AUTUMN POPULATIONS OF BIRDS IN RIPARIAN HABITAT OF CALIFORNIA'S CENTRAL VALLEY

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ABSTRACT: Using mist netting and area-search censuses, we monitored fall landbird migration in remnant riparian habitat along the Sacramento, San Joaquin, and Cosumnes rivers from 1995 to 1999. We detected 125 species, 73 of which we captured in mist nets. Six species of passerines were captured in mist nets but not detected on area searches; 22 passerines were detected on area searches but not captured in mist nets. Age ratios in each region ranged from two to four young for every adult captured. In the Central Valley the ratio of young to adults is lower for most species than along the coast of central California, implying that the valley is more important as a migration route than the coast. At 74.6 birds per 100 net hours capture rates were approximately twice as high along the Cosumnes River than in the other two regions, the Sacramento and San Joaquin rivers. The capture rate of neotropical migrants was highest along the Sacramento River, where 18 species were caught. Capture rates along the Cosumnes River were highest for resident species and along the San Joaquin River for wintering species. The use of these remnant riparian sites by numerous species, many of current conservation interest in California, suggests the importance of this habitat to landbirds in the West during the autumn.

The Central Valley of California lies between the Sierra Nevada to the east and the Coast Range to the west. The valley's two major rivers, the Sacramento and the San Joaquin, running along the valley floor and emptying into the delta and eventually the San Francisco Bay, historically contained one of the largest systems of riparian woodland in the West. Development, agriculture, grazing, water diversion, and channelization have drastically reduced the riparian habitat along these rivers and their tributaries to approximately 5% of its historic extent (Katibah 1984). The importance of the Central Valley's remaining riparian habitat to breeding landbirds has been well established (Miller 1951, Gaines 1977, RHJV 2000). Data on habitat use in general by migrating landbirds, however, are scarce (Petit 2000), and systematic surveys in Central Valley riparian habitat are virtually nonexistent (Cogswell 1962).

To determine autumn use of this remnant habitat by migrant and resident landbirds, the Point Reyes Bird Observatory (PRBO) conducted constant-effort mist netting and area searches at sites along the Sacramento, San Joaquin, and Cosumnes rivers from August through October, 1995 through 1999. While mist nets sample primarily smaller landbirds, area searches sample all bird species. We determined capture rates and age ratios for each species in the three regions and compared results derived from mist nets and area searches. For selected migrants we also present capture rates throughout the season and rates of recaptures in successive years.

STUDY AREA AND METHODS

We monitored eight sites, three along the San Joaquin River, two along the Cosumnes, and three along the Sacramento (Figure 1). Individual sites

Figure 1. Location of Central Valley study sites.

were run for two to five consecutive autumns (Table 1). All sites were located in remnant riparian habitat surrounded by agriculture, isolated from other native habitats.

Our three sites along the Sacramento River were in the Sacramento River National Wildlife Refuge, in Glenn and Tehama counties, on land cooperatively managed by the U.S. Fish and Wildlife Service and the Nature Conservancy. The tree community at these sites is dominated by Goodding's Black Willow (*Salix gooddingii*), Sandbar Willow (*Salix sessilifolia*), Fremont Cottonwood (*Populus fremontii*), and Valley Oak (*Quercus lobata*). The shrub layer consists primarily of Sandbar Willow, Blue Elderberry (*Sambucus mexicana*), California Blackberry (*Rubus ursinus*), and nonnative Himalayan Blackberry (*Rubus discolor*). The surrounding landscape is predominantly orchard.

Our two sites along the Cosumnes River were in the Cosumnes River Preserve near Galt, Sacramento County, on land managed primarily by the Nature Conservancy. The vegetation here is similar to that at the Sacra-

Table 1 Summary Statistics for Fall Migration Banding in Three Regions of the Central Valley

Sacramento River NWR	Cosumnes Preserve	San Luis NWR
Years of mist-netting and area searches		
Ohm: 95–99	Tall Forest: 95–97	North SL: 95–97
Phelan Island: 95–99	Wendell's Levee: 96–97	South SL: 95–97
Sul Norte: 95, 99		Oxbow: ½ 96, 97
Total number of net hours (nh)		
5712	2379	3640
Total number of area-search censuses[a]		
361	117	192
Overall capture rate (per 100 nh)		
39.6	74.6	32.0
Mean annual capture rate per 100 nh (SD)		
42.8 (16.9)	72.0 (32.4)	32.2 (7.4)
Species richness (mist-netting only)		
55	49	51
Species richness (area searches only)		
109	76	89
Species richness (mist-nets and area searches)		
112	81	96
Age ratio (young/adult)		
2.23:1	3.90:1	2.06:1
Percent of individuals aged		
74%	88%	80%
Capture rate of neotropical migrants (per 100 nh)		
15.4	10.9	3.5
Capture rate of residents (per 100 nh)		
9.9	37.9	11.9
Capture rate of wintering species (per 100 nh)		
13.8	23.0	15.1

[a]Each survey of one plot equals one census.

mento River sites but with less Blue Elderberry in the shrub layer. One site was located adjacent to a large remnant woodland of Valley Oak, the other along a levee lacking Valley Oaks. Surrounding agriculture includes row crops, rice, alfalfa fields, and grazed pastures.

The three sites along the San Joaquin River were in the San Luis National Wildlife Refuge, Merced County, north of Los Banos. Goodding's Black Willow, Sandbar Willow, and Himalayan Blackberry dominate the tree and shrub layers at these sites. The surrounding agricultural landscape includes cotton and alfalfa fields.

We ran 10 nets (30-mm mesh, 12 m long) once a week at each site between 18 August and 31 October, for approximately 10 visits to each site each year. The exception was one site at San Luis, established mid-season in 1996 and monitored on only seven visits that autumn. Net locations remained constant throughout the study. Nets were opened 15 minutes after sunrise, remained open for 5 hours, and were opened and closed in the

same order. Thus, when conditions permitted, each day represented 50 net hours of banding. Birds captured in the mist nets were banded, aged, sexed, measured, and weighed. Age was determined by skull pneumatization, plumage, and other appropriate characteristics (Pyle et al. 1987). Birds determined to be hatched in the year of capture were aged as young; those hatched earlier were classified as adults. Some individuals could not be aged reliably and were classified as unknown.

In addition to mist netting, we designated three census plots for area searches at each site within the riparian habitat around the nets. Plots covered approximately 3 hectares, sampled the same general area as the nets, and were restricted to the riparian habitat. Each plot was censused approximately once a week during the first few hours after sunrise, generally the same morning as mist netting. On some mornings when capture rates in the nets were high, biologists were unable to conduct area searches; occasionally they were done the following day. During an area search the observer covered the entire plot in 20 minutes, recording all birds using the habitat within the plot; see Ralph et al. (1993) and Slater (1994) for more details of this method.

For all species we determined the number of individuals captured per 100 net hours within each region and calculated the age ratio of birds captured (young/adult) and the percentage of birds that could be classified by age. We discuss age ratios only for species of which we caught $\geq$20 individuals and aged $\geq$80% of them. We assume no bias in favor of either age group being caught. We excluded from these analyses individuals released without bands, including species for which we did not have bands (e.g., larger birds and hummingbirds) and birds accidentally released before banding. For migrant species of sufficient sample size ($\geq$20 captures in each of two or more regions) we calculated the number of captures per 100 net hours by week, all years combined, except the final "week" extended from 20 to 30 October. In all these analyses we used only the first capture of an individual each year. For those species that do not breed in the Central Valley but use the region for migration or wintering, we determined the percentage of individuals captured in more than one year. We also present the species detected during area searches in each region.

RESULTS

At all sites combined, we captured a total of 73 landbird species (26 or 20.4% of them neotropical migrants) during the autumns of 1995 to 1999. Including the results of the area searches brings this total to 125 species (37 neotropical migrants). We captured 14 species (35.6% of all captures) that winter in the Central Valley but breed elsewhere and 29 year-round residents (40.7% of all captures).

At the Sacramento River National Wildlife Refuge, we netted 2264 birds (39.6 birds per 100 net hours) (Table 1). One hundred twelve species were detected with mist nets or area searches (see Tables 2 and 3 for species lists and capture data). The most frequently captured species were the Yellow Warbler and Ruby-crowned Kinglet. We caught more neotropical migrants than residents or winter visitors (see Table 2 for assignment of species to

Table 2 Numbers of Birds Banded and Area-Search Detections at Three Central Valley Riparian Sites[a]

Species	Status[b]	Sacramento River NWR	Cosumnes Preserve	San Luis NWR
Pied-billed Grebe (*Podilymbus podiceps*)	P	–		
Double-crested Cormorant (*Phalacrocorax auritus*)	P	–		–
Black-crowned Night-heron (*Nycticorax nycticorax*)	P			–
Snowy Egret (*Egretta thula*)	P	–		–
Great Egret (*Casmerodius albus*)	P	–		–
Great Blue Heron (*Ardea herodias*)	P	–	–	–
Wood Duck (*Aix sponsa*)	P	–	–	
Mallard (*Anas platyrhynchos*)	P		–	–
Turkey Vulture (*Cathartes aura*)	P	–	–	
Osprey (*Pandion haliaetus*)	P	–		–
White-tailed Kite (*Elanus leucurus*)	P	–		–
Northern Harrier (*Circus cyaneus*)	P	–		–
Sharp-shinned Hawk (*Accipiter striatus*)	W	3	1	2
Cooper's Hawk (*A. cooperii*)	P	–		–
Red-shouldered Hawk (*Buteo lineatus*)	P	–	–	
Red-tailed Hawk (*B. jamaicensis*)	P	–	*	–
Swainson's Hawk (*B. swainsoni*)	B[c]	–	–	
American Kestrel (*Falco sparverius*)	P	–	–	–
Merlin (*F. columbarius*)	W	–		
Ring-necked Pheasant (*Phasianus colchicus*)	P	–	–	–
Wild Turkey (*Meleagris gallopavo*)	P	–		
California Quail (*Callipepla californica*)	P	*	–	–
Sora (*Porzana carolina*)	P			–
Common Moorhen (*Gallinula chloropus*)	P			–
American Coot (*Fulica americana*)	P			–
Sandhill Crane (*Grus canadensis*)	W	–	–	
Killdeer (*Charadrius vociferus*)	P	–	–	–
Greater Yellowlegs (*Tringa melanoleuca*)	W	–		
Common Snipe (*Gallinago gallinago*)	W	–		
Mourning Dove (*Zenaida macroura*)	P	–	–	*
Yellow-billed Cuckoo (*Coccyzus americanus*)	B[d]	–		
Barn Owl (*Tyto alba*)	P			–
Great Horned Owl (*Bubo virginianus*)	P	–		–
Lesser Nighthawk (*Chordeiles acutipennis*)	B	–		–
Common Nighthawk (*C. minor*)	N	–		–
Common Poorwill (*Phalaenoptilus nuttallii*)	N	–		*
Vaux's Swift (*Chaetura vauxi*)	N	–		
Black-chinned Hummingbird (*Archilochus alexandri*)	B	*	*	*
Anna's Hummingbird (*Calypte anna*)	P	*		*
Rufous Hummingbird (*Selasphorus rufus*)	N	*		
Belted Kingfisher (*Ceryle alcyon*)	P	–	–	–
Acorn Woodpecker (*Melanerpes formicivorus*)	P	–		
Red-breasted Sapsucker (*Sphyrapicus ruber*)	W	–		
Nuttall's Woodpecker (*Picoides nuttallii*)	P	18	2	10
Downy Woodpecker (*P. pubescens*)	P	15	5	3
Red-shafted Flicker (*Colaptes auratus*)	I	10	–	4
Western Wood-Pewee (*Contopus sordidulus*)	B	20	–	–
Willow Flycatcher (*Empidonax traillii*)	N	102	32	12

Table 2 (*Continued*)

Species	Status[b]	Sacramento River NWR	Cosumnes Preserve	San Luis NWR
Hammond's Flycatcher (*E. hammondii*)	N	–		
Dusky Flycatcher (*E. oberholseri*)	N	2		
Gray Flycatcher (*E. wrightii*)	N			1
Pacific-slope Flycatcher (*E. difficilis*)	B, N[e]	29	82	13
Black Phoebe (*Sayornis nigricans*)	P	20	7	6
Ash-throated Flycatcher (*Myiarchus cinerascens*)	B	5	–	2
Western Kingbird (*Tyrannus verticalis*)	B	–	–	–
Loggerhead Shrike (*Lanius ludovicianus*)	I	–		1
Cassin's Vireo (*Vireo cassinii*)	N	1	2	1
Hutton's Vireo (*V. huttoni*)	P	–	5	2
Warbling Vireo (*V. gilvus*)	N	3	6	2
Western Scrub-Jay (*Aphelocoma californica*)	P	3	5	2
Yellow-billed Magpie (*Pica nuttalli*)	P	–	–	–
American Crow (*Corvus brachyrhynchos*)	P	–	–	–
Tree Swallow (*Tachycineta bicolor*)	N	–		–
Violet-green Swallow (*T. thalassina*)	N	–		
Barn Swallow (*Hirundo rustica*)	B	–	–	
Cliff Swallow (*H. pyrrhonota*)	B		–	
Oak Titmouse (*Baeolophus inornatus*)	P	47	6	–
Bushtit (*Psaltriparus minimus*)	P	83	69	127
Red-breasted Nuthatch (*Sitta canadensis*)	W	–	–	–
White-breasted Nuthatch (*S. carolinensis*)	P	1	–	–
Brown Creeper (*Certhia americana*)	W	2		
Bewick's Wren (*Thryomanes bewickii*)	P	188	32	94
House Wren (*Troglodytes aedon*)	S	38	59	52
Winter Wren (*T. troglodytes*)	W	3	1	1
Marsh Wren (*Cistothorus palustris*)	P		2	7
Golden-crowned Kinglet (*Regulus satrapa*)	W	2	1	–
Ruby-crowned Kinglet (*R. calendula*)	W	302	102	79
Blue-gray Gnatcatcher (*Polioptila caerulea*)	N	2	1	4
Western Bluebird (*Sialia mexicana*)	I	2		
Swainson's Thrush (*Catharus ustulatus*)	N	2	–	–
Hermit Thrush (*C. guttatus*)	W	69	60	44
American Robin (*Turdus migratorius*)	I	1	–	–
Varied Thrush (*Ixoreus naevius*)	W	–		
Wrentit (*Chamaea fasciata*)	P	1	39	–
Northern Mockingbird (*Mimus polyglottos*)	P	–		2
California Thrasher (*Toxostoma redivivum*)	P			5
European Starling (*Sturnus vulgaris*)	P	–	–	–
American Pipit (*Anthus rubescens*)	W	–		
Cedar Waxwing (*Bombycilla cedrorum*)	W	–	–	
Orange-crowned Warbler (*Vermivora celata*)	N[f]	259	32	49
Nashville Warbler (*V. ruficapilla*)	N	21	1	1
Yellow Warbler (*Dendroica petechia*)	N[g]	325	9	22
Myrtle Warbler (*D. coronata coronata*)	W	24	1	1
Audubon's Warbler (*D. c. auduboni*)	W	168	3	18
Black-throated Gray Warbler (*D. nigrescens*)	N	2	–	2
MacGillivray's Warbler (*Oporornis tolmiei*)	N	55	16	3
Common Yellowthroat (*Geothlypis trichas*)	I	29	106	17
Wilson's Warbler (*Wilsonia pusilla*)	N	25	63	12

Table 2 *(Continued)*

Species	Status[b]	Sacramento River NWR	Cosumnes Preserve	San Luis NWR
Yellow-breasted Chat (*Icteria virens*)	B	5	3	
Western Tanager (*Piranga ludoviciana*)	N	6	2	–
Spotted Towhee (*Pipilo maculatus*)	P	74	63	43
California Towhee (*P. crissalis*)	P	12	1	6
Rufous-crowned Sparrow (*Aimophila ruficeps*)	W	–		
Chipping Sparrow (*Spizella passerina*)	N		1	
Brewer's Sparrow (*S. breweri*)	M			1
Lark Sparrow (*Chondestes grammacus*)	I	–	9	2
Savannah Sparrow (*Passerculus sandwichensis*)	W	–	2	8
Fox Sparrow (*Passerella iliaca*)	W	4	80	22
Song Sparrow (*Melospiza melodia*)	I, W[h]	32	65	32
Lincoln's Sparrow (*M. lincolnii*)	W	104	106	88
Puget Sound White-crowned Sparrow (*Zonotrichia leucophrys pugetensis*)	W	11	2	
Gambel's White-crowned Sparrow (*Z. l. gambelii*)	W	21	74	240
Golden-crowned Sparrow (*Z. atricapilla*)	W	21	73	35
Dark-eyed Junco (*Junco hyemalis*)	W	19	–	4
Black-headed Grosbeak (*Pheucticus melanocephalus*)	B	2	1	1
Blue Grosbeak (*Guiraca caerulea*)	B	–		1
Lazuli Bunting (*Passerina amoena*)	B	8	7	–
Red-winged Blackbird (*Agelaius phoeniceus*)	P	–	–	–
Western Meadowlark (*Sturnella neglecta*)	P	–	–	–
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	P			–
Brewer's Blackbird (*Euphagus cyanocephalus*)	P	–	–	–
Brown-headed Cowbird (*Molothrus ater*)	I	–	1	–
Bullock's Oriole (*Icterus bullockii*)	B	–	1	
Purple Finch (*Carpodacus purpureus*)	W			–
House Finch (*C. mexicanus*)	P	26	69	8
Pine Siskin (*Carduelis pinus*)	W			
Lesser Goldfinch (*C. psaltria*)	P	20	2	–
American Goldfinch (*C. tristis*)	P	14	414	64
House Sparrow (*Passer domesticus*)	P			–

[a]—, species detected only by area searches; *, species captured but released unbanded.

[b]P, permanent resident; I, found year round in Central Valley with fall movement including winter influx; M, winters in North America but probably only passes through Central Valley; N, neotropical migrant passing through but not breeding in Central Valley; B, neotropical migrant breeding in Central Valley; S, short-distance migrant occurring in Central Valley primarily in summer; W, winter only (Gaines 1977, Grinnell and Miller 1944, Natl. Geo. 1999, PRBO unpubl. data).

[c]California threatened species; this neotropical migrant winters rarely in the Central Valley (Sibley 2000).

[d]California endangered species; among our study areas, currently breeds only at the Sacramento River sites.

[e]Currently only a rare breeder in the Central Valley; at our study sites bred in very reduced numbers at one Cosumnes site only, where local extirpation was likely during this period.

[f]Some individuals likely overwinter (Sogge et al. 1994, PRBO unpubl. data).

[g]Historical breeder; most likely extirpated from Central Valley sites but may be returning to the Sacramento River NWR sites as of 1999.

[h]Permanent resident and breeder at San Luis and Cosumnes; none currently breed at the Sacramento River sites, but migrants occur during fall and winter.

status categories). Migrants with the highest ratio of young to adults were the Myrtle Warbler, Audubon's Warbler, and Pacific-slope Flycatcher; those with the lowest ratios were Lincoln's Sparrow and Yellow Warbler.

At the Cosumnes River Preserve, we captured 1774 individuals (74.6 birds per 100 net hours) (Table 1). A total of 81 species was detected with both census methods combined (Tables 2 and 3). The American Goldfinch, Common Yellowthroat, and Lincoln's Sparrow were the species captured most frequently. Capture rates were highest for residents. Migrants with the highest ratio of young to adults were the Pacific-slope and Willow Flycatchers; those with lowest ratios were the Orange-crowned Warbler and Hermit Thrush.

At San Luis National Wildlife Refuge, we captured 1164 birds (32.0 birds per 100 net hours) (Table 1). A total of 96 species was detected with both census methods (Tables 2 and 3). Gambel's White-crowned Sparrow and Bushtit were the species most frequently captured. Capture rates were highest for wintering birds (Table 1). Migrants with the lowest ratio of young to adult were the Fox and Lincoln's Sparrows; no migrant fitting our criteria for sample size and proportion aged had a high age ratio.

Figure 2 presents the capture rates by week for 11 migratory species in regions where sample sizes were sufficient. Among five species (Willow Flycatcher, Orange-crowned Warbler, Lincoln's Sparrow, Gambel's White-crowned Sparrow, and Golden-crowned Sparrow), peak capture rates were earlier at northern sites than at southern sites.

We recaptured in a year after the initial capture individuals of six species that do not breed in the Central Valley (Table 4). Five of the species winter commonly in the Central Valley; the sixth (Orange-crowned Warbler) is predominantly a migrant through the valley, but some individuals overwinter (Sogge et al. 1994). All of these individuals were recaptured at the same banding site, and one-third at the same net location, where they were originally caught. Approximately half were initially banded as young birds. Only one, a Lincoln's Sparrow at the Sacramento River, was captured in three consecutive years.

DISCUSSION

Riparian woodland is important breeding habitat for many resident and migrant landbirds, supporting greater diversity and abundance than any other habitat in California (Miller 1951, Gaines 1977, RHJV 2000). Loss and destruction of riparian habitat have been identified as among the main causes of landbirds' population declines in western United States (DeSante and George 1994). A better understanding of the role of this endangered habitat in all aspects of landbird biology will help ensure that efforts to protect, restore, and enhance it continue. By detailing the extensive use of these study sites by many migrant, resident, and wintering birds in regions where little or no other native habitat is available, our data further emphasize the importance of riparian vegetation in the Central Valley.

From normal clutch sizes and survival rates, Ralph (1971) maintained that the normal ratio of young to adults of a landbird in fall migration should be between 1:1 and 4:1 and that ratios outside that range reflect age classes'

Table 3 Mist-Net Capture Data from Three Central Valley Riparian Sites[a]

Species	Sacramento River NWR				Cosumnes Preserve				San Luis NWR			
	Capture Rate	Range	Age Ratio	% Aged	Capture Rate	Range	Age Ratio	% Aged	Capture Rate	Range	Age Ratio	% Aged
Sharp-shinned Hawk	0.05	0–0.21	2.0	100%	0.04	0–0.1	0	100%	0.05	0–0.15	0	100%
Nuttall's Woodpecker	0.32	0.10–0.47	1.1	94%	0.08	0–0.18	0	50%	0.27	0.20–0.30	3.0	80%
Downy Woodpecker	0.26	0.12–0.43	0.6	87%	0.21	0–0.55	0.5	60%	0.08	0–0.15	2.0	100%
Red-shafted Flicker	0.18	0.07–0.41	0.4	70%	0			0.11	0.08–0.15	1.0	100%	
Western Wood-Pewee	0.35	0–0.74	2.3	100%	0				0			
Willow Flycatcher	1.79	0.93–2.82	2.5	100%	1.35	0.37–2.66	14.5	97%	0.33	0.10–0.61	11:0	92%
Dusky Flycatcher	0.04	0–0.13	2:0	100%	0				0			
Gray Flycatcher	0				0				0.03	0–0.08	1:0	100%
Pacific-slope Flycatcher	0.51	0.14–0.87	6.3	100%	3.45	2.58–4.96	19.3	99%	0.36	0.23–0.45	11.0	92%
Unidentified *Empidonax*	0				0.04	0–0.12	0	100%	0			
Black Phoebe	0.35	0.14–0.61	1.60	65%	0.29	0–0.41	1.5	71%	0.16	0–0.08	0.2	100%
Ash-throated Flycatcher	0.09	0–0.20	1.50	100%	0				0.05	0–0.15	1.0	100%
Loggerhead Shrike	0				0				0.03	0–0.08	0	100%
Cassin's Vireo	0.02	0–0.07	1:0	100%	0.08	0–0.12	1.0	100%	0.03	0–0.10	1:0	100%
Hutton's Vireo	0				0.21		3.0	80%	0.05	0–0.08	2:0	100%
Warbling Vireo	0.05	0–0.20	3:0	100%	0.25	0–0.69	6:0	100%	0.05	0–0.08	2:0	100%
Western Scrub-Jay	0.05	0–0.23	2.00	100%	0.21	0–0.35	1.5	100%	0.05	0–0.15	1.0	100%
Oak Titmouse	0.82	0.71–1.51	1.4	66%	0.25	0.18–0.35	0.5	100%	0			
Bushtit	1.45	0.57–2.55	11.7	46%	2.90	1.27–5.69	3.3	49%	3.49	2.59–5.03	8.5	45%
White-breasted Nuthatch	0.02	0–0.12	1:0	100%	0				0			
Brown Creeper	0.04	0–0.10	2:0	100%	0				0			
Bewick's Wren	3.29	2.75–4.88	7.2	74%	1.35	1.28–1.50	22.0	72%	2.58	2.40–3.01	5.9	73%
House Wren	0.67	0.34–1.02	6.0	92%	2.48	2.27–2.89	7.0	95%	1.43	1.05–1.98	3.4	77%
Winter Wren	0.05	0–0.13	2.0	100%	0.04	0–0.18	1:0	100%	0.03	0–0.08		0%
Marsh Wren	0				0.08	0–0.12	1.0	100%	0.19	0.08–0.40	1.0	86%
Golden-crowned Kinglet	0.04	0–0.10		0%	0.04	0–0.18	1:0	100%	0			
Ruby-crowned Kinglet	5.29	2.21–8.32	5.5	9%	4.29	3.12–5.88	1.3	9%	2.17	1.00–3.23	1.3	9%
Blue-gray Gnatcatcher	0.04	0–0.10	2:0	100%	0.04	0–0.12	1:0	100%	0.11	0–0.23	1:0	25%
Western Bluebird	0.04	0–0.07	1.0	100%	0				0			
Swainson's Thrush	0.04	0–0.13	2:0	100%	0				0			
Hermit Thrush	1.21	0.72–1.93	4.9	86%	2.52	2.02–2.68	6.5	100%	1.21	0.70–1.73	3.0	100%
American Robin	0.02	0–0.07	1:0	100%	0				0			
Wrentit	0.02	0–0.10		0%	1.64	0.73–2.20	4.8	90%	0			

Northern Mockingbird	0				0				0.05	0–0.15		0%
California Thrasher	0				0				0.14	0.08–0.30	4:0	80%
Orange-crowned Warbler	4.53	1.43–10.33	3.3	77%	1.35	0.81–3.12	5.8	84%	1.35	1.00–1.52	5.0	61%
Nashville Warbler	0.37	0–0.74	1.7	90%	0.04	0–0.12	1:0	100%	0.03	0–0.08	1:0	100%
Yellow Warbler	5.69	1.86–9.79	1.1	80%	0.38	0.21–0.55	1.7	89%	0.60	0.30–1.07	2.20	73%
Myrtle Warbler	0.42	0–0.61	9.5	88%	0.04	0–0.18	1:0	100%	0.03	0–0.10		0%
Audubon's Warbler	2.94	2.03–4.29	6.4	84%	0.13	0–0.23	0	67%	0.49	0.38–0.70	7.0	89%
Black-throated Gray Warbler	0.04	0–0.07	2:0	100%	0				0.05	0–0.15	2:0	100%
MacGillivray's Warbler	0.96	0.36–1.68	1.7	98%	0.67	0.18–0.83	2.2	100%	0.08	0–0.15	0.5	100%
Common Yellowthroat	0.51	0.2–0.82	4.4	93%	4.46	3.20–5.90	3.1	89%	0.47	0.30–0.61	4.0	88%
Wilson's Warbler	0.44	0.20–0.60	4.8	92%	2.65	1.62–4.77	7.6	95%	0.33	0.15–0.60	0.8	75%
Yellow-breasted Chat	0.09	0–0.13	4.0	100%	0.13	0–0.23	2.0	100%	0			
Western Tanager	0.11	0–0.20	0.5	100%	0.08	0–0.18	2:0	100%	0			
Spotted Towhee	1.30	0.92–2.05	1.7	99%	2.65	1.47–3.35	2.2	92%	1.18	1.10–1.37	1.1	98%
California Towhee	0.21	0–0.40	1.2	92%	0.04	0–0.12	1:0	100%	0.16	0–0.38	6:0	100%
Chipping Sparrow	0				0.04	0–0.10	1:0	100%	0			
Brewer's Sparrow	0				0				0.03	0–0.08	1:0	100%
Lark Sparrow	0				0.38	0–0.62	8.0	100%	0.05	0–0.15	1:0	50%
Savannah Sparrow	0				0.08	0–0.12	2:0	100%	0.22	0.08–0.50	3.0	100%
Fox Sparrow	0.07	0–0.23	4:0	100%	3.36	1.10–6.09	2.8	100%	0.60	0.68–0.70	1.2	100%
Song Sparrow	0.56	0.27–1.02	3.0	88%	2.73	1.96–4.51	1.6	95%	0.88	0.30–1.30	2.2	100%
Lincoln's Sparrow	1.82	0.61–3.07	0.8	100%	4.46	0.55–5.88	2.0	100%	2.42	1.30–4.12	1.2	99%
Unidentified White-crowned Sparrow	0.05	0–0.10	0	100%	1.98	0–2.58	8.4	100%	0.22	0–0.53	1.7	100%
Puget Sound White-crowned Sparrow	0.19	0.07–0.71	0.6	100%	0.08	0–0.23	2:0	100%	0			
"Gambel's" White-crowned Sparrow	0.37	0–0.80	3.2	100%	3.11	0.55–4.28	6.4	100%	6.59	4.58–9.76	1.6	100%
Golden-crowned Sparrow	0.37	0.13–0.58	1.1	100%	3.07	0–4.13	3.7	97%	0.96	0.40–1.75	1.9	100%
Dark-eyed Junco	0.33	0–0.40	1.8	74%	0				0.11	0–0.23	3:0	75%
Black-headed Grosbeak	0.04	0–0.20	1.0	100%	0.04	0–0.10	1:0	100%	0.03	0–0.10	1:0	100%
Blue Grosbeak	0				0				0.03	0–0.08	1:0	100%
Lazuli Bunting	0.14	0–0.40	1.7	100%	0.29	0–0.69	2.5	100%	0			
Brown-headed Cowbird	0				0.04	0–0.18	1:0	100%	0			
Bullock's Oriole	0				0.04	0–0.12	1:0	100%	0			
House Finch	0.46	0–1.07	0.9	92%	2.90	0–4.74	1.7	99%	0.22	0.08–0.30	4.0	63%
Lesser Goldfinch	0.35	0–0.80	1.2	100%	0.08	0–0.23	2:0	100%	0			
American Goldfinch	0.25	0–0.87	0.6	100%	17.4	1.65–41.86	5.3	94%	1.76	0.53–3.13	0.7	95%

[a]Capture rate is per 100 net hours, range is of annual capture rate, age ratio of captures is young/adult birds, and % aged is percent of banded individuals that were aged.

Table 4 Recaptures in Subsequent Years of Migrants or Winter Visitors

Species	Region	Number originally banded[a]	Number captured in multiple years	Percent captured in multiple years
Ruby-crowned Kinglet				
	Sacramento River NWR	271	2	0.7%
	San Luis NWR	53	1	1.9%
Orange-crowned Warbler				
	Sacramento River NWR	231	4	1.7%
	Cosumnes Preserve	25	1	4%
Fox Sparrow				
	Cosumnes Preserve	64	3	4.7%
	San Luis NWR	14	3	21.4%
Golden-crowned Sparrow				
	Cosumnes Preserve	40	2	5%
	San Luis NWR	13	1	7.7%
Gambel's White-crowned Sparrow				
	San Luis NWR	117	7	6.0%
Lincoln's Sparrow				
	Sacramento River NWR	87	2	2.3%
	San Luis NWR	34	1	2.9%

[a]Number of birds banded prior to the final year of mist-netting, i. e., individuals that could have been recaptured in subsequent years of the study.

using an area disproportionately. Ralph also (1981), finding that the proportion of young birds among fall migrants on the east coast of the U.S. is higher than inland, suggested that this "coastal effect" implies the coast is on the periphery of many species' migration route and that lower age ratios inland may indicate the primary migration route. In California, Stewart et al. (1974) also found ratios of young to adults lower inland than at coastal and island sites. We found age ratios to be 2 to 19 times lower at our inland sites than on the coast (Taylor et al. 1994) for 10 of 11 species examined (Table 5). Of particular interest are the low age ratios of some neotropical migrants (e.g., Nashville Warbler and MacGillivray's Warbler; see also Table 5), particularly at our Sacramento River sites. On the coast such ratios are disproportionately biased toward young birds (Taylor et al. 1994). These findings suggest that the Central Valley may be a primary migratory corridor for some species and further support the theory of a "coastal effect" in California.

While age ratios can provide useful insights into migration, they may misrepresent the use of a migratory corridor or stopover site by age groups if individuals of one age group stop more frequently or for longer periods of time, or if either group migrates predominantly outside the period monitored, a pattern observed in some species (Weston 1947, Stewart et al. 1974). As we operated our banding sites during the summer as well (with nets run once every 10 days until the onset of fall migration monitoring), we were able to address the latter consideration by examining data recorded before we began

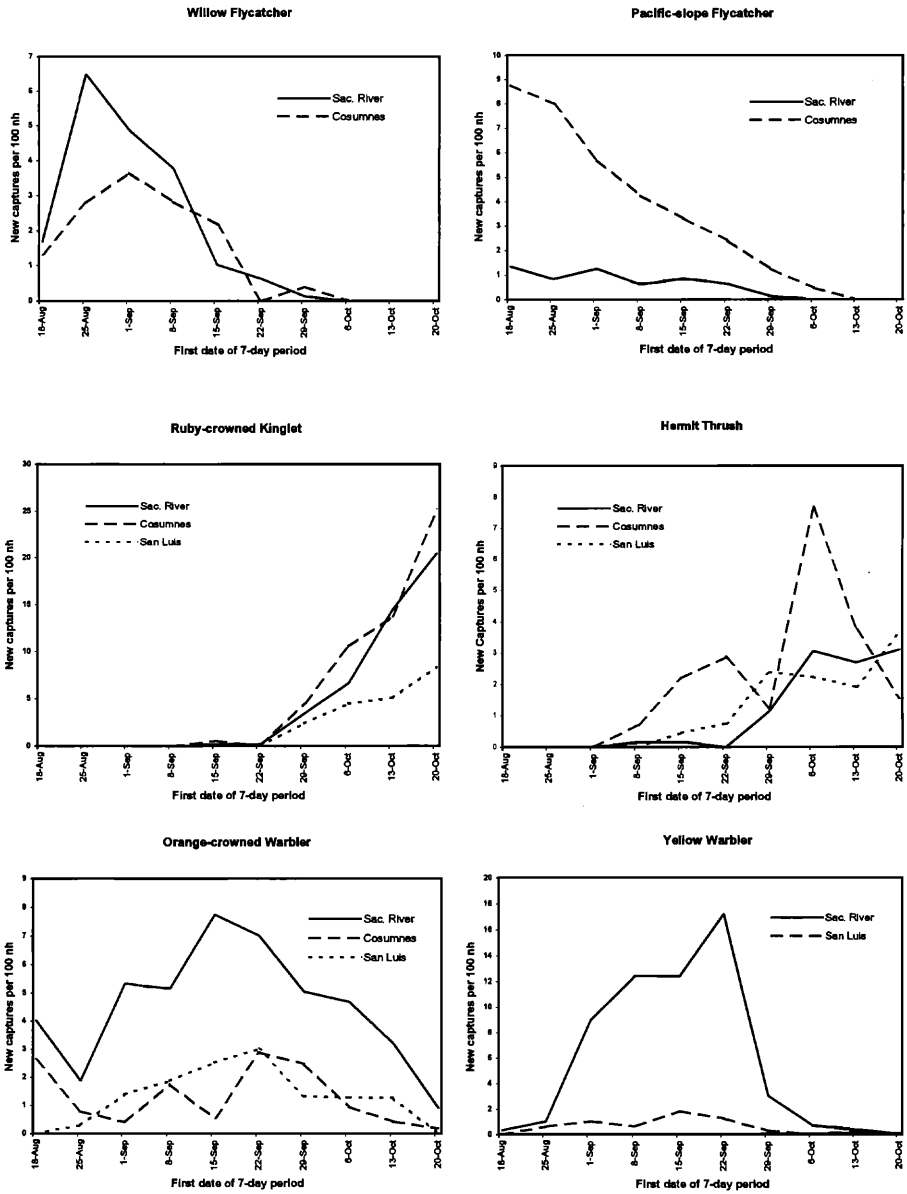
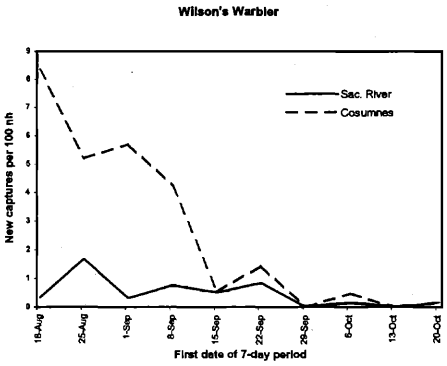
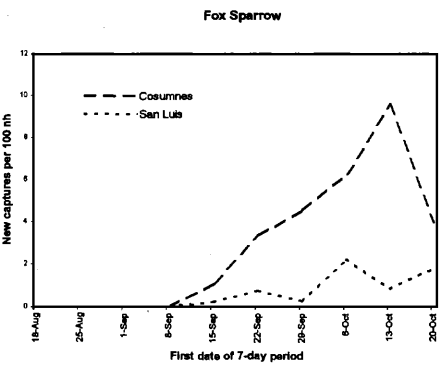
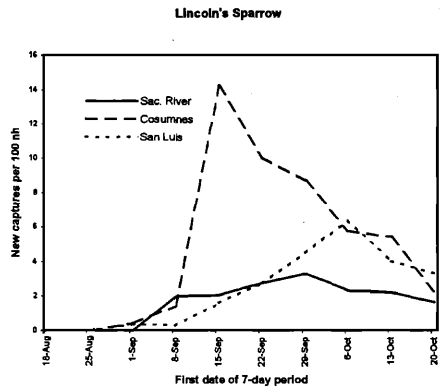
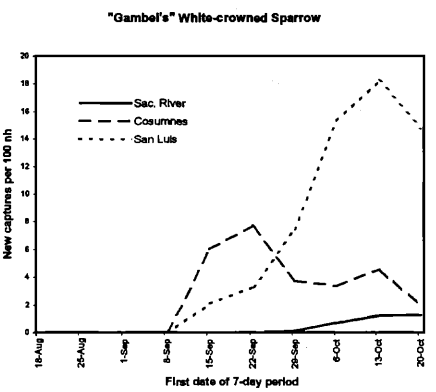


Figure 2. Dates of fall captures of select migrants in the Central Valley.









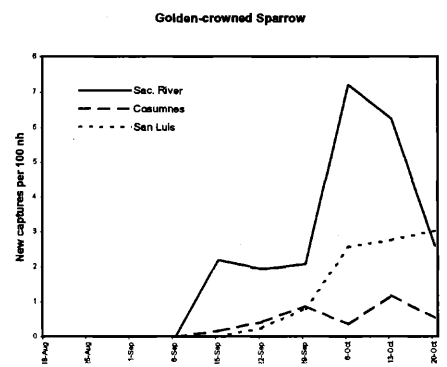


Figure 2 (*Continued*)

Table 5 Comparison of Age Ratios[a] of Fall Migrants Netted at One Coastal and Three Central Valley Sites

Species	Site			
	Palomarin, Marin Co.[b]	Sacramento R. NWR	Cosumnes Preserve	San Luis NWR
Western Wood-Pewee	6.8	2.3[c]	—	—
Willow Flycatcher	30.0	2.5 (2.0, *n* = 109)	14.5	—
Pacific-slope Flycatcher	60.9	6.3 (2.6, *n* = 43)	19.3 (12.2, *n* = 119)	—
Hermit Thrush	44.7	4.9	6.5	3.0
Orange-crowned Warbler	6.3	—	5.8 (5.2, *n* = 31)	—
Yellow Warbler	4.9	1.1 (1.1, *n* = 268)	—	—
Myrtle Warbler	2.8	9.5	—	—
Audubon's Warbler	3.3	6.4	—	—
Wilson's Warbler	18.0	4.8 (4.2, *n* = 31)	7.6 (6.3, *n* = 88)	—
Fox Sparrow	5.5	—	2.8	1.2
Lincoln's Sparrow	11.2	0.8	2.0	1.2
Golden-crowned Sparrow	6.0	1.1	3.7	1.9

[a]Young/adult. Presented only for species and sites with at least 20 individuals of known age 20 captured (Central Valley sites), 3 or more captures annually at Palomarin, and for which >80% of individuals captured in the Central Valley were of known age. We present in parentheses age ratios and sample sizes of known-aged birds after inclusion of captures prior to the initiation of fall-migration monitoring (18 August); species with no such data presented were not captured before fall monitoring.

[b]Data from 1976 to 1986, 18 August to 25 November (Taylor et al. 1994).

[c]Migrants prior to 18 August not examined because local breeders confound the data set.

our fall regime. We did this for all migrants of which we had an autumn sample size of at least 20 individuals in a region. Including these preseason data reduced age ratios slightly for the Willow Flycatcher and Wilson's Warbler at the Sacramento River and for the Orange-crowned and Wilson's Warblers at Cosumnes River. It reduced them more substantially for the Pacific-slope Flycatcher in both regions (Table 5), indicating early movement of adults of this species. For all other species age ratios were unchanged.

Of particular interest is the number of Willow Flycatchers, Yellow Warblers, and Song Sparrows at these Central Valley sites, all species of current conservation interest in California where they have been extirpated from parts of their breeding range (Gaines 1974; see RHJV 2000 for review). The high capture rate of the Pacific-slope Flycatcher at the Cosumnes River Preserve also merits note. Stewart et al. (1974) suggested that this species migrates primarily along the coast, yet our capture rate at Cosumnes from 1995 to 1997 was nearly twice as high as it was at the Palomarin Field Station on the coast of Marin County from 1976 to 1986 (Taylor et al. 1994) and 1.5 times as high as the capture rate at Palomarin from 1995 to 1997 (PRBO unpubl. data). It appears that this inland Central Valley route is widely used by the Pacific-slope Flycatcher. While the ratios of young to adults for this species were high at both sites, adult Pacific-slope Flycatchers were relatively more common at Cosumnes than at Palomarin, and the age ratio was low at the Sacramento River (Table 5; Taylor et al. 1994). This

suggests that more adult flycatchers migrate through the Central Valley than down the coast, although even more adults likely migrate along unexamined routes.

Different suites of species varied considerably in their relative abundance between study areas. Neotropical migrants were most abundant at the Sacramento River National Wildlife Refuge sites, year-round residents at the Cosumnes River Preserve, and wintering birds at the San Luis National Wildlife Refuge. Also at the Cosumnes River Preserve (which had the highest capture rate of all three regions), permanent residents were captured at a rate at least three times greater than in the other two regions. The total list of species recorded being greatest at the Sacramento River may reflect only the greater number of seasons we monitored there. Because we were more interested in describing fall composition of the birdlife at each of these sites than in comparing the sites to one another we did not limit the scope of this paper to only 1995 to 1997. Our results also show that for most species examined year-to-year return rates of wintering individuals were highest at San Luis, suggesting not only high use of this site by wintering species but the suitability of this site as well.

Pooling results of area searches and mist-netting captures yielded higher species counts than either method alone, providing a more complete picture of birds' use of these sites. All regions combined, 22 passerines, including the European Starling, blackbirds, swallows, and corvids, were never captured in mist-nets but were detected on area searches, along with most nonpasserines. Other species, often uncommon or reticent ones, were captured in mist nets but never detected on area searches. Such species were the Dusky Flycatcher, Brown Creeper, and Yellow-breasted Chat at the Sacramento River, the Winter Wren, Yellow-breasted Chat, Chipping Sparrow, Lark Sparrow, Savannah Sparrow, and Lesser Goldfinch at the Cosumnes Preserve, and the Common Poorwill, Gray Flycatcher, Hutton's Vireo, Warbling Vireo, Nashville Warbler, Myrtle Warbler, MacGillivray's Warbler, Brewer's Sparrow, and Black-headed Grosbeak at San Luis. Such sampling differences are even more pronounced when only a single site is considered. We recommend that other migration studies supplement mist netting with additional census methods to describe and monitor bird communities, as ours and other studies have done (Pyle and Henderson 1991, Finch and Yong 2000).

Because these studies lasted only a few years (2 to 5 years at each site), results may not reflect average numbers of species using the habitat or region. Annual numbers of fall migrants recorded in long-term studies at Palomarin (Taylor et al. 1994) and on Southeast Farallon Island off the California coast (DeSante 1983) are highly variable, so short-term fall migration monitoring may underestimate or exaggerate an area's importance as a stopover site by a species or suite of species. Nevertheless our data establish the use of the remaining riparian habitat in the Central Valley by western landbirds during autumn, including resident, migrant and wintering species. In a region lacking continuous, wide stretches of riparian habitat, where the surrounding landscape often lacks substantial vegetative structure, and in the absence of any other large forest patches (Petit 2000), these and other remnant sites of varying quality are likely important for migrating birds.

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LITERATURE CITED

Cogswell, H. L. 1962. Operation recovery begun in California's Central Valley. W. Bird Bander 37:52–54.

DeSante, D. F. 1983. Annual variability in the abundance of migrant landbirds on Southeast Farallon Island, California. Auk 100:826–852.

DeSante, D. F., and George, T. L. 1994. Population trends in the landbirds of western North America. Studies Avian Biol. 15:173–190.

Finch, D. M., and Yong, W. 2000. Landbird migration in riparian habitats of the middle Rio Grande: A case study. Studies Avian Biol. 20:88–98.

Gaines, D. 1974. A new look at the nesting riparian avifauna of the Sacramento Valley, California. W. Birds 5:61–80.

Gaines, D. F. 1977. The valley riparian forests of California: Their importance to bird populations, *in* Riparian Forests in California: Their Ecology and Conservation (A. Sands, ed.), pp. 57–85. Inst. Ecol. Publ. 15, Univ. Calif., Davis.

Grinnell, J., and Miller, A. H. 1944. The distribution of the birds of California. Pac. Coast Avifauna 27.

Katibah, E. F. 1984. A brief history of riparian forests in the Central Valley of California, *in* California Riparian Systems: Ecology, Conservation, and Productive Management (R. E. Warner and K. M. Hendrix, eds.). Univ. Calif. Press, London.

Miller, A. H. 1951. An analysis of the distribution of the birds of California. Univ. Calif. Publ. Zool. 50:531–643.

National Geographic Society. 1999. Field Guide to the Birds of North America, 3rd ed. Natl. Geogr. Soc., Washington, D.C.

Petit, D. R. 2000. Habitat use by landbirds along nearctic–neotropical migration routes: Implications for conservation of stopover habitats. Studies Avian Biol. 20:15–33.

Pyle, P., and Henderson, R. P. 1991. The birds of Southeast Farallon Island: Occurrence and seasonal distribution of migratory species. W. Birds 22:41–84.

Pyle, P., Howell, S. N. G., Yunick, R. D., and DeSante, D. 1987. Identification Guide to North American Passerines. Slate Creek Press, Bolinas, CA.

Ralph, C. J. 1971. An age differential of migrants in coastal California. Condor 73:243–246.

Ralph, C. J. 1981. Age ratios and their possible use in determining autumn routes of passerine migrants. Wilson Bull. 93:164–188.

Ralph, C. J., Geupel, G. R., Pyle, P., Martin, T. E., and DeSante, D. F. 1993. Field methods for monitoring landbirds. U.S. Dept. Agric. Forest Serv. Publ. PSW-GTR 144, Albany, CA (order from Pacific Southwest Research Station, P. O. Box 245, Berkeley, CA 94701-0245).

RHJV (Riparian Habitat Joint Venture). 2000. Version 1.0. The Riparian Bird Conservation Plan: A Strategy for Reversing the Decline of Riparian Associated Birds in California. California Partners in Flight (request from Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach CA 94970; also available at http://www.prbo.org/CPIF/Riparian/Riparian.html).

Sibley, D. A. 2000. The Sibley Guide to Birds. Knopf, New York.

Slater, P. J. 1994. Factors affecting the efficiency of the area search method of censusing birds in open forests and woodlands. Emu 94:9–16.

Sogge, M. K., Gilbert, W. M., and van Riper III, C. 1994. Orange-crowned Warbler (*Vermivora celata*), *in* The Birds of North America (A. Poole and F. Gill, eds.), no. 101. Acad. Nat. Sci., Philadelphia.

Stewart, R. M., Mewaldt, L. R., and Kaiser, S. 1974. Age ratios of coastal and inland fall migrant passerines in central California. Bird-Banding 45:46–57.

Taylor, D. M., DeSante, D. F., Geupel, G. R., and Houghton, K. 1994. Autumn populations of landbirds along central coastal California, 1976–1986. J. Field Ornithol. 65:169–185.

Weston, H. G. 1947. Breeding behavior of the Black-headed Grosbeak. Condor 49:54–73.

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