.1	15	23.1
TOTAL	136.2	100.0	65	99.9

DESERT PSAMMOPHYTIC SCRUB

SPECIES	Dominance[1]	Relative Dominance[2]	Frequency[3]	Relative Frequency[4]
Croton *Croton wigginsii*	9.9	77.3	11	68.8
Desert Dicoria *Dicoria canescens*	0.8	6.3	1	6.3
Mormon-tea *Ephedra trifurca*	1.5	11.7	3	18.8
Blazing star *Mentzelia longiloba*	0.6	4.7	1	6.3
TOTAL	12.8	100.0	16	100.2

OPEN SONORAN CREOSOTE BUSH SCRUB

SPECIES	Dominance[1]	Relative Dominance[2]	Frequency[3]	Relative Frequency[4]
Palo Verde *Cercidium floridum*	1.1	9.6	1	10
Indigo Bush *Dalea emoryi*	0.5	4.4	1	10
Jimson Weed *Datura discolor*	0.2	1.8	1	10
Brittle-Bush *Encelia farinosa*	0.3	2.6	1	10

Table 1 (cont.)

SPECIES	Dominance[1]	Relative Dominance[2]	Frequency[3]	Relative Frequency[4]
Galleta Grass *Hilaria rigida*	0.8	7.0	1	10
Creosote Bush *Larrea tridentata*	8.2	71.9	4	40
Spanish Needles *Palafoxia arida* var. *arida*	0.3	2.6	1	10
TOTAL	11.4	99.9	10	100
DENSE SONORAN CREOSOTE BUSH SCRUB				
Creosote Bush *Larrea tridentata*	68.9	100	23	100

1 Dominance = Number of meters a given species was encountered along a 100 m line-intercept transect.

2 Relative dominance (percent) = (Dominance of a species/Total dominance of all species) x 100.

3 Frequency=The number of plants of a given species encountered on the line-intercept..

4 Relative frequency (percent) = (Frequency of a species/Total frequency) x 100.

Table 2. Avian species composition, densities, and distribution in the Algodones Dunes, Imperial County, California.

BREEDING DENSITY (BIRDS/40 ha)

SPECIES	Desert Microphyll Woodland	Desert Psammophytic Scrub	Open Sonoran Creosote Bush Scrub	Dense Sonoran Creosote Bush Scrub
Turkey Vulture *Cathartes aura*		V	V	
Red-tailed Hawk *Buteo jamaicensis*	V	V	V	
Marsh Hawk *Circus cyaneus*	V			4.0
Prairie Falcon *Falco mexicanus*		V		
American Kestrel *Falco sparverius*		V		
Gambel's Quail *Lophortyx gambelii*	20.6			
White-winged Dove *Zenaida asiatica*	8.3		V	
Mourning Dove *Zenaida macroura*	57.8	V	4.0	P
Ground Dove *Columbina passerina*			V	

Table 2 (cont.)

SPECIES	Desert Micro-phyll Wood-land	Desert Psammo-phytic Scrub	Open Sonoran Creosote Bush Scrub	Dense Sonoran Creosote Bush Scrub
Roadrunner *Geococcyx californianus*	8.3			P
Long-eared Owl *Asio otus*	8.3			
Lesser Nighthawk *Chordeiles acutipennis*	*	4.0	V	4.0
Costa's Hummingbird *Calypte costae*	8.3			
Ladder-backed Woodpecker *Picoides scalaris*	8.3			
Ash-throated Flycatcher *Myiarchus cinerascens*	24.8			
Black Phoebe *Sayornis nigricans*	V			
Say's Phoebe *Sayornis saya*	V			
Cliff Swallow *Petrochelidon pyrrhonota*				V
Verdin *Auriparus flaviceps*	54.5		12.0	4.0
Cactus Wren *Campylorhynchus brunneicapillus*	24.8			
LeConte's Thrasher *Toxostoma lecontei*	16.6	V		4.0
Crissal Thrasher *Toxostoma dorsale*	8.3	V		4.0
Black-tailed Gnatcatcher *Polioptila melanura*	30.3		9.3	20.0
Loggerhead Shrike *Lanius ludovicianus*	4.2	V		
Starling *Sturnus vulgaris*	V			
House Finch *Carpodacus mexicanus*	24.8		V	
TOTAL DENSITY	308.2	4.0	25.3	40.0
Number of breeding species	15	1	3	6
Number of migrant species	28	3	8	11
Census dates	20, 21, 22, 23, 27 Apr.	21, 22, 27, 28 Apr. 4, 6 May	27, 28, 29 Apr.	20, 21, 22, 29 Apr.

V = visitor (seen throughout the spring and summer in the area but not nesting on the plot).

P = Present, breeding density undetermined.

* = Breeding within 0.5 km in nearby creosote scrub.

Avian Species Composition and Densities

The desert microphyll woodland contained the highest density of breeding birds as well as the greatest number of breeding species (Table 2). More species including migrants and visitors, were observed there than in any other habitat. Verdins, Black-tailed Gnatcatchers and House Finches were particularly abundant in the woodland. The dense Creosote Bush scrub supported the next highest density and contained five breeding species. Of 17 species noted in the open creosote habitat, only 3 were nesting, with the Verdin achieving the highest density.

Desert psammophytic scrub was the least utilized habitat. Only the Lesser Nighthawk was observed nesting there.

The avifauna of the microphyll woodland habitat represented the highest bird species diversity (BSD) value (2.44) in contrast to a diversity of zero in the psammophytic scrub plot. Dense Creosote Bush scrub possessed a higher BSD than did open Creosote Bush scrub (1.64 versus 1.01 respectively).

DISCUSSION

Species occurrence is determined by how closely a given habitat meets the species' niche requirements. Such requisites include, but are not limited to, food (quality, accessibility, quantity), nest sites, song posts, cover, water availability (critical for some species), presence of predators, foliage volume, and climate. The quality of the habitat influences the total density of the avifauna. Cover and the amount of foliage available are particularly important since they provide, at least for many species, nest sites, song posts, food, habitat for insects upon which insectivorous birds prey, foraging surface, and protection against both inclement weather conditions and predators.

The results of this study provide an estimate of breeding bird density and are not absolute values. Because of the rather broad nesting period for these desert birds the plots could not be censused at the peak of the breeding season for every species. For example, when the study was initiated one pair of Long-eared Owls was feeding nestlings. In contrast, Lesser Nighthawks were in the process of establishing territories and young did not hatch until June. Even though the censuses were somewhat late for some species and early for at least one other, the results represent an estimation of breeding bird density at a particular stage in the breeding season. For most species, this represents a reasonably accurate estimate.

Several species undoubtedly foraged in a habitat type different from that in which they nested. Such was the case for the Long-eared Owl which nested in microphyll woodland but foraged over the nearby open creosote scrub and psammophytic scrub habitats. Because of this, their density was probably overestimated since their territory encompassed a larger area than just the woodland. Most of the species, however, both foraged and nested within the same territory.

In this study the microphyll woodland provided far more cover, as reflected in the dominance figures, than did any of the other habitats. The robust Palo Verde trees and dense understory were particularly attractive to certain species. For example, thicket-dwelling species such as the Crissal Thrasher, Gambel's Quail and Ladder-backed Woodpecker appeared to be restricted to this habitat. Some species such as the Long-eared Owl, Ladder-backed Woodpecker, Ash-throated Flycatcher and House Finch require tall plants for nesting (Raitt and Maze 1968). The vegetation in the microphyll woodland provided considerable foraging substrate in addition to nest sites and song posts. It also served as a refuge against the hot summer temperatures. During the migratory season many migrants took advantage of the attributes of this habitat.

The total avifauna density in the microphyll woodland approximates the estimation of the breeding bird density for Milpitas Wash (328-342 birds/40 ha, Tomoff, unpubl.), a microphyll woodland about 32 km east of the microphyll woodland plot in this study. In contrast to the microphyll woodland, the psammophytic scrub habitat provided very little cover and a relatively low plant species diversity. Consequently this habitat type supported a very meager avifauna.

It is not just the foliage volume or density but, perhaps more importantly in many cases, the kind or quality of vegetation available in a habitat that influences species density. Although extensive stands of pure creosote are prevalent throughout the deserts of the Southwest, few birds select them as breeding habitats. Hensley (1954) found no nesting birds in a pure Sonoran Creosote Bush flat in Organ Pipe Cactus National Monument, Arizona. However, if creosote is part of a fairly diverse plant community and is intermingled with cacti, mesquite *(Prosopis* sp.) or Catclaw *(Acacia greggii)*, a fairly substantial number of birds will use it (Anderson and Anderson 1946). A habitat of Creosote Bush, Burro-Weed *(Ambrosia dumosa)*, Brittle-Bush, Buckhorn Cholla *(Opuntia acanthocarpa)*, and Catclaw, supported 127 birds/40 ha and 14 species (Hutchinson 1942). In another study in Arizona, a Sonoran Creosote Bush scrub plot supported a density of 70 birds/40 ha and 16 species (Hensley 1954).

Though few studies have examined its use, some foraging may occur within Creosote Bushes. Anderson and Anderson (1946) found Verdins and gnatcatchers (*Polioptila* sp.) apparently searching for insects on creosote. They observed Cactus Wrens walking along the ground, peering at the twigs, and jumping upward to catch foliage-inhabiting insects. They also noted House Finches and House Sparrows *(Passer domesticus)* nibbling on the creosote buds, pulling off the fruits, crushing them, and eating the seeds.

Presumably Creosote Bushes are of limited value in providing suitable nest sites because of their relatively thin twigs and non-supportive branches. However, the large Creosote Bushes present in the dense Creosote Bush habitat provided more elaborate branches and stronger support. Black-tailed Gnatcatchers and Verdins evidently had little difficulty in using these Creosote Bushes for nest sites.

It has generally been thought that the more floristically diverse habitats have a more diverse and complex fauna. Both the number of plant species and amount of vegetative cover may influence avian densities. In the dense Creosote Bush plot, the plant species diversity was zero, yet this habitat contained more birds than did the more botanically diverse sparse Creosote Bush plot. Presumably this was because the dense Creosote Bush habitat provided a greater structural diversity than the open Creosote Bush. In a study of various habitats in the Sonoran Desert of southern Arizona, Tomoff (1974) found a positive relationship between BSD and physiognomic coverage diversity along a habitat gradient. In desert scrub habitats, plant species composition was extremely significant in determining makeup of breeding bird communities and in providing suitable nest sites (Tomoff 1974). Apparently it is not just the amount of and distribution of cover among the various life-forms but also the floral composition which is important.

Other workers have noted a positive correlation between BSD and the foliage height diversity (FHD) (MacArthur and MacArthur 1961, MacArthur et al. 1962, 1966, Karr and Roth 1971, and others). Yet this relationship does not hold for all habitats (Balda 1969, Carothers et al. 1974, and others). Tomoff (1974) found the MacArthur model to be inconsistent in predicting BSD from FHD values in desert scrub communities. Since FHD values following the above cited method were not derived for the plots in this study, a comparison with the aforementioned results cannot be made.

Presumably, along with FHD and PSD, the actual plant species present should be considered. Certain plant species evidently are of more value to birds than are others. Hence, it is not just the diversity of plants (either with respect to FHD or PSD) which may influence BSD but also factors such as the composition of the flora, the amount of foliage available, and the structural complexity of the habitat.

SUMMARY

Avian species composition, breeding bird densities and habitat preferences were determined for four habitats in the Algodones Sand Dunes in southeastern California. Desert microphyll woodland supported the highest breeding bird density (308.2 birds/40 ha), the most breeding species (15), the greatest overall number of species (49, including migrants and visitors) and the highest bird species diversity (2.44). This

is in contrast to sparsely vegetated psammophytic scrub habitat which contained a density of 4.0 birds/40 ha and only one breeding species. Dense, luxuriant, pure Creosote Bush scrub habitat and an open Creosote Bush scrub habitat supported densities of 40.0 and 25.3 birds/40 ha, respectively.

A vegetational analysis indicated that the microphyll woodland had the highest dominance value (136.2), which is an indication of cover, and both the highest frequency and plant species diversity values (65 and 1.26 respectively). The open Creosote Bush scrub contained the least amount of cover, whereas the dense Creosote Bush scrub achieved a value of zero for plant species diversity.

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COMMENTS ON THE STATUS AND DISTRIBUTION OF WESTERN AND MOUNTAIN BLUEBIRDS IN WASHINGTON

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Concern has been expressed for many years over the decrease in numbers of both Western Bluebirds *(Sialia mexicana)* and Mountain Bluebirds *(S. currucoides)* in Washington. One major problem in attempting to document this reported decline is the lack of comprehensive status and distribution data. Seasonal reports in *American Birds* provide summaries of observations but often these are not quantitative in nature. Recent breeding bird surveys conducted by the U. S. Fish and Wildlife Service (Robbins and Van Velzen 1969, Van Velzen and Robbins 1971) are quantitative but often provide only limited data on bluebirds. The purpose of this study is to supply quantitative information on the status and distribution of both bluebird species in Washington for the summer of 1974, to provide an analysis of Breeding Bird Survey (BBS) data for 1968 through 1976, and to evaluate population trends during the past 80 years.

MATERIALS AND METHODS

I conducted timed censuses throughout the state in areas that seemed to satisfy basic habitat requirements (elevated perches, open spaces, some cover, one or more nest cavities) of bluebirds. Each census, begun at times when bluebird activity was considered to be greatest, consisted of a 1 to 3 hour walk through an area. During the nesting period (see below) bluebirds were active throughout the day, whereas after the young had fledged, maximum activity occurred in early morning and late evening. The walk was usually in a circular pattern covering 1 to 5 km. After the initial census, a 1 to 2 hour search for nests was conducted. Four of the five areas with active nests were censused a second time, approximately 3 weeks later, to check the accuracy of the census method and to obtain data concerning reproductive success.

To gain perspective on the historical status and distribution of Western and Mountain bluebirds, species lists, surveys, and museum collections made between 1894 and 1966 were examined.

For purposes of comparison, Washington was divided into western and eastern sections with the crest of the Cascade Range serving as the dividing line. The breeding season, based on Jewett et al. (1953) and personal observations, was defined as follows: Western Bluebird, 5 April to 12 August and Mountain Bluebird, 28 April to 25 July.

Forty-nine questionnaires, requesting current information on numbers, species, and habitat of bluebirds, were mailed in 1974 to persons actively engaged in field work or with access to areas which may have been suitable for bluebirds. Those contacted included U. S. Forest Service district rangers, National Park Service biologists, Fish and Wildlife Service refuge personnel, Indian Agency superintendents, and managers of state wildlife recreation areas. Thirty individuals (13 west and 17 east of the Cascade Range) completed the questionnaires.

An analysis, based on the method of Neu et al. (1974), of life zone and habitat utilization was made. Confidence intervals were placed on the proportion of each bluebird species observed in a life zone or habitat type, then compared with expected values. The expected number of bluebirds was taken to be the proportion of the total census time that was spent in each area multiplied by the total number of bluebirds observed on all areas. The 0.05 level of significance was used. For this analysis, both bluebird species were assumed to have equal accessibility to all areas.

From 10 June to 28 August 1974, 48 full-time days were spent in the field. Seventeen part-time days were spent in the field from 14 February to 23 May 1974.

RESULTS AND DISCUSSION

Former Status and Distribution

Early published reports by Dawson (1909), Taylor and Shaw (1927), Burleigh (1930), Kitchin (1930) and Miller et al. (1935) indicated that Western Bluebirds were most often observed west of the Cascade Range. Later reports listed this species as rare (Pearse 1946) or as a migrant and winter visitor only (Wick 1958) in extreme northwestern Washington. In eastern Washington, Edson (1932), Wing (1944), and others noted isolated sightings. King (1953) and Hudson and Yocom (1954) classed Western Bluebirds as rare summer residents in southeastern Washington. Jewett et al. (1953:523) stated that this species "while not abundant anywhere, enjoys a wide distribution in the state."

For the Mountain Bluebird in western Washington, the only published observations during the breeding season are from Whatcom County (Edson 1926) and from Mount Rainier National Park (Dawson 1909, Scheffer 1934, Kitchin 1939). All other reports from this part of the state come from migratory periods (Jewett et al. 1953). Records from eastern Washington are more abundant and many observers reported the bird as common (Dice 1918, Hurley 1921, Larrison 1943, Burdick 1944, Yocom 1945, Jewett et al. 1953, King 1953, Hudson and Yocom 1954).

Figures 1 and 2 show locations for museum specimens collected during the breeding season for Western Bluebirds between 1894 and 1960 and for Mountain Bluebirds between 1897 and 1966. Before 1947, Western Bluebirds were taken primarily in western Washington (65%), whereas after 1948, 62% of the birds were collected east of the Cascades. For the entire period, 75% of the Mountain Bluebirds were from eastern Washington.

Although the number of birds taken in a given area is a reflection of collecting effort, an important trend in the number of Western Bluebirds in western Washington is suggested by a decrease in specimens. Coupled with a decrease of published observations, fewer museum specimens seem to point to a decline in the breeding population of Western Bluebirds west of the Cascades. No important changes have been noted for Western Bluebirds east of the mountains, or for Mountain Bluebirds throughout the state.

The distribution of both bluebird species, based on life zone or habitat use, has been described by many authors. Jewett et al. (1953) reported that Western Bluebirds were found most commonly in the Upper Sonoran and Transition zones, whereas Mountain Bluebirds were found from the Transition to Hudsonian Zone. Dice (1918) recorded Western Bluebirds as migrants in bunchgrass and in cottonwood-willow habitat and as summer residents in yellow pine habitat, in southeastern Washington. He recorded Mountain Bluebirds as summer residents in bunchgrass, cottonwood-willow, yellow pine and alpine-fir habitats. Observations by Dumas (1950) closely paralleled those of Dice for both species.

Present Status and Distribution

Seventy-nine Western Bluebirds were seen during timed censuses. Seven censuses conducted between 0600 and 1200 resulted in 49 bird observations. Six censuses conducted between 1200 and 2000 resulted in 30 sightings. Thirty-nine and 40 Western Bluebirds were counted in June and July, respectively. None were seen during timed censuses in August. Seven sightings made while traveling between census areas were recorded but not included in field census counts. Flocks, numbering between 6 and 20, were observed on three occasions during censuses, but in no instance were more than 5 adults seen at any location. Although nearly 16% of my field time was spent west of the Cascade Range, no Western Bluebirds were seen there (Appendix A).

Thirty-one Mountain Bluebirds were seen during timed censuses (Appendix A). Two censuses, conducted between 0600 and 1200, resulted in 6 sightings. Four censuses between 1200 and 2000 had a total count of 25. Nineteen, 10, and 2 Mountain Bluebirds were counted in June, July and August, respectively. Three additional sightings were made

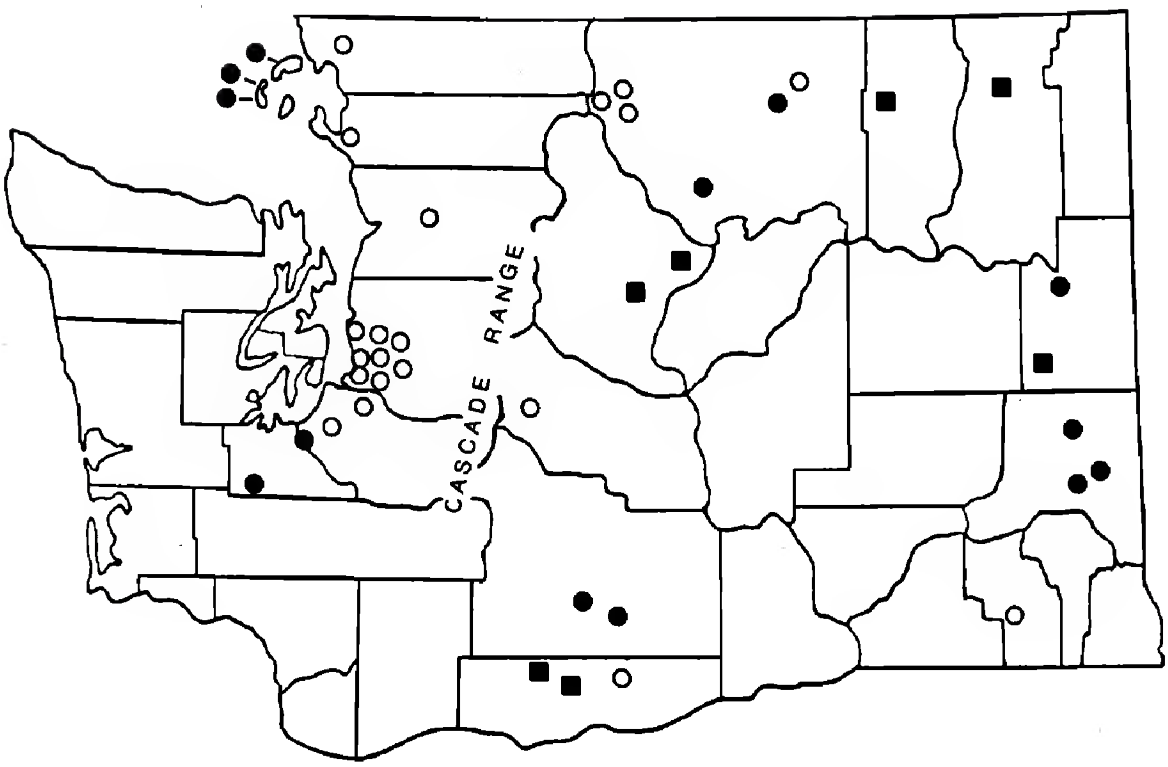

Figure 1. Breeding season locations in Washington for Western Bluebird museum specimens 1894 to 1947 (○), 1948 to 1960 (●), and personal observations and questionnaire reports, summer 1974 (■).

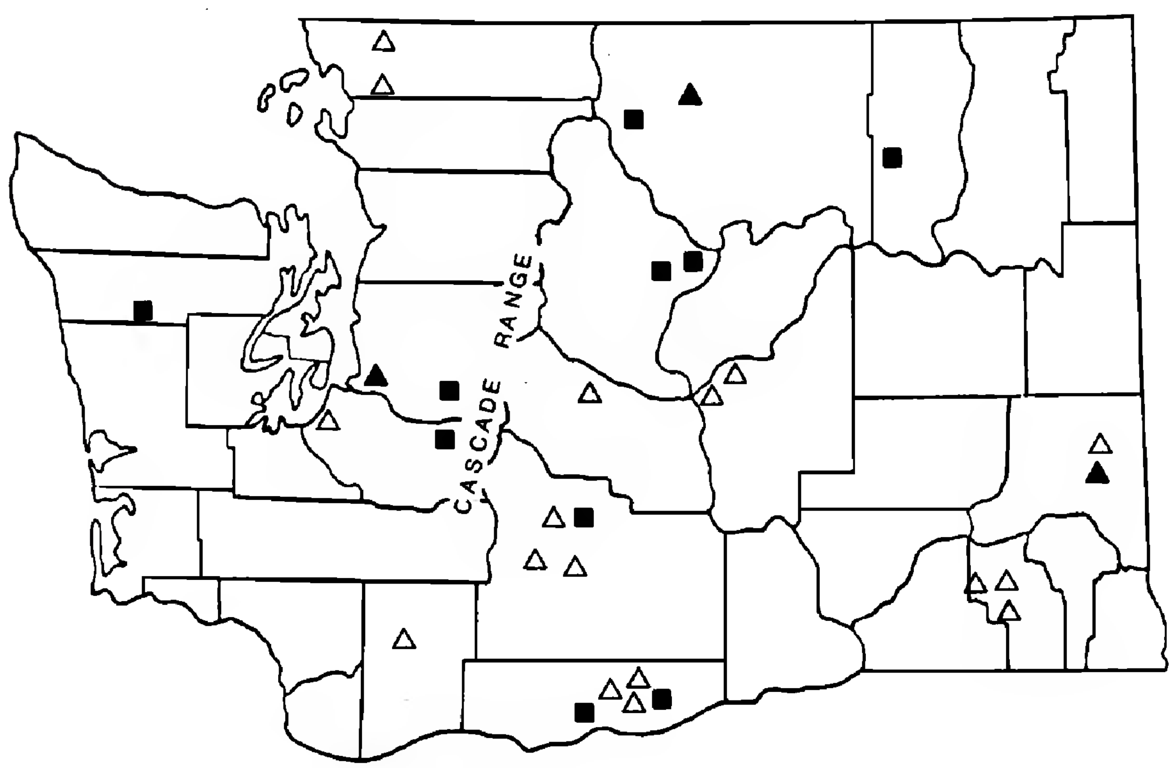

Figure 2. Breeding season locations in Washington for Mountain Bluebird museum specimens 1897 to 1947 (△), 1948 to 1966 (▲), and personal observations and questionnaire reports, summer 1974 (■).

while traveling between census areas. The only birds seen on the west side of the Cascade Range during timed censuses were 2 at Sunrise in Mount Rainier National Park.

All sightings of Western Bluebirds reported on questionnaires were from eastern Washington, except one record from the Olympic Peninsula listing this species as migratory only. Mountain Bluebirds were reported in 6 areas west and in 16 areas east of the Cascade Range. Five of these (Mitchell Creek, Chelan County; Gold Ridge, Chelan County; Lake Quinault, Jefferson County; White River, Pierce County; Rimrock Lake, Yakima County) were sightings, ranging from 1 to 12 birds, made during the breeding season. Additionally, T. Wahl (pers. comm.) reported Mountain Bluebirds in June on Hurricane Ridge in Olympic National Park, Clallam County, and in western Whatcom County. The remaining 17 observations were made during periods when juvenile bluebirds form large flocks and move widely prior to migration (Power 1966).

Table 1 summarizes results of timed censuses I conducted in areas corresponding to the four life zones, and presents an analysis of life zone use by bluebirds. Western Bluebirds seemed to use Transition preferentially to all other zones, whereas Mountain Bluebirds used Transition, Canadian and Hudsonian as expected. Neither species was seen in Upper Sonoran areas during the breeding season, probably because of the absence of suitable nesting sites. Although bluebirds will use nest boxes placed in Upper Sonoran, they generally leave the area and move to Transition when the nestlings fledge (Power 1966).

Six habitat types were censused during 1974 (Table 2). Western Bluebirds were seen in edge and burn areas; Mountain Bluebirds were seen in burn, farmland and subalpine. All sightings of Western Bluebirds in edge habitat were from Klickitat County (in the south-central part of the state) where the vegetation consists primarily of Cheatgrass Brome *(Bromus tectorum)*, Oregon White Oak *(Quercus garryana)* and Ponderosa Pine *(Pinus ponderosa)*. Western Bluebirds were counted in burns at Turnbull National Wildlife Refuge, Sherman Pass, Mitchell Creek and Gold Ridge. In these areas, nest cavities were seen in larger (20 cm or greater diameter breast height [dbh])fire-killed trees or stubs. The burn at Gold Ridge consisted of two distinct habitats. Only small (less than 20 cm dbh) trees remained throughout much of the area, probably because of post-fire tree salvage. All bluebirds were observed near the edges of the burn or on steeper slopes where larger stubs containing cavities were located.

Mountain Bluebirds were seen in burns at Sherman Pass and at Mitchell Creek, as well as in subalpine meadow-forest mosaic (Franklin and Dyrness 1973) at Sunrise and at Cutthroat Pass. The observations in farmland were of a late breeding pair using a nest box near Bickleton, Klickitat County.

Table 1. Life zone utilization by Western and Mountain bluebirds in Washington, summer 1974. Proportion observed is the proportion of the species total. Proportion expected is based on census hours in the life zone relative to total census hours.

Life Zone	Number of Censuses	Census Hours	Species	Number Seen	Number Per Hour	Proportion Observed	Proportion Expected	Confidence Interval on Proportion Observed	Observed Compared to Expected
Upper Sonoran	2	2.0	Western	0	0.00	0.00	0.05	. . .	less
			Mountain	0	0.00	0.00	0.05	. . .	less
Transition	21	22.5	Western	71	3.16	0.90	0.59	$0.82 \leq p_i \leq 0.98$	more
			Mountain	17	0.76	0.55	0.59	$0.33 \leq p_i \leq 0.77$	no difference
Canadian	4	7.5	Western	8	1.07	0.10	0.20	$0.02 \leq p_i \leq 0.18$	less
			Mountain	10	1.33	0.32	0.20	$0.11 \leq p_i \leq 0.53$	no difference
Hudsonian	5	6.0	Western	0	0.00	0.00	0.16	. . .	less
			Mountain	4	0.67	0.13	0.16	$0.00 \leq p_i \leq 0.28$	no difference
Totals	32	38.0	Western	79	2.08				
			Mountain	31	0.82				

Table 2. Habitat use by Western and Mountain bluebirds in Washington, summer 1974. Proportion observed is the proportion of the species total. Proportion expected is based on census hours in a habitat type relative to total census hours.

Habitat Type	Number of Censuses	Census Hours	Species	Number Seen	Number Per Hour	Proportion Observed	Proportion Expected	Confidence Interval on Proportion Observed	Observed Compared to Expected
Edge	8	8.5	Western	35	4.12	0.44	0.22	$0.29 \leq p_i \leq 0.59$	more
			Mountain	0	0.00	0.00	0.22	. . .	less
Burn	13	15.0	Western	44	2.93	0.56	0.39	$0.41 \leq p_i \leq 0.71$	more
			Mountain	25	1.67	0.81	0.39	$0.63 \leq p_i \leq 0.99$	more
Farmland	1	1.0	Western	0	0.00	0.00	0.03	. . .	less
			Mountain	2	2.00	0.07	0.03	$0.00 \leq p_i \leq 0.17$	no difference
Subalpine	7	10.5	Western	0	0.00	0.00	0.28	. . .	less
			Mountain	4	0.38	0.13	0.28	$0.00 \leq p_i \leq 0.29$	no difference
Grassland	2	2.0	Western	0	0.00	0.00	0.05	. . .	less
			Mountain	0	0.00	0.00	0.05	. . .	less
Clearcut	1	1.0	Western	0	0.00	0.00	0.03	. . .	less
			Mountain	0	0.00	0.00	0.03	. . .	less
Totals	32	38.0	Western	79	2.08				
			Mountain	31	0.82				

Bluebird use of clearcuts for foraging has been reported by Hooven (1969) and Nyquist (1973), but no bluebirds were seen in the single clearcut (Gifford Pinchot National Forest, Cowlitz County) I censused during the present study. Ground vegetation was widely spaced within the clearcut, however no cavities were found in the adjacent timbered areas. R. E. Johnson (pers. comm.) found Western and Mountain bluebirds using clearcuts in June near Mount Misery in Garfield County. No bluebirds were seen by me in grassland probably because of the lack of elevated perches and nest cavities.

The analysis of habitat use in Table 2 indicates that both species used burns more than expected. This may have been because, in burns, insects seemed plentiful and understory vegetation was not sufficiently developed (4 to 7 years after the fire) to hinder feeding by bluebirds. The transition area between forest and grassland (edge) probably was used more than expected by Western Bluebirds because of the presence of elevated perches from which the birds scanned adjacent grassland and because of natural cavities located in many of the older Oregon White Oaks. Mountain Bluebirds were seen as expected in both farmland and subalpine.

Bluebirds were seen in a variety of habitat types, all of which are characterized by widely spaced understory vegetation and major tree species usually clustered to form areas of dense cover adjacent to, or within, the more open spaces. Power (1966) observed that open spaces were used by adults for feeding, and that areas of denser cover served as protection for newly fledged young. In the absence of a nest cavity otherwise suitable habitat often remains unused (Hildén 1965). Censuses conducted during 1974 support this observation in that areas meeting all the basic habitat requirements of bluebirds, including seemingly adequate food and cover, were not occupied when nest cavities were absent (e.g., Gold Ridge and Gifford Pinchot National Forest).

The distribution of Western Bluebirds described by Jewett et al. (1953) is probably not entirely accurate today. Museum specimens, published reports and personal observations indicate little use of Upper Sonoran in Washington. All breeding activities seem to be restricted to Transition east of the Cascades where basic habitat requirements of nest cavities, elevated perches and fairly sparse ground cover are met. Mountain Bluebird distribution shows little, if any, change from that reported by Jewett et al. (1953).

Bluebirds vs. Starlings

One possible cause for the decline in bluebird populations is nest site competition with Starlings *(Sturnus vulgaris)* (Rogers 1956). First reports of Starlings in the Northwest were by Mills (1943), Olson (1943) and Wing (1943). Early nesting records were reported by Hudson and King (1951) and by Braden (1953). Starlings were classed as a "common winter visitor and rare breeder" in southeastern Washington by Hudson and Yocom (1954:38). Reports of declining bluebird populations in northwestern Washington (e.g., Pearse 1946) preceeded the establishment of Starlings as breeding birds east of the Cascades. Factors other than competition with Starlings, such as increased urbanization and development west of the Cascades, may have been responsible for the early decrease of Western Bluebird populations in that area. Low population levels coupled with increased pressure from Starlings in later years could have resulted in the apparent exclusion of Western Bluebirds as breeders in western Washington. Starlings do not occur in the habitats of either Western or Mountain bluebirds in eastern Washington (T. Wahl pers. comm.), which could, in part, explain the apparent stability of those bluebird populations.

The most comprehensive census data for both bluebirds and Starlings between 1968 and 1976 is provided by the Breeding Bird Survey (BBS). A maximum of 30 census routes have been run in Washington in any one year. Sixteen routes are east and 14 routes are west of the Cascades. Bluebirds have been reported on seven different census routes, all east of the Cascades. There are no BBS records for bluebirds from western Washington. Starlings have been reported on 27 census routes: 15 east and 12 west of the Cascades. Starlings were counted on every route reporting bluebirds.

The average number of bluebirds counted per hour for each route reporting that species ranged from 0 to 2.4 for Western Bluebirds and from 0 to 0.7 for Mountain Bluebirds. Starling census counts were between 5.1 and 27.0 birds per hour. Correlations between the number of Western Bluebirds and Starlings and between Mountain Bluebirds and Starlings were both negative, but neither statistic was significant. The negative correlations do however suggest a decreased number of bluebirds where Starlings are present.

No consistent trends were identified for bluebird numbers during the 9 year period. The census counts for both species fluctuated widely from year to year. Starling numbers also showed wide fluctuations and tended to parallel bluebird numbers, although Starlings were consistently 10 times more abundant than bluebirds. When Starling routes were grouped according to whether they were in eastern or western Washington, the same trends as described above were noted. The average number of Starlings observed was greater in western than in eastern Washington (41.7 vs. 32.3), but the difference was not statistically significant.

ACKNOWLEDGMENTS

I would like to thank the members of my thesis committee, R. J. Jonas, R. E. Johnson and T. S. Russell, for providing help and encouragement during this study. Numerous individuals contributed many hours of their time observing and recording bluebird activity or sent me their field notes. Among these, I am particularly indebted to J. F. Acton, F. H. Anderson, C. Banko, J. R. Bernatz, T. E. Burke, A. Eliason, R. Holtby, B. A. Lausch, B. Moorhead, L. Napier, D. Pridmore, T. H. Rogers, D. Seesholtz, J. W. TerLouw, T. R. Wahl and H. W. Wills. G. D. Alcorn, University of Puget Sound, and R. E. Johnson, Charles R. Conner Museum, Washington State University, allowed me access to the collections under their charge. Lists of museum specimens were obtained from: M. R. Browning, National Museum of Natural History; R. H. Clem, Whitman College; T. Hill, Walla Walla College; and S. Rohwer, Thomas Burke Memorial Washington State Museum, University of Washington. R. E. Johnson, J. R. King and G. Murray critically reviewed the manuscript. This study was made possible by a grant from the Non-Game Division, Washington Department of Game to R. E. Johnson. Additional travel funds were provided by the Graduate and Professional Students Association, Washington State University.

I would also like to thank P. Mattocks, Jr. for supplying much of the Breeding Bird Survey data for Washington.

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APPENDIX A. Locations and results of timed censuses conducted in Washington, summer 1974. Numbers following each location represent the number of census hours, the number of censuses (in parentheses), and the numbers of Western and Mountain bluebirds, respectively. Abbreviations: SWRA—State Wildlife Recreation Area, NF—National Forest, NP—National Park, NWR—National Wildlife Refuge.

Eastern Washington

Mitchell Creek, Wenatchee NF, Chelan Co. 4.5 (4):26, 15; Sherman Pass, Ferry Co. 2.0 (2):8, 10; Klickitat SWRA, Klickitat Co. 3.5 (3):25, 0; Little Pend Oreille

SWRA, Stevens Co. 5.0 (5):13, 0; Turnbull NWR, Spokane Co. 4.5 (4):5, 0; Gold Ridge, Wenatchee NF, Chelan Co. 4.0 (3):5, 0; Cutthroat Creek, Okanogan NF, Okanogan Co. 5.5 (3):0, 2; 5.0 km S. Bickleton, Klickitat Co. 1.0 (1):0, 2; Hanford Reservation, Benton Co. 2.0 (2):0, 0.

Western Washington
Sunrise, Mount Rainier NP, Pierce Co. 2.0 (2):0, 2; Hurricane Ridge, Olympic NP, Clallam Co. 2.0 (1):0, 0; Gifford Pinchot NF, Cowlitz Co. 1.0 (1):0, 0; Three-legged Bear Avalanche, Rainy Pass, Okanogan NF, Okanogan Co. 1.0 (1):0, 0.

Totals, with percent of statewide total: Eastern Washington—32 census hours (84.2%), 27 censuses, 79 Western Bluebirds (100%), 29 Mountain Bluebirds (93.5%). Western Washington—6 census hours (15.8%), 5 censuses, 0 Western Bluebirds, 2 Mountain Bluebirds (6.5%).

Accepted 6 March 1978

NOTES

FIRST RECORD OF THE LITTLE BLUE HERON FOR BRITISH COLUMBIA AND WASHINGTON

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In late October 1974, an immature Little Blue Heron *(Florida caerulea)* was reported by Bud Anderson from Judson Lake, a small lake (about 1.5 km long) lying astride the British Columbia-Washington boundary, about 7 km southwest of Abbotsford, British Columbia. Local residents later told us that the bird had been present since about 15 October. On 2 November 1974 Eugene Hunn visited the lake and confirmed Anderson's identification. On 3 November the heron was studied by Wayne Weber and by many other experienced observers, and it was seen frequently until 10 November on both the Canadian and American sides of the lake. The only subsequent sighting was on 5 January 1975, when Ian D. MacDonald again saw the bird at the lake. During this two-month gap in records, the heron may possibly have visited other small lakes in the vicinity.

Detailed field notes on the bird were taken by Michael Force, J. E. V. Goodwill, Al Grass, Eugene Hunn, Ian D. MacDonald, David M. Mark, John Toochin and Wayne Weber. Hunn's notes are on file at the T. H. Burke Memorial Museum, University of Washington, Seattle, and the others at the British Columbia Provincial Museum, Victoria. A summary of relevant field marks noted is as follows: size of bird, close to or slightly greater than that of a Snowy Egret *(Egretta thula)*; plumage, completely white except for dark tips on at least some of the primaries; a single short plume extending out and down from the crown; iris, pale yellow, surrounded by a thin dark ring; legs and feet, uniformly pale greenish or olive greenish; bill, bluish-gray at the base and black on the distal one-third or so; bill shape, thicker than a Snowy Egret's bill. Although immature Little Blue Herons and Snowy Egrets can be confused, the Judson Lake bird was clearly distinguishable from the latter species by the absence of yellow lores and of any black color on the legs, by the dark tips on the primaries (noted by at least one observer), and by the bill shape.

The heron spent much of its time wading in rather deep water, and was frequently seen to catch and eat frogs and small fish. Color slides of the bird obtained by Ervio Sian and David M. Mark have been deposited as No. 373 in the Photoduplicate File for British Columbia vertebrates (see Campbell and Stirling 1971), now housed at the Provincial Museum. Additional color slides by Ken Brunner and Eugene Hunn are on file at the Burke Memorial Museum. Sian's photographs are particularly good, and clearly show the bird's diagnostic features.

Northward dispersal of juvenile herons is well-known (Bent 1926:183-185, Coffey 1943, Rydzewski 1956), but the Little Blue Heron of Judson Lake must surely be an extreme example of this phenomenon. To our knowledge, this is the first record of the species, not only for British Columbia and Washington, but also for the entire Pacific Northwest. It has occurred in all the Southwestern states, but even in California is considered only a casual visitor, with no records north of Marin County (Small 1974:45). Breeding has been reported in New Mexico, but not until 1975 (Witzeman et al. 1975). Thus the Judson Lake bird must have wandered 2600 km or more from its birthplace, whether it came from the nearest colonies east of the Rocky Mountains (in Oklahoma and Texas) or from the Pacific coast of Mexico.

We thank R. Wayne Campbell and Jerome A. Jackson for comments on the manuscript.

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BALD EAGLE CONCENTRATIONS IN GLACIER NATIONAL PARK

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Bald Eagles *(Haliaeetus leucocephalus)* congregate in Glacier National Park, Montana, each autumn to feed upon spawning Kokanee Salmon *(Oncorhynchus nerka)*. Systematic observations and censuses of these eagle concentrations were initiated in 1965. McClelland (Condor 75:121-123, 1973) reported the results of the censuses for 1965-1966 and 1968-1970. From September to early December during 1971 and 1972 I conducted a study of the eagles in the same area, with special emphasis on recommendations for management. The purpose of this note is to present findings supplemental to McClelland's, including the results of my censuses during 1971 and 1972, and censuses conducted during 1973 through 1977 by Park personnel.

The study area and the history of the salmon runs and eagle concentrations have been described in detail by McClelland (op. cit.) and Shea (MS thesis, Univ. of Montana, Missoula, 1973). The area includes the foot of Lake McDonald and the entire 3.9 km of lower McDonald Creek in Glacier National Park, and 7.1 km of the Middle Fork of the Flathead River (Figure 1). My study efforts were concentrated in McDonald Creek's big bend area, which is ideally suited for observation because of good spawning conditions for the salmon, an abundance of perching and feeding sites for the eagles and good visibility for the observer.

Kokanee Salmon were first introduced into the Flathead River drainage around 1916, and into Lake McDonald in 1922 and 1923 (Glacier National Park files). The first indication of large numbers of eagles gathering to feed on the salmon was noted in 1939, when Park Rangers counted 37 eagles along McDonald Creek. Numbers gradually increased annually, and from 1965 through 1970, the average maximum count was 249 eagles.

I made 12 censuses by canoe along the 11 km water route during each of the two autumns, using the method described by McClelland (op. cit.). Eagles were counted and classified as matures or immatures. They were considered immature unless the heads and tails appeared completely white (Southern, Jack-Pine Warbler 45:70-80, 1967). The 1973 through 1976 counts by Park personnel differed in that fewer counts were made each season, and in that the Flathead River portion of the count was discontinued during several of these years. The maximum counts for these years are comparable to those made previously, as most birds are present along McDonald Creek. During 1977, more personnel were involved, enabling more complete coverage of the entire Lake McDonald area to the inlet. This additional coverage added 41 birds to the 1977 maximum count.

In addition to censuses, I made observations of feeding behavior and daily activity patterns from three blinds erected along McDonald Creek.

Systematic censuses provide a general basis for future comparisons of total eagle numbers and percentages of immature birds. Dates of maximum counts are variable, apparently influenced by fluctuations in the salmon runs, and to a lesser extent, by the weather.

Immature Bald Eagles tend to move south earlier in the fall than do the adults (Sprunt and Ligas, Proc. 62nd Ann. Conv., Natl. Audubon Soc., 1966), and this trend was evident in four of the seven years (Glacier National Park files). Because of this there is apt to be a higher percentage of immatures during years when maximum counts occurred earlier. The 1977 maximum count was the highest ever recorded in Glacier.

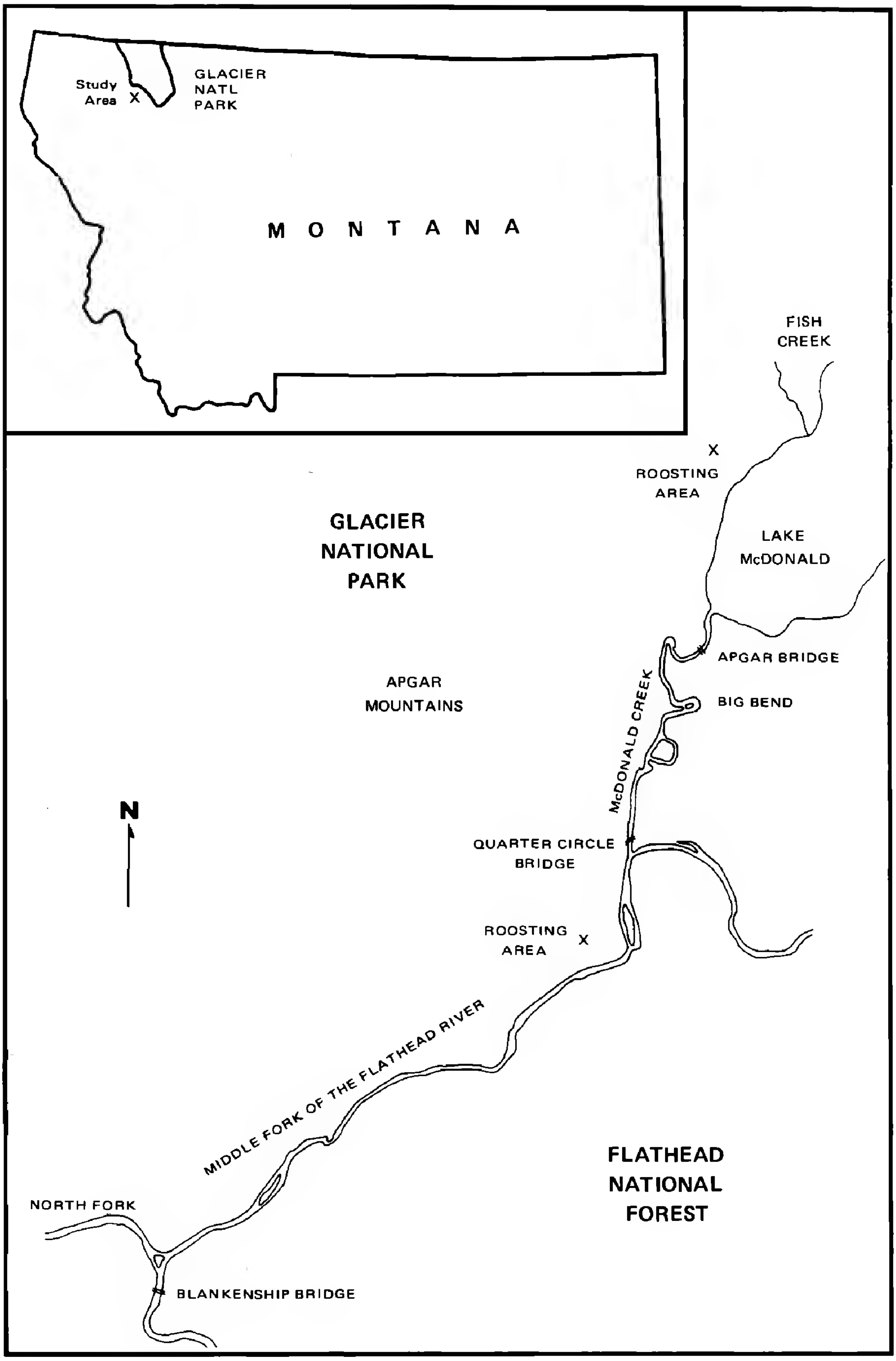

Figure 1. Location of Glacier National Park and of the study area.

Table 1. Maximum Bald Eagle numbers and percentages of immatures in the maximum counts for the period 1971 through 1977.

Year	Date	Total	% Immature
1971	10 November	267	54
1972	9 November	261	33
1973	21 November	357	34
1974	15 November	359	30
1975	25 November	377	25
1976	16 November	361	26
1977	30 November	444	30

Adult Bald Eagles were found to be very adept at capturing salmon. Most often eagles dived from a high perch and stooped upon weakly swimming, spawned-out fish. I observed 312 of these dives and found that mature birds successfully captured salmon on 84% of their attempts. If undisturbed, an adult eagle usually consumed a fish (about 32 cm average total length), often leaving the head, in 3 to 6 minutes. One adult captured and ate three entire salmon in 45 minutes. In contrast, subadult eagles did not attempt to capture salmon by diving as often as did adults, and when they did so, they were less successful. Of 99 observed attempts, 64% were successful. Young birds more often secured their food by picking up salmon along the shore, wading after salmon in shallow water, or by stealing from other eagles. They also took longer to consume their catch; one immature took 19 minutes to eat a single salmon. Hunting and feeding skills apparently develop during the long subadult period.

Daily activities and movements of eagles on McDonald Creek followed a definite pattern. Virtually no birds were present along the Creek at night, but they began arriving from their roosts at an average of 30 minutes (range of 24 to 39 minutes) before actual sunrise. This was followed by a 2 to 3 hour period of intensive feeding. Activities during the rest of the day included long periods of perching, interspersed with feeding, occasional short flights along the Creek, and bathing and preening. Departure from the feeding areas to the roosts in the evening began about 30 minutes before actual sunset. Two principal roosts were located, one on the west bank of the Middle Fork about 1.1 km south of the confluence with McDonald Creek, and the other adjacent to the southwest shore of Lake McDonald, about 3.2 km north of the feeding areas (Figure 1). Favored roost trees were large Black Cottonwoods *(Populus trichocarpa)* and Western Larch *(Larix occidentalis)*. On the evening of 2 November 1972, I counted 76 eagles flying north to the Lake McDonald roost from the north end of McDonald Creek, or 37% of the total number counted earlier the same day during a census by canoe. The latest observed flight of an eagle to the roost was 15 minutes after actual sunset.

I would like to thank B. Riley McClelland, University of Montana, for reviewing this note, and Glacier National Park for providing materials and assistance during the study.

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WHITE PELICANS NESTING AT HONEY LAKE, CALIFORNIA

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The breeding status of the White Pelican *(Pelecanus erythrorhynchos)* has been reviewed in papers by Thompson (1933), Lies and Behle (1966) and Sloan (1973). These papers show that, although the number of breeding birds may fluctuate considerably in any one colony from year to year, colonies tend to remain in ancestral locations. For example, it appears that the only new colony established west of the Rockies between 1965 and 1972 was at Crump Lake, Oregon.

We were thus surprised to find a White Pelican nesting colony on Hartson Reservoir, adjacent to Honey Lake, Lassen County, California, in June 1976. Although pelicans reportedly laid eggs at Honey Lake in the early 1950s (A. M. Lapp pers. comm.), this appears to be the first record of a productive colony at this location.

Honey Lake is a saline sink with a water area of approximately 120 km^2 in normal rainfall years and receives the flows of several streams draining the eastern escarpment of the Diamond Mountains at the northern end of the Sierra Nevada. It is located about 80 km NNW of Pyramid Lake, Nevada, and 200 km SSE of the Klamath-Clear Lake complex on the California-Oregon border, the locations of the closest White Pelican colonies.

The colony discovered on 5 June 1976 was located on a sparsely vegetated peninsula about 50 m wide by 300 m long, running parallel to the eastern shoreline of Hartson Reservoir. The pelican breeding area was shared with Double-crested Cormorants *(Phalacrocorax auritus)*, Snowy Egrets *(Egretta thula)*, Black-crowned Night Herons *(Nycticorax nycticorax)*, Ring-billed Gulls *(Larus delawarensis)* and Caspian Terns *(Sterna caspia)*. After an initial group of about 20 pelican nests with eggs was found, photographs were quickly obtained. To minimize disturbance, no further intrusion into the colony was made and consequently the total number of nests was not counted. A second visit on 20 June revealed another pelican colony on an adjacent island about 0.5 ha in extent. With the aid of a telescope, Tait counted approximately 800 adult pelicans in both colonies on this occasion. About 200 of these individuals were sitting, and possibly brooding eggs or young.

On 6 July, 705 young pelicans were counted by Kennedy and Knopf. Most of these were well feathered and nearly adult-sized. It was also noticed that some adults were still attending chicks in nests. Since these chicks were not included in the count, a return visit was made to the colony site on July 14. At that time, the smaller chicks in nests numbered 249 and were about four weeks old.

No definite conclusions relating to the production of fledged young can be drawn from these figures. The apparent anomaly of 200 possible nests counted one day, and then 705 young counted 16 days later, serves to illustrate the problems in counting tightly clumped groups of pelicans with no elevated vantage point from which to make observations. To produce 705 young would require at least 353 nests; to allow for natural mortality of young, more than 700 nests is more realistic. Careful observations in coming years are obviously required to accurately document the size and productivity of the White Pelican colony at Honey Lake.

Figure 1. White Pelicans (*Pelecanus erythrorhynchos*) and Double-crested Cormorants (*Phalacrocorax auritus*) nesting at Hartson Reservoir, Lassen Co., California, 5 June 1976

Photo by Ian C Tait

No evidence of human intrusion or animal predation was observed at the colony during visits in June and July. However, on 7 August Tait found an adult pelican with shot holes through a humerus. It is hoped that the California Department of Fish and Game will take the necessary measures to prevent future incidents that could endanger the survival of the colony. Such measures should at least include the posting of an area bounded by a line 500 m (say) from the colony edge during the months of May and June. The Department should also consider suspending their routine patrols through this area over critical periods such as during nest establishment and incubation.

The water surface of Honey Lake progressively diminished during the spring and summer of 1976 due to low precipitation the previous winter. Towards year's end, the lake dried completely and remained dry through the 1977 nesting season. Fish availability, either through higher production or the concentrating effect of the decreasing water level, was very high during 1976. This may have attracted large numbers of pelicans to the lake; an observer reported more than 10,000 birds present in July (Lapp 1976) which indicates the possibility of a massive movement from one or more of the other traditional colonies. Evidence as to the sources of these birds, however, is lacking.

We would like to express our thanks to David Ainley, Al Lapp, Robert Mallette, Gary Page, and Robert Stewart for their kindness in reviewing this paper. This is Contribution 138 of the Point Reyes Bird Observatory.

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PREDATION BY A RUBBER BOA ON CHESTNUT-BACKED CHICKADEES IN AN ARTIFICIAL NESTING SITE

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During the past 9 years, by use of artificial nest boxes, we have conducted studies on the life history of the Mountain *(Parus gambeli)* and Chestnut-backed *(P. rufescens)* chickadees and their impact on insect populations. Nine study plots consisting of 50 nesting boxes per plot at 100 m intervals (area of 50 ha) have been established in several montane regions of California (Dahlsten and Copper, unpublished manuscript).

During the study years various mortality factors (weather, disease, starvation, parasites and predators) have acted upon these avian populations and use of nesting boxes has facilitated the detection of predation during the nesting period. Although considerable nest predation (presumably by weasels, mice and chipmunks) was noted, the evidence has always been circumstantial. In most instances the nests have been found in disarray and have contained remnants of adults and/or nestlings. However, on numerous occasions nests have been found in which eggs

Rubber Boa *(Charina bottae)* in nest box of Chestnut-backed Chickadee *(Parus rufescens)*, Blodgett Experimental Forest, El Dorado Co., California, 6 June 1974.
Photo by Cliff Ohmart

and/or nestlings have disappeared with little or no disturbance to the nest.

In these instances birds or snakes would seem to be the most likely predators. A large bird such as a jay can reach its head inside the nest box and pluck out the nestlings (Copper, pers. observation of Scrub Jay, *Aphelocoma coerulescens)*, and small snakes can simply glide through the 32 mm diameter opening. The latter was the case on 6 June 1974 at the University of California's Blodgett Experimental Forest, El Dorado Co., California (elevation 1300 m), when a Rubber Boa *(Charina bottae)* was found preying upon a nest of a Chestnut-backed Chickadee.

Rubber Boas are believed to be good climbers and have been found in tree cavities (Ross 1931) and behind loose bark of dead trees (Robert F. Hoyer pers. comm.). Only one report (Weeks and Davis 1963), however, refers to this snake taking birds in the wild. Judging from what little is known of their habits, these snakes could and probably would prey upon many ground nesting birds or their nestlings. However, the degree to which these boas forage in trees for cavity or cup nesting birds is unknown.

The nest box in which the boa was found had been checked the previous afternoon (5 June) and contained six nestlings 9 days old. It was attached about 5 feet above the ground to the trunk of a Ponderosa Pine *(Pinus ponderosa)*, 25-30 cm in diameter at breast height. The nest box was approached at 0930 on a sunny, warm day. The adult birds were calling in a highly distressed manner. The Rubber Boa (60 cm long) was already one-third inside the box and was virtually motionless. The adult chickadees were flitting from branch to branch around the box. After 10 minutes (0940) of this activity, first one adult then the other flew off. Five minutes later (0945) one bird, then the other, returned with food. They at once became excited and either ate, dropped or, as we have observed in the past, placed the food on a branch. The snake remained motionless. At 0954 one bird left, to return with food at 1000. By 1002 both birds had left again. At 1012 one bird returned with food. This time the bird did not seem as excited, even though it still could not enter the nest box. This bird left by 1019 and a few seconds later the snake began slow, intermittent movements into the nest box. One bird returned with food at 1022 and the other by 1024. One of these birds left almost immediately. The movement of the snake evoked an instant response from the remaining bird, which began calling repeatedly and flying at the snake. The latter disappeared into the box at 1028. After a few minutes (1030) the single remaining bird flew to the entrance, looked into the box and returned to a nearby branch. At 1032 the snake's head appeared at the entrance. The bird immediately flew at it, causing the snake to retreat. At 1035 the other bird returned and the snake's head appeared again at the entrance. As the snake began to emerge both birds flew and struck at its head, again making the snake retreat. The snake again began to emerge at 1046. Both birds flew and struck the head and "neck" area repeatedly, but by 1047 the snake was out of the box and on the trunk of the tree. Once the snake was out of the box and on the tree the birds left (1050). The snake moved easily straight down along the crevices in the bark and was on the ground by 1052. The birds returned to the box again at 1053 with food, but flew off almost immediately without entering. The box was observed until 1121, but neither of the birds returned. Examination of the box showed the nest material only slightly disturbed and pressed down. All six nestlings were gone.

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Accepted 21 April 1978

TREASURER'S REPORT

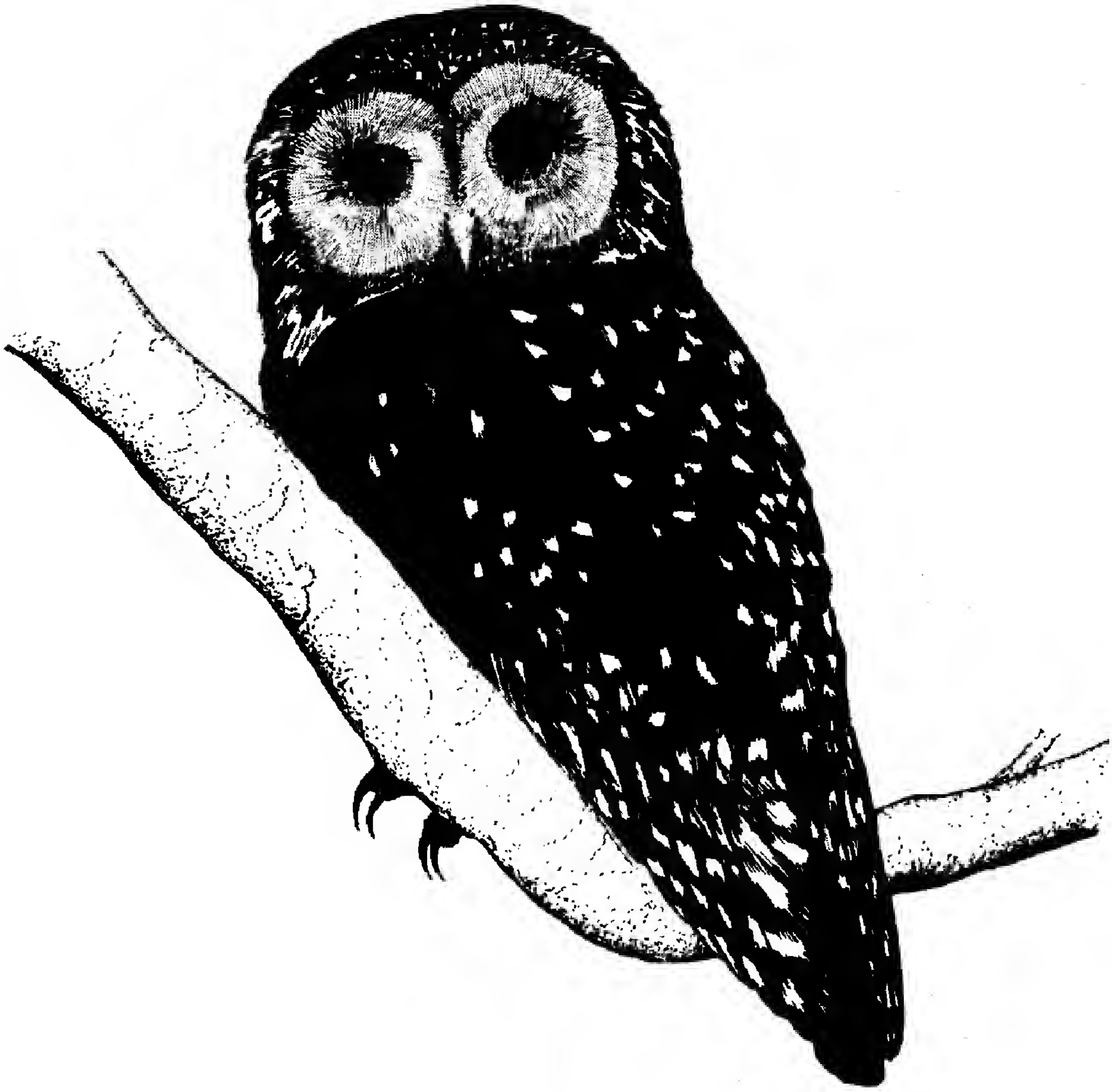
WESTERN FIELD ORNITHOLOGISTS

Cash Flow Statement 1 January 1977 to 31 December 1977.

Cash on hand 1 January 1977		$ 7,973.95
Gibralter Savings and Loan (Savings)	$4,773.31	
Crocker National Bank (Checking)	3,200.64	
RECEIPTS		
Membership	$7,934.31	
Boat Trips	7,877.00	
Annual Meeting	4,224.50	
Back Issues — Western Birds	964.32	
Reprints — Western Birds	629.57	
Interest	307.64	
Donations	132.50	
Sales Tax Received	62.88	
Advertising	60.00	$22,192.72
		$30,166.67
DISBURSEMENTS		
Western Birds	$4,665.15	
Boat Trips	7,895.23	
Postage	1,715.45	
Annual Meeting	3,784.28	
Reprints	304.53	
Promotion	467.50	
Sales Tax Paid	43.20	
Bird Records Committee	59.91	
Miscellaneous	303.55	$19,238.80
		$10,927.87
Cash on hand 31 December 1977		
Gibralter Savings and Loan (Savings)	$3,846.92	
Crocker National Bank (Checking)	7,080.95	

(prepared without audit)

Philip P. Schaeffer, *Treasurer*



Sketch by Cameron Barrows

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Manuscripts should be sent to Alan M. Craig, 3532 Winston Way, Carmichael, CA 95608. For matters of style consult *Suggestions to Contributors to Western Birds* (6 pp. mimeo available at no cost from the Editor) and *CBE Style Manual*, 3rd ed., 1972 (available from American Institute of Biological Sciences, 3900 Wisconsin Ave.,NW, Washington, DC 20016 for $6.00).

Papers are desired that are based upon field studies of birds, that are both understandable and useful to amateurs, and that make a significant contribution to scientific literature. Appropriate topics include distribution, migration, status, behavior, ecology, population dynamics, habitat requirements, the effects of pollution, and techniques for identifying, censusing, sound recording and photographing birds in the field. Papers of general interest will be considered regardless of their geographic origin, but particularly desired are papers dealing with studies accomplished in or bearing on Rocky Mountain states and provinces westward, including Alaska and Hawaii; adjacent portions of the Pacific Ocean and Mexico; and western Texas.

Authors are provided 50 free reprints of each paper. Additional reprints can be ordered at author's expense from the Editor when proof is returned or earlier.

Good photographs of rare and unusual birds, unaccompanied by an article but with caption including species, date, locality and other pertinent information, should be submitted to Stephen Laymon, 68 Gurnsey Avenue, Red Bluff, CA 96080.