NONGAME AND UPLAND GAMEBIRD SURVEYS ON SACRAMENTO VALLEY NATIONAL WILDLIFE REFUGES, 1986–1993

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The Sacramento Valley forms the northern reach of California's Central Valley, one of the most intensively farmed regions in North America. Over 90% of the Central Valley's wetlands and riparian habitats have been lost or degraded through agriculture and urban development since the early 1900s (U.S. Fish and Wildlife Service 1978, Frayer et al. 1989). In spite of habitat loss, the Sacramento Valley still provides important breeding areas and serves as critical wintering grounds for millions of migratory birds in the Pacific Flyway (Gilmer et al. 1982). The importance of the Sacramento Valley to the Pacific Flyway and the scarcity of its remaining natural habitats emphasize the need for closely monitoring avian use of these areas.

Information on the abundance and distribution of nongame species in the Sacramento Valley is sparse, especially in comparison to game species such as waterfowl. In an effort to expand bird monitoring, managers at the Sacramento National Wildlife Refuge Complex (NWRC) developed a long-term survey program to gather basic information on nongame migratory bird populations. Based on support from trained volunteer staff, surveys were initiated in 1986. The initiation of year-round refuge surveys complemented traditional Breeding Bird Surveys (Robbins et al. 1986) conducted nearby off the refuges.

The purpose of this paper is to describe surveys of nongame and upland gamebird populations conducted from 1986 through 1993 and to report the findings on seasonal distribution, frequency of occurrence, and trends in abundance of selected species on the Sacramento NWRC.

STUDY AREAS

The surveyed areas included the Sacramento, Delevan, Colusa, and Sutter refuges of the Sacramento NWRC. All refuges are located within a 30-km radius of Colusa in the Sacramento Valley (Figure 1) and range in size from 1161 (Sutter) to 4415 ha (Sacramento). The climate is characterized by mild wet winters and long hot summers. Annual precipitation averages 46 cm, most falling from October through April.

Seasonal wetland is the most common habitat type on all the refuges (Table 1). Typically, these wetlands are drawn down in April or May, remain mostly dry during summer, and are reflooded in late summer and early fall. Uplands consist mostly of halophytic herbaceous vegetation and annual grasslands with lesser acreages of riparian woodlands along waterways

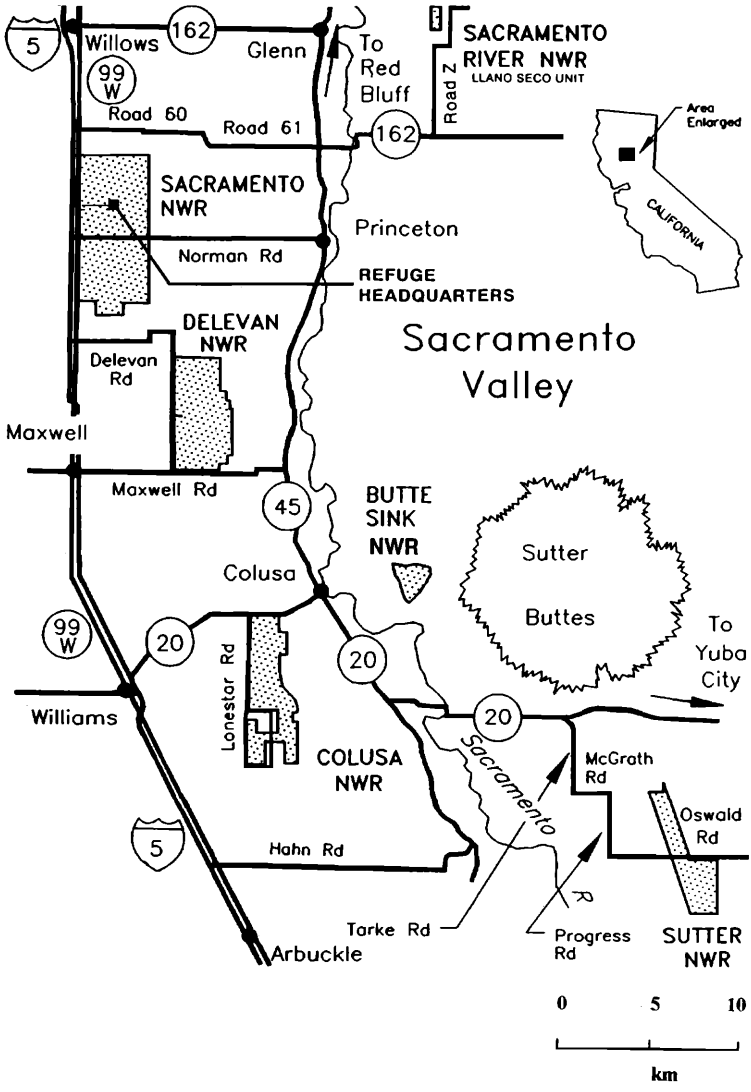

Figure 1. Sacramento Valley, California, and study areas, including Sacramento, Delevan, Colusa, and Sutter national wildlife refuges.

(Oswald and Silveira 1995). Permanent wetlands constitute less than 10% of all wetlands.

Sacramento, Delevan, and Colusa refuges are situated in the Colusa Plains, historically an alkali grassland interspersed with seasonal wetlands

Table 1 Habitat Types on Sacramento NWRC Refuges and at Survey Stops, 1986–1993

	Refuge				
	Sacramento	Delevan	Colusa	Sutter	Total
Size (ha)	4415	2296	1654	1161	9526
Percentage of refuge sampled	33.1	37.3	37.4	52.0	37.0
Percentage seasonal wetland					
Overall	70.4	82.2	68.2	66.7	72.4
Stops	70.3	69.1[a]	61.6[a]	68.9	68.3
Percentage permanent wetland					
Overall	3.4	1.9	8.2	9.5	4.6
Stops	4.1	3.3	10.0	11.4	6.2
Percentage riparian woodland					
Overall	2.6	2.8	3.5	17.0	4.6
Stops	3.4	2.0	4.5	17.9	5.7
Percentage grassland					
Overall	23.6	13.1	20.1	6.8	18.4
Stops	22.2	25.6[a]	23.9	1.8[a]	19.8

[a]Habitat proportion in sample significantly different from in refuge ($\alpha = 0.05$).

and sparse trees and shrubs along drainages (Hall 1975). Intensive rice cultivation began in the Colusa Plains in the early and mid-1900s, and rice growing continued on certain refuge units until the late 1980s. Currently refuge lands are managed mostly as seasonally flooded marshes and natural uplands. Riparian woodlands now occur on many of the developed waterways that originally were treeless ephemeral streams.

Sutter Refuge is located almost entirely within a 1.6-km-wide bypass channel built to control flooding by containing overflow water from the Sacramento River. Historically, this area was part of the lower reaches of Butte Creek, a tributary of the Sacramento River. Rice was cultivated at Sutter Refuge through the mid-1980s, but the area is currently managed for wetlands. Sutter Refuge supports more riparian woodland than the other refuges because of its relatively high water table and floodplain location.

METHODS

On each refuge, surveys were conducted by means of fixed-radius roadside point counts modified from Hutto et al. (1986). Routes were established along improved roads, with stops spaced 0.8 km apart to avoid disturbance to vegetation and wildlife. We used a systematic rather than a randomized spacing of stops to ensure reliable access, repeatable sampling of habitats, and to enable use of a standardized radius for observations. Route length and the number of stops per survey route were 27 km, 34 stops at Sacramento, 21 km, 26 stops at Delevan, 18 km, 22 stops at Colusa, and 14 km, 18 stops at Sutter. At each stop, nongame birds and four upland gamebird

species seen or heard within a visually estimated 0.4-km radius and within 5 minutes were recorded. Any portion of the circular sample site that was outside the refuge boundary was not considered. Ten-power binoculars and a 15- to 45-power spotting scope were used to aid species identification. Most surveys were conducted during the middle of each month throughout the year, with additional surveys in the spring (March, April, May) and fall (September, October, November) (Table 2) when migrants were present and trained volunteers were available. To maximize bird detection, surveys were started at about 0700 and usually completed within 4 hours. If winds exceeded approximately 24 km/hr, or visibility was below 1.6 km, the survey was postponed until the next acceptable day. Some stops or routes were omitted temporarily during the 8-year study because of flooding or poor road conditions. Seasonal flooding occasionally hindered our normal survey schedule, especially at Sutter and Colusa refuges. Monthly surveys on each refuge were conducted on different days, but surveys in the same month were usually done within 14 days of each other.

We used a geographic information system (ESRI 1995) to determine the area of habitat type (seasonal wetlands, permanent wetlands, riparian woodlands, and grasslands) within each refuge and within 0.4 km of each stop. We compared the habitat composition of survey stops to the overall habitat composition of each refuge habitat using an overall chi-square test of independence (SAS Institute 1989) and a Bonferroni Z statistic (Neu et al. 1974) to determine specific variations in habitat proportions.

Regression analyses (SAS Institute 1989) were used to evaluate trends in species' frequency of occurrence (the percentage of stops on a survey where at least one individual of the species was observed) and number observed (the mean number of a given species observed on a survey for all stops where the species was observed) over the eight years of the study. To ensure a reasonable sample of observations as a basis for assessing change, we selected only species that were observed on more than two surveys per season per year, and considered only the spring and fall seasons when surveys were conducted most consistently.

Table 2 Bird Surveys Conducted in the Sacramento NWRC, 1986–1993

	Number of Surveys[a]				
Refuge	Winter	Spring	Summer	Fall	Total
Sacramento	13 (7)	22 (8)	5 (2)	17 (7)	57
Delevan	8 (5)	22 (8)	3 (3)	18 (7)	51
Colusa	7 (4)	20 (8)	5 (3)	18 (7)	50
Sutter	4 (2)	14 (7)	3 (2)	12 (5)	33
Total	32	78	16	65	191

[a]Number of years surveys conducted shown in parentheses.

We compared the portion of wetland at each stop with total spring plus fall observations for each species group (i.e., diving birds, wading birds, shorebirds, raptors, and other landbirds). We pooled data for Sacramento, Delevan, and Colusa refuges because of the nearly equal survey effort for each refuge and their similar habitats. Sutter Refuge was omitted because of its lower survey effort and unique habitat. A total observation value (observations/stop) for combined spring and fall surveys was determined for each category and for each species group.

RESULTS

Species Richness and Abundance

We observed 139 species (Table 3) during a total of 191 surveys at 5141 stops, for 28,635 sightings on the four refuges over eight years. Species richness was greatest during spring, when we identified a total of 88 species of landbirds and 40 of waterbirds on all refuges combined. The number of species observed per stop was highest for landbirds at Sutter in the spring (7.74) and for waterbirds at Delevan in spring (1.96).

Species detected during all surveys and at more than 25% of all stops were the Red-winged Blackbird (44% of stops), Red-tailed Hawk (43%), and Marsh Wren (38%) during winter; Ring-necked Pheasant (62%), Western Meadowlark (56%), Marsh Wren (51%), and Red-winged Blackbird (49%) during spring; Red-winged Blackbird (35%), Western Kingbird (32%), and Western Meadowlark (29%) during summer; and Red-winged Blackbird (56%), Red-tailed Hawk (30%), and Marsh Wren (27%) during fall. In contrast, 17 species were sighted only once during the entire eight years.

Population Trends

Observations of 56 species were sufficient to test for population trends in spring (53 species) and fall (42 species). In spring, 15 species had positive trend estimates, 21 had negative trends, and 17 had mixed trends for frequency of occurrence and number observed; of these, the trend was significant ($P < 0.05$) for 15 (Table 4). In fall, seven species had positive trend estimates, 17 had negative trends, and 18 had mixed trends; the trend was significant for nine (Table 4). The Ring-necked Pheasant declined significantly in both variables in spring, as did Brewer's Blackbird in both spring and fall.

Diving birds (six species, including the Belted Kingfisher) peaked during spring migration. The Pied-billed Grebe was the most common diver (583 observations), the Eared the least (9). During spring and fall diving birds were observed most frequently (0.26 observations/survey/stop) at Colusa Refuge, where deep water was more abundant along survey routes than on other refuges. Trends in this group (Table 4) included declines of the Pied-billed Grebe and Double-crested Cormorant in fall and spring, respectively, and an increase in the frequency of occurrence of the American White Pelican in spring.

Wading birds (13 species) were common year round. The Great Egret, the most commonly encountered wader (995 observations), and Great Blue

Table 3 Seasonal Bird Observations during Surveys in the Sacramento NWRC, 1986–1993

Species	Migratory status[a]	Season[b]								Observed	
		Winter		Spring		Summer		Fall			
		% Stops[c]	Mean[d]	% Stops	Mean	% Stops	Mean	% Stops	Mean	Refuges[e]	Years[f]
Diving birds											
Pied-billed Grebe, *Podilymbus podiceps*	R	8.9	1.2	19.6	1.2	6.8	1.2	6.0	1.5	S, D, C, Su	8
Eared Grebe, *Podiceps nigricollis*	W	0.2	1.0	0.2	1.7	0.0	0.0	0.3	2.0	S, D, C	5
Clark's/Western Grebe, *Aechmophorus clarkii/occidentalis*[g]	B	0.4	1.3	0.5	3.8	0.5	4.0	0.1	2.5	S, C	6
American White Pelican, *Pelecanus erythrorhynchos*	T	2.2	17.1	4.4	11.3	3.5	12.9	2.3	12.7	S, D, C, Su	8
Double-crested Cormorant, *Phalacrocorax auritus*	R	5.4	1.9	5.2	3.6	4.3	1.7	4.6	2.0	S, D, C, Su	8
Wading birds											
American Bittern, *Botaurus lentiginosus*	R	2.9	1.0	9.0	1.2	2.0	1.0	4.4	1.3	S, D, C, Su	8
Least Bittern, *Ixobrychus exilis*	R	0.0	0.0	0.0	0.0	0.3	1.0	0.0	0.0	S	1
Great Blue Heron, *Ardea herodias*	R	15.0	1.3	20.1	1.8	15.8	1.5	14.2	1.2	S, D, C, Su	8
Great Egret, *A. alba*	R	20.1	1.6	24.0	3.1	19.6	3.1	17.0	2.4	S, D, C, Su	8
Snowy Egret, *Egretta thula*	R	2.9	2.6	10.3	3.4	13.8	9.3	5.5	6.0	S, D, C, Su	8
Cattle Egret, *Bubulcus ibis*	R	0.2	3.0	0.0	0.0	0.0	0.0	0.6	29.9	S, D, C	6
Green Heron, *Butorides virescens*	R	0.0	0.0	0.2	1.0	0.5	1.5	0.2	1.3	S, D, Su	6
Black-crowned Night-Heron, *Nycticorax nycticorax*	R	1.9	12.1	9.3	3.8	9.5	4.8	2.3	6.5	S, D, C, Su	8
White-faced Ibis, *Plegadis chihi*	R	2.1	12.9	2.3	13.3	2.8	12.0	0.8	12.8	S, D, C, Su	6
Virginia Rail, *Rallus limicola*	R	1.1	1.0	0.8	1.0	0.0	0.0	1.6	1.0	S, D, C, Su	8
Sora, *Porzana carolina*	R	0.1	1.0	0.9	1.1	0.0	0.0	1.4	1.6	S, D, C, Su	8

Common Moorhen, *Gallinula chloropus*	R	2.3	1.4	1.8	1.6	1.3	2.0	2.5	1.7	S, D, C, Su	8
Sandhill Crane, *Grus canadensis*	W	0.1	65.0	0.1	1.0	0.0	0.0	0.2	15.7	S, D, Su	4
Shorebirds											
Black-bellied Plover, *Pluvialis squatarola*	T	0.0	0.0	0.7	15.5	0.3	1.0	0.4	7.2	S, D, C	7
Semipalmated Plover, *Charadrius semipalmatus*	T	0.0	0.0	0.2	4.0	0.0	0.0	0.0	0.0	S, D, Su	3
Killdeer, *C. vociferus*	R	11.2	1.7	22.3	1.6	7.5	1.6	15.7	2.7	S, D, C, Su	8
Black-necked Stilt, *Himantopus mexicanus*	R	6.2	5.8	15.0	4.4	6.0	8.5	4.9	13.8	S, D, C, Su	8
American Avocet, *Recurvirostra americana*	B	1.5	3.4	15.5	4.5	3.0	4.4	0.5	4.0	S, D, C, Su	8
Greater Yellowlegs, *Tringa melanoleuca*	T	4.4	1.5	10.0	2.6	1.5	3.3	4.2	2.5	S, D, C, Su	8
Lesser Yellowlegs, *T. flavipes*	T	0.1	1.0	0.4	2.3	0.5	1.0	0.7	3.6	S, D, C	8
Willet, *Catoptrophorus semipalmatus*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	S	1
Whimbrel, *Numenius phaeopus*	T	0.0	0.0	0.2	3.0	0.0	0.0	0.1	2.0	S, C, Su	2
Long-billed Curlew, *N. americanus*	T	2.1	22.3	1.3	14.6	0.8	3.0	2.7	39.7	S, D, C, Su	8
Marbled Godwit, *Limosa fedoa*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	D	1
Western Sandpiper, *Calidris mauri*	T	0.0	0.0	1.1	57.5	0.8	42.7	0.6	32.0	S, D, C, Su	7
Least Sandpiper, *C. minutilla*	T	0.0	0.0	0.3	28.7	0.0	0.0	0.3	12.5	S, D, C, Su	4
Undifferentiated Sandpiper	T	2.1	34.2	1.6	34.8	0.5	22.5	1.4	9.2	S, D, C, Su	8
Dunlin, *C. alpina*	T	1.4	65.8	2.9	150	0.0	0.0	1.3	22.8	S, D, C	8
Long-billed Dowitcher, *Limnodromus scolopaceus*	T	3.7	61.3	4.9	128.7	0.8	22	3.9	101.3	S, D, C, Su	8
Common Snipe, *Gallinago gallinago*	T	0.8	1.4	0.4	2.4	0.0	0.0	1.1	1.3	S, D, C, Su	6
Wilson's Phalarope, *Phalaropus tricolor*	T	0.0	0.0	0.1	3.5	0.0	0.0	0.0	0.0	S, C	2
Red-necked Phalarope, *P. lobatus*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.2	8.3	S, D, C	3
Gulls and terns											
Ring-billed Gull, *Larus delawarensis*	W	9.1	4.6	3.4	5.2	0.3	5.0	3.9	30.2	S, D, C, Su	8
Herring Gull, *L. argentatus*	W	5.4	6.2	0.7	2.6	0.0	0.0	0.6	3.1	S, D, C, Su	7
Caspian Tern, *Sterna caspia*	T	0.0	0.0	0.2	1.7	0.0	0.0	0.3	2.3	S, C, Su	5
Forster's Tern, *S. forsteri*	T	0.0	0.0	0.1	4.0	0.5	1.0	0.0	0.0	S, D	3

(*continued*)

Table 3 (*Continued*)

Species	Migratory status[a]	Season[b]								Observed	
		Winter		Spring		Summer		Fall			
		% Stops[c]	Mean[d]	% Stops	Mean	% Stops	Mean	% Stops	Mean	Refuges[e]	Years[f]
Black Tern, *Chlidonias niger*	B	0.0	0.0	0.9	9.4	0.0	0.0	0.0	0.0	S, D	6
Raptors, vultures, and owls											
Turkey Vulture, *Cathartes aura*	R	10.1	1.9	4.8	1.5	18.8	1.8	10.7	1.8	S, D, C, Su	8
White-tailed Kite, *Elanus leucurus*	R	5.9	1.3	2.5	1.3	5.0	1.3	5.1	1.2	S, D, C, Su	8
Bald Eagle, *Haliaeetus leucocephalus*	W	0.4	1.0	0.1	1.0	0.0	0.0	0.0	0.0	S, C	3
Northern Harrier, *Circus cyaneus*	R	24.5	1.3	11.4	1.2	9.3	1.2	17.5	1.2	S, D, C, Su	8
Sharp-shinned Hawk, *Accipiter striatus*	W	0.2	1.0	0.1	1.0	0.0	0.0	0.1	1.0	S, D, Su	2
Cooper's Hawk, *A. cooperii*	W	1.4	1.1	0.2	1.0	0.0	0.0	0.7	1.1	S, D, C, Su	7
Red-shouldered Hawk, *Buteo lineatus*	R	0.7	1.0	0.1	1.0	0.3	1.0	1.1	1.0	S, D, C, Su	7
Swainson's Hawk, *B. swainsoni*	B	0.0	0.0	0.0	0.0	0.3	1.0	0.0	0.0	S	1
Red-tailed Hawk, *B. jamaicensis*	R	42.7	1.5	17.0	1.2	18.1	1.2	30.2	1.3	S, D, C, Su	8
Rough-legged Hawk, *B. lagopus*	W	0.6	1.0	0.2	1.0	0.0	0.0	0.3	1.0	S, D	7
Golden Eagle, *Aquila chrysaetos*	W	1.1	1.0	0.7	1.2	2.0	1.1	0.4	1.0	S, D, C, Su	6
American Kestrel, *Falco sparverius*	R	3.2	1.1	1.3	1.1	1.8	1.1	4.7	1.1	S, D, C, Su	8
Merlin, *F. columbarius*	W	0.2	1.0	0.0	0.0	0.0	0.0	0.5	1.0	S, D, C, Su	5
Peregrine Falcon, *F. peregrinus*	W	2.3	1.0	0.3	1.0	0.8	1.0	1.1	1.0	S, D, C, Su	8
Prairie Falcon, *F. mexicanus*	W	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	S	2
Barn Owl, *Tyto alba*	R	0.6	1.0	0.2	1.3	0.5	1.0	0.4	1.3	S, D, C, Su	7
Great Horned Owl, *Bubo virginianus*	R	0.9	1.0	1.7	1.2	2.5	1.3	1.2	1.1	S, D, C, Su	8
Burrowing Owl, *Athene cunicularia*	B	0.1	1.0	0.1	1.0	0.0	0.0	0.0	0.0	S	2

Long-eared Owl, *Asio otus*	W	0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	Su	1
Short-eared Owl, *A. flammeus*	W	0.1	1.0	0.1	1.0	0.0	0.0	0.1	2.0	C	2
Gamebirds											
Ring-necked Pheasant, *Phasianus colchicus*	R	23.9	3.6	61.6	2.3	24.3	2.0	27.1	2.6	S, D, C, Su	8
California Quail, *Callipepla californica*	R	0.0	0.0	0.5	1.5	0.3	2.0	0.1	5.5	S, D, Su	6
Band-tailed Pigeon, *Columba fasciata*	T	0.0	0.0	0.5	1.0	0.0	0.0	0.0	0.0	S	1
Mourning Dove, *Zenaida macroura*	R	3.2	2.8	22.1	1.8	28.1	2.0	4.4	4.0	S, D, C, Su	8
Other landbirds											
Anna's Hummingbird, *Calypte anna*	T	0.0	0.0	0.0	0.0	0.3	1.0	0.0	0.0	S	1
Belted Kingfisher, *Ceryle alcyon*	R	1.2	1.1	0.4	1.4	0.3	2.0	1.4	1.0	S, D, C, Su	7
Nuttall's Woodpecker, *Picoides nuttallii*	R	2.8	1.0	4.8	1.1	8.3	1.4	6.0	1.1	S, D, C, Su	8
Downy Woodpecker, *P. pubescens*	T	0.6	1.0	0.9	1.1	1.0	1.3	1.1	1.1	S, D, C, Su	7
Northern Flicker, *Colaptes auratus*	R	3.6	1.2	1.6	1.2	0.3	1.0	6.5	1.2	S, D, C, Su	8
Olive-sided Flycatcher, *Contopus cooperi*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	D	1
Western Wood-Pewee, *C. sordidulus*	B	0.0	0.0	0.4	1.0	0.0	0.0	0.3	1.0	S, D, Su	7
Pacific-slope Flycatcher, *Empidonax difficilis*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	D	1
Black Phoebe, *Sayornis nigricans*	R	10.6	1.1	8.8	1.2	7.0	1.2	16.7	1.1	S, D, C, Su	8
Say's Phoebe, *S. saya*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.1	1.0	D, C	2
Ash-throated Flycatcher, *Myiarchus cinerascens*	B	0.0	0.0	3.4	1.3	5.5	1.3	0.0	0.0	S, D, C, Su	8
Western Kingbird, *Tyrannus verticalis*	B	0.0	0.0	23.7	1.8	31.8	2.5	0.1	1.5	S, D, C, Su	8
Horned Lark, *Eremophila alpestris*	T	0.2	25.0	0.0	0.0	0.0	0.0	0.1	40.5	S, D	3
Tree Swallow, *Tachycineta bicolor*	B	4.3	8.9	27.8	11.5	12.5	12.5	2.5	16.6	S, D, C, Su	8
Violet-green Swallow, *T. thalassina*	B	0.1	4.0	0.4	3.0	1.0	1.5	0.0	0.0	S, C, Su	5
N. Rough-winged Swallow, *Stelgidopteryx serripennis*	T	0.0	0.0	0.0	0.0	1.0	1.5	0.1	2.0	S, D, Su	2
Bank Swallow, *Riparia riparia*	B	0.0	0.0	0.0	0.0	0.3	1.0	0.0	0.0	S	1

(*continued*)

Table 3 (*Continued*)

Species	Migratory status[a]	Season[b]								Observed	
		Winter		Spring		Summer		Fall			
		% Stops[c]	Mean[d]	% Stops	Mean	% Stops	Mean	% Stops	Mean	Refuges[e]	Years[f]
Cliff Swallow, *Petrochelidon pyrrhonota*	B	0.2	20.0	9.4	48.4	16.5	39.9	0.3	15.0	S, D, C, Su	8
Barn Swallow, *Hirundo rustica*	B	0.0	0.0	8.5	2.8	12.8	2.4	1.4	3.2	S, D, C, Su	8
Western Scrub-Jay, *Aphelocoma californica*	R	0.4	1.0	1.0	1.2	2.0	1.6	1.8	1.7	D, C, Su	8
Yellow-billed Magpie, *Pica nuttalli*	R	6.5	2.0	8.0	1.6	5.3	4.0	7.6	2.0	S, D, C, Su	8
American Crow, *Corvus brachyrhynchos*	R	3.0	1.5	5.0	1.7	3.3	2.7	5.2	3.1	S, D, C, Su	8
Common Raven, *C. corax*	R	4.4	2.0	2.3	1.4	0.3	2.0	1.0	1.3	S, D, C	8
Oak Titmouse, *Baeolophus inornatus*	B	0.6	1.2	1.9	1.2	1.5	1.8	0.8	1.2	C, Su	7
Bushtit, *Psaltriparus minimus*	R	0.4	12.7	1.0	2.7	1.5	5.8	0.8	6.4	S, D, Su	8
Rock Wren, *Salpinctes obsoletus*	T	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	Su	1
Bewick's Wren, *Thryomanes bewickii*	R	1.2	1.0	3.0	1.2	3.5	1.4	1.8	1.1	S, D, C, Su	8
House Wren, *Troglodytes aedon*	B	0.1	1.0	6.1	1.4	2.5	1.6	1.4	1.0	S, D, C, Su	8
Marsh Wren, *Cistothorus palustris*	R	38.2	1.7	50.6	2.3	19.8	1.8	27.4	1.7	S, D, C, Su	8
Ruby-crowned Kinglet, *Regulus calendula*	W	3.0	1.2	0.8	1.0	0.3	1.0	2.2	1.4	S, D, C, Su	8
Hermit Thrush, *Catharus guttatus*	T	0.6	1.0	0.1	1.0	0.0	0.0	0.4	1.1	S, Su	6
American Robin, *Turdus migratorius*	B	1.2	2.4	2.7	1.3	2.0	2.3	0.7	1.0	S, D, C, Su	8
Northern Mockingbird, *Mimus polyglottos*	R	0.2	1.0	1.9	1.0	4.8	1.2	0.6	1.0	S, D, C, Su	8
American Pipit, *Anthus rubescens*	W	10.7	2.1	3.1	2.2	0.0	0.0	4.9	1.6	S, D, C, Su	8
Cedar Waxwing, *Bombycilla cedrorum*	T	0.1	10.0	0.1	10.0	0.0	0.0	0.0	0.0	D, Su	2
Loggerhead Shrike, *Lanius ludovicianus*	R	5.8	1.2	2.7	1.1	6.3	1.1	7.0	1.1	S, D, C, Su	8

European Starling, *Sturnus vulgaris*	R	3.3	6.4	3.5	1.6	2.0	1.9	3.9	5.5	S, D, C, Su	8
Cassin's Vireo, *Vireo cassinii*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	S	1
Hutton's Vireo, *V. huttoni*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	D	1
Warbling Vireo, *V. gilvus*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	S, C	1
Orange-crowned Warbler, *Vermivora celata*	T	0.0	0.0	0.1	1.0	0.3	1.0	0.4	1.0	S, D, C, Su	4
Nashville Warbler, *V. ruficapilla*	T	0.0	0.0	0.3	1.2	0.0	0.0	0.6	1.6	S, D, C, Su	6
Yellow Warbler, *Dendroica petechia*	T	0.0	0.0	0.1	1.5	0.0	0.0	1.5	1.7	S, D, C, Su	5
Yellow-rumped Warbler, *D. coronata*	W	18.7	2.2	8.8	2.3	0.0	0.0	11.3	2.0	S, D, C, Su	8
Townsend's Warbler, *D. townsendi*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	C	1
MacGillivray's Warbler, *Oporornis tolmiei*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	S	1
Common Yellowthroat, *Geothlypis trichas*	B	0.4	1.0	3.2	1.1	4.8	1.2	1.1	1.2	S, D, C, Su	8
Wilson's Warbler, *Wilsonia pusilla*	T	0.0	0.0	1.6	1.1	0.8	1.7	0.1	1.0	S, D, C, Su	8
Western Tanager, *Piranga ludoviciana*	T	0.0	0.0	0.3	1.0	0.3	1.0	0.1	1.0	D, C, Su	5
Black-headed Grosbeak, *Pheucticus melanocephalus*	B	0.0	0.0	3.3	1.1	2.5	1.2	0.0	0.0	S, D, C, Su	8
Blue Grosbeak, *Guiraca caerulea*	B	0.0	0.0	0.7	1.0	2.8	1.2	0.0	0.0	S, D, C, Su	8
Lazuli Bunting, *Passerina amoena*	B	0.0	0.0	0.1	1.5	0.5	1.0	0.0	0.0	S, D, Su	3
Spotted Towhee, *Pipilo maculatus*	B	0.1	1.0	0.2	1.0	0.8	1.0	0.4	1.3	D, C, Su	4
California Towhee, *P. crissalis*	R	0.6	1.0	1.1	1.3	1.5	1.2	1.1	1.4	S, D, C, Su	8
Chipping Sparrow, *Spizella passerina*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	D	2
Lark Sparrow, *Chondestes grammacus*	W	0.0	0.0	0.1	3.0	0.0	0.0	0.1	1.0	D	1
Savannah Sparrow, *Passerculus sandwichensis*	R	12.8	5.1	9.0	3.6	0.3	1.0	13.4	4.7	S, D, C, Su	8
Fox Sparrow, *Passerella iliaca*	T	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	S, C	2
Song Sparrow, *Melospiza melodia*	T	7.2	1.1	3.6	1.2	2.8	1.2	8.1	1.3	S, D, C, Su	8
Lincoln's Sparrow, *M. lincolnii*	T	0.7	1.5	0.2	1.3	0.0	0.0	0.6	1.2	S, D, C, Su	6
Golden-crowned Sparrow, *Zonotrichia atricapilla*	W	7.5	7.0	3.0	3.4	0.0	0.0	4.1	3.4	S, D, C, Su	8

(*continued*)

Table 3 (*Continued*)

Species	Migratory status[a]	Season[b]								Observed	
		Winter		Spring		Summer		Fall			
		% Stops[c]	Mean[d]	% Stops	Mean	% Stops	Mean	% Stops	Mean	Refuges[e]	Years[f]
White-crowned Sparrow, *Z. leucophrys*	W	19.6	10.0	11.1	5.1	0.0	0.0	23.5	7.0	S, D, C, Su	8
Dark-eyed Junco, *Junco hyemalis*	W	1.4	6.5	0.6	1.5	0.0	0.0	0.6	2.3	S, D, C, Su	8
Red-winged Blackbird, *Agelaius phoeniceus*	R	44.3	68.3	48.6	20.8	34.6	39.3	55.5	66.7	S, D, C, Su	8
Tricolored Blackbird, *A. tricolor*	R	0.1	100.0	0.4	19.3	1.8	23.7	0.4	128.9	S, D, C	6
Western Meadowlark, *Sturnella neglecta*	R	31.1	2.5	55.5	1.9	29.1	2.1	26.3	2.5	S, D, C, Su	8
Yellow-headed Blackbird, *Xanthocephalus xanthocephalus*	B	0.1	100.0	1.9	6.5	1.0	2.0	0.7	7.1	S, D, C, Su	8
Brewer's Blackbird, *Euphagus cyanocephalus*	R	7.2	18.2	15.7	7.4	6.3	5.8	10.8	11.3	S, D, C, Su	8
Brown-headed Cowbird, *Molothrus ater*	R	0.5	1.0	9.8	1.4	7.3	3.0	0.3	4.2	S, D, C, Su	8
Bullock's Oriole, *Icterus bullockii*	B	0.0	0.0	10.8	1.3	10.3	1.7	0.0	0.0	S, D, C, Su	8
House Finch, *Carpodacus mexicanus*	R	7.0	8.6	23.0	2.1	19.6	3.0	5.0	3.3	S, D, C, Su	8
Lesser Goldfinch, *Carduelis psaltria*	W	1.5	7.7	1.3	2.7	1.0	1.0	3.0	7.9	S, D, C, Su	7
American Goldfinch, *C. tristis*	W	1.3	17.2	1.0	1.5	0.5	6.5	0.6	4.6	S, D, C, Su	7
House Sparrow, *Passer domesticus*	R	5.6	3.7	8.0	2.7	5.3	3.4	4.8	3.8	S, D, C, Su	8

[a]B, summer breeder; R, year-round resident; W, winter resident; T, transient/migrant.

[b]Winter: December, January, February; spring: March, April, May; summer: June, July, August; fall September, October, November.

[c]Percentage of stops on which the species was observed.

[d]Mean number of birds per stop.

[e]S, Sacramento; D, Delevan; C, Colusa; Su, Sutter.

[f]Number of years (of a maximum 8) in which the species was observed.

[g]Observations for these two species were combined.

Heron (814) were routinely encountered at all seasons. In contrast, we observed only one Least Bittern. Cattle Egrets occurred in relatively great numbers for short durations, but sightings (11) were sporadic. The White-faced Ibis reached peak numbers during winter in 1989 and 1990. Wading birds were observed at the highest rate (0.63 obs./survey/stop) during spring and fall at Delevan Refuge. Declines in mean number observed were noted for the Snowy and Great Egrets during spring and fall, respectively (Table 4). The Great Blue Heron declined in frequency of occurrence during spring. Numbers of shorebirds (18 species) peaked in spring and, to a lesser degree, fall, as migrants sought out shallow refuge wetlands. Routine marsh drawdowns in spring and flooding in late summer and fall provided suitable water depths for feeding and loafing. The Killdeer was the most commonly observed shorebird (817 observations). Shorebirds, gulls, and terns combined were observed at the highest rate (0.68 observations/survey/stop) during spring and fall at Delevan Refuge. The Black-necked Stilt and Killdeer declined in the percentage of survey stops where they were observed in fall and spring, respectively. An increase was noted for Long-billed Curlew in the fall (Table 4).

All five species of gulls and terns were observed during the spring but fewer were recorded at other seasons. The Ring-billed was the most common (208 observations), although the Herring was common on the refuges in winter, when they concentrated to feed on waterfowl carcasses resulting from avian cholera outbreaks. No significant trends were detected in this group.

Diurnal raptors and vultures (15 species) reached peak numbers during the nonbreeding seasons. The most prominent species were the Red-tailed Hawk (1261 observations), Northern Harrier (755), and Turkey Vulture (429). White-tailed Kites typically were observed as pairs, but flocks of 20 or more were occasionally recorded outside the breeding season. All raptors were observed at the highest rate (0.63 observations/survey/stop) during spring and fall at Colusa Refuge. As expected, because our surveys were during the day, we rarely observed owls (5 species), except for nesting Great Horned Owls (71 observations), which were encountered regularly in spring. We saw the Burrowing Owl only twice, despite the availability of apparently suitable habitats along survey routes. No significant trends in raptors were detected during the 8-year survey.

Gamebirds (4 species) were dominated by the Ring-necked Pheasant (1947 observations) and Mourning Dove (641), although pheasants seen in spring declined during the study (Table 4). Trends in other gamebird species were not apparent. California Quail (13 observations) were seen mostly as occasional pairs in the spring. Quail densities were low in comparison to historical numbers, but the current population appears stable. Mourning Dove were abundant as breeders on the refuges in the spring and summer, with fewer seen at other times. Large flocks occurred on nearby agricultural lands in winter.

Dominant species of songbirds were the conspicuous Red-winged Blackbird (2370 observations), Western Meadowlark (1895), and Marsh Wren (1841). Many species (e.g., Anna's Hummingbird, Bank Swallow, Cedar Waxwing, Macgillivray's and Townsend's Warblers, Olive-sided and Western Flycatch-

Table 4 Species Showing Significant[a] Trends on the Sacramento, Delevan, and Colusa National Wildlife Refuges, 1986–1993

Species	Variable[b]	Season[c]	n[d]	Slope	SE[e]	r^{2}[f]	T[g]	P[g]
Diving birds								
Pied-billed Grebe	M	F	44	-0.100	0.045	0.105	-2.216	0.032
Am. White Pelican	P	S	33	1.002	0.441	0.142	2.270	0.030
Double-crested Cormorant	M	S	45	-0.378	0.179	0.094	-2.113	0.041
Wading birds								
Snowy Egret	M	S	56	-0.261	0.109	0.096	-2.396	0.020
Great Egret	M	F	52	-0.248	0.103	0.104	-2.412	0.020
Great Blue Heron	P	S	61	-1.298	0.533	0.091	-2.436	0.018
Shorebirds								
Black-necked Stilt	P	F	35	-1.218	0.400	0.219	-3.045	0.005
Killdeer	P	S	59	-2.42	0.656	0.193	-3.691	0.001
Long-billed Curlew	P	F	26	0.802	0.349	0.180	2.297	0.031
Gamebirds								
Ring-necked Pheasant	P	S	61	-2.633	0.823	0.148	-3.198	0.002
	M	S	61	-0.205	0.049	0.227	-4.164	0.000
Other landbirds								
Barn Swallow	M	S	47	-0.252	0.070	0.225	-3.611	0.001
American Crow	P	S	25	-0.775	0.346	0.179	-2.237	0.035
Marsh Wren	M	F	53	-0.081	0.027	0.144	-2.935	0.005
European Starling	P	S	26	0.386	0.129	0.269	2.974	0.007
Savannah Sparrow	P	S	39	1.349	0.608	0.118	2.220	0.033
Golden-crowned Sparrow	M	F	25	0.498	0.221	0.181	2.252	0.034
Western Meadowlark	P	S	61	-1.464	0.597	0.092	-2.451	0.017
	P	F	53	-2.287	0.927	0.107	-2.467	0.017
Red-winged Blackbird	M	S	61	2.319	0.737	0.144	3.146	0.003
Brewer's Blackbird	M	S	57	-1.149	0.536	0.077	-2.143	0.037
	P	S	57	-2.629	0.477	0.355	-5.502	0.000
	M	F	47	-1.744	0.780	0.100	-2.236	0.030
	P	F	47	-2.009	0.516	0.252	-3.891	0.000
Brown-headed Cowbird	P	S	43	-1.077	0.483	0.108	-2.227	0.032
House Finch	M	S	60	0.107	0.049	0.076	2.183	0.033
	M	F	30	0.608	0.262	0.162	2.325	0.028

[a] $\alpha = 0.05$.

[b] M, mean number of a species observed on a survey for all stops where the species was observed; P, percentage of stops on a survey where at least one individual of the species was observed.

[c] S, spring; F, fall.

[d] Number of surveys observed.

[e] Coefficient of determination.

[f] T statistic for testing H_0: slope = 0.

[g] Probability > |T|.

ers, Hutton's, Warbling and Solitary Vireos, Chipping, Fox and Lark Sparrows) were sighted less than three times each. Landbirds (including gamebirds) were observed at the highest rate (5.8 obs./survey/stop) at Sutter Refuge. Refuge grasslands and other upland habitats were attractive to certain species, as reflected in the abundance of the American Goldfinch, and Savannah, White-crowned, and Golden-crowned Sparrows during migration. Blackbirds, especially the Red-winged and Brewer's, were common at all seasons, but numbers of Brewer's Blackbird declined significantly in both spring and fall. The Tricolored and Yellow-headed Blackbirds were present at all seasons, but their numbers varied greatly because colonies occasionally shifted in relation to survey routes. The mean number observed declined for the Barn Swallow, Marsh Wren, and Brewer's Blackbird but increased for the Golden-crowned Sparrow, Red-winged Blackbird, and House Finch (Table 4). The frequency of occurrence declined for American Crow, Western Meadowlark, Brewer's Blackbird, and Brown-headed Cowbird but increased for the European Starling and Savannah Sparrow (Table 4).

Habitat Relationships

The habitat composition of survey stops generally reflected the habitat composition of the refuge (Table 1), but survey-route constraints did result in some differences ($\chi^2 \leq 78$, 3 df, $P \geq 0.001$). Our stops oversampled grasslands at Delevan but undersampled grasslands at Sutter and seasonal wetlands at Delevan and Colusa ($Z = 2.5$, 3 df, Bonferroni $P \leq 0.05$). Seasonal wetlands (68%) were the dominant habitat type for all survey routes, followed by grasslands (20%), permanent wetlands (6%), and riparian woodlands (6%) (Table 1).

As expected, wetland-dependent species were observed at the highest rates at survey stops comprising a high proportion of seasonal and permanent wetlands. In contrast, high rates of landbird and raptor observations were associated with stops containing more diverse habitats. On Sacramento, Delevan, and Colusa refuges, non-wetland areas were mostly grasslands, whereas on Sutter Refuge these habitats were mostly riparian woodlands. Observation rates (obs./stop) for spring and fall for Sacramento, Delevan, and Colusa refuges combined (mean 39 surveys) for each species group and habitat category (A >90% wetland, B 50–90% wetland, C <50% wetland) were as follows: diving birds, A = 10.5, B = 9.5, C = 3.1; wading birds, A = 26.6, B = 26.9, C = 11.2; shorebirds, gulls and terns, A = 38.7, B = 22.5, C = 14.3; raptors, A = 21.3, B = 22.6, C = 24.8; other landbirds (including gamebirds), A = 132.0, B = 138.0, C = 164.0.

DISCUSSION

Survey Design and Utility

Survey methods for this study were selected to optimize survey costs in relation to the quality and utility of the acquired data. This design gave us baseline data on a wide range of species at minimum cost but restricted our analyses to comparisons of relative change in abundance and distribution. Population estimates would require visibility corrections. Reproductive infor-

mation such as nest success and recruitment would require more intensive and costly methods, such as mist-netting and nest searches, that normally focus only on a few species.

Species Richness and Diversity

The influx of spring migrants produced peaks in the number of species observed per stop on all refuges. Highest spring and overall species densities were observed on Sutter Refuge, which contained the largest contiguous tract of riparian woodlands. The structural diversity (MacArthur and MacArthur 1961) created by extensive riparian woodlands adjacent to other natural habitats made Sutter Refuge highly attractive to landbirds, especially spring migrants. Stevens et al. (1977) reported that western riparian areas contain up to 10 times more migrants per hectare than adjacent nonriparian habitats.

Highest species densities of waterbirds were characteristic of the larger refuges with greater wetland diversity and better opportunity for observing waterbird species. Waterbird numbers on Sutter were consistently lower than on other refuges. This may have been because wetlands at Sutter are densely vegetated and become attractive for shorebirds and other waterbirds only during brief drawdown and flood-up cycles. Additionally, survey effort at Sutter Refuge was consistently the lowest, contributing to the lower species densities observed during winter.

Population Trends

Trends on the Sacramento NWRC may result from local, regional, or continental changes in populations. The results of our trend analysis may reflect actual population changes, but these variations may also be explained by normal population fluctuations, variations in timing of migration, redistribution of birds because of habitat conditions (e.g., drought), or observational chance.

Local habitat changes may cause local shifts in populations. For instance, an increase in pelican observations may have been caused when these birds were attracted to abundant fish on refuge wetlands. Regional changes in populations may have been reflected in an increase in the use of Sacramento NWRC by the White-faced Ibis during the period of survey. During the 1970s ibis were rarely observed on the refuges. Peterjohn et al. (1995) reported that breeding populations of ibis in North America have increased dramatically since 1966, whereas others (Johnson and Jehl 1994) suggested tht geographic shifts may account for such changes. Diurnal raptor observations increased through fall and winter (Wilkinson and Debban 1980) as these birds, especially the Red-tailed Hawk, found numerous perching sites and abundant prey on the refuges.

Breeding Bird Surveys (BBS) conducted from 1966 to 1992 (Peterjohn et al. 1995) suggest national trends. Like our findings, the BBS noted negative trends for the Ring-necked Pheasant, Brewer's Blackbird, and Brown-headed Cowbird and a positive trend for the American White Pelican. In contrast to our study, however, the BBS suggested trends increasing for the American Crow and decreasing for European Starling and Red-winged

Blackbird. It implied no significant trend for the other 17 species for which we noted increases or decreases.

Christmas Bird Counts (CBC) are another source of trend data that can be compared to surveys on the Sacramento NWRC. Using CBC data, Root and McDaniel (1995) inferred population trends for 27 species of songbirds. They reported that the Western Meadowlark and Savannah Sparrow declined in several states and increased in no state, whereas the American Crow increased in more states than it declined. Similarly, we found significant negative trends for frequency of occurrence in both spring and fall for the Western Meadowlark at Sacramento NWRC. In contrast to the CBC analysis, the Savannah Sparrow increased and American Crow decreased in our spring surveys. Additional studies are needed to determine whether agreement between our results and national surveys (e.g., BBS and CBC) reflects true population changes. Agreement on species with negative trends should reinforce the need to determine causes.

Habitat Relationships

Fragmentation of riparian zones that link the foothills surrounding the Sacramento Valley with the valley floor may affect the abundance and diversity of migrant songbirds on the refuges. Several creeks that flow through the Sacramento NWRC have been converted to water-delivery systems with augmented banks and associated water-control structures. Off-refuge maintenance of these systems typically involves elimination of riparian vegetation.

Exotic species and modification of original habitats can increase bird diversity (Knopf 1992), especially for landbirds. Furthermore, the availability of riparian and wetland vegetation on the refuges has increased because of year-round water management. These habitats may increase diversity but possibly at the expense of habitat for grassland species such as Swainson's Hawk, Western Meadowlark, Savannah Sparrow, and Burrowing Owl.

Rare or Absent Species

Several riparian breeding species, including the Yellow Warbler, Song Sparrow, and Warbling Vireo, were observed in very low numbers or not detected during breeding season. Their scarcity is supported by data from the nearby Sacramento River (Geupel et al. 1996). These species appear to breed in substantial numbers in the upper Sacramento River basin but not in the lower reaches of the Sacramento Valley.

Our daylight surveys were inadequate to detect most owls with the exception of the Burrowing. Once a common breeder on the Sacramento NWRC, it was rarely observed during this study. Sparse sightings of the Burrowing Owl during other wildlife surveys conducted by refuge staff (unpubl. data) agree with our findings. Encroachment of thick ground vegetation may have reduced open areas required for suitable owl burrows. The Great Horned Owl, a suspected predator of the Burrowing in the Sacramento NWRC (J. Silveria pers. comm.), has benefited from an increase in trees along riparian corridors. It consumes primarily birds (61%) during the nesting season in central North Dakota (Gilmer et al. 1983). Feral cats, common on all refuges (G. Mensik pers. comm.), eat mainly birds,

especially in the spring (Hubbs 1951). Glading (1938) noted feral cats preying on quail nests. Undoubtedly, feral cats, and concentrations of predators on the refuges, have a detrimental effect on ground- and burrow-nesting birds such as the Western Meadowlark, California Quail, Ring-necked Pheasants, and Burrowing Owl.

CONCLUSIONS

The study achieved some noteworthy goals: the data collected established baseline information on nongame bird populations that may serve as a basis for evaluating future findings, the survey methods will serve as a basis for developing the next generation of nongame surveys, and the study demonstrated that with adequate planning, staff support, and trained volunteers, ongoing long-term surveys can be an integral part of refuge-management programs.

Future surveys should be more frequent and focus on a few key nongame species (e.g., riparian obligates, species of special concern, threatened or endangered species) in order to address specific management needs. A potential improvement may be the use of a variable- (rather than fixed-) radius survey stop. For instance, a small (100 m) radius would facilitate counting small or difficult-to-detect birds (particularly in riparian woodlands), an intermediate radius (200 m) could be used for relatively visible small to medium-sized birds (e.g., shorebirds), and a large radius (0.4 km) could be used for the largest and most visible birds. Survey routes and number of stops may have to be reduced to allow for more intensive sampling. Innovative and more intensive surveys (e.g., nest searches) needed to assess management programs will become more important as resource professionals are expected to carry out comprehensive management strategies. The integration of local survey programs into national programs such as MAPS (Monitoring Avian Productivity and Survivorship) and BBIRD (Breeding Biology Research and Monitoring Database) (Martin et al. 1995) will increase our understanding of how local, regional, and continental population changes are related. A network of local and national surveys can provide much higher-quality and responsive information on status and trends by measuring demographics and patterns of change throughout the range of many species. An important consideration will be standardization of monitoring techniques. An ongoing mist-netting program, such as proposed by the MAPS program, would augment demographic information (Ralph et al. 1993) on target species at specific sites (e.g., Swainson's Thrush at Sutter Refuge).

Future studies should attempt to identify relationships between native species and their habitat requirements such as patch size, successional stage, and dispersal corridors. Data on landbird use of seasonal wetlands in the Sacramento Valley are scarce, and the refuge complex would be an appropriate area to study this relationship. The approach we took of conducting a general, long-term survey for baseline data on the distribution and abundance of nongame and upland gamebirds in the Sacramento NWRC was a first step to assist refuge managers in evaluating overall avian

resources. The tabulation of species and the frequency of observations provide a basis for developing more refined survey methodologies and improving management strategies for monitoring bird diversity and status.

The Sacramento NWRC has been involved in habitat-development projects that focus primarily on waterbirds. The number of riparian and grassland bird species observed suggests that these habitats should be protected and enhanced where appropriate to conserve bird species diversity.

SUMMARY

We conducted a study of nongame bird populations on the Sacramento, Delevan, Colusa, and Sutter national wildlife refuges involving standardized surveys approximately every month over an 8-year period from 1986 to 1993. Survey objectives, weather, and personnel constraints necessitated that the survey effort focus on the spring and fall with reduced survey schedules during the summer and winter. The study provided the first comprehensive assessment of the refuges' nongame birds and will serve as a basis for developing future refuge surveys to assist in the conservation of nongame birds.

ACKNOWLEDGMENTS

We thank all the Sacramento NWRC staff that provided their ideas and effort in designing and conducting this project, especially Pat O'Halloran, Greg Mensik, Marguerite Ross-Hills, and Mark Strong. Melanie Paquin, Mike Casazza, John Day, and Chris Gregory provided assistance in data processing. Bruce Deuel, Joe Fleskes, Geoffrey Geupel, Greg Mensik, and Joe Silveira provided helpful suggestions in the preparation of the manuscript.

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Accepted 13 January 1998