MONITORING TRENDS IN A BREEDING BIRD ASSEMBLAGE WITH IMPLICATIONS FOR RIPARIAN CONSERVATION

DAVID L. RIENSCHE, East Bay Regional Park District, 2950 Peralta Oaks Court, P.O. Box 5381, Oakland, CA 94605.

MARTHA MORROW, Ohlone Audubon Society, 102 Sunnyside Ave, Piedmont CA 94611

MAGGIE CLARK, Ohlone Audubon Society, 3227 Rohrer Drive, Lafayette, CA 94549

CHRISTOPHER L. KITTING, California State University East Bay, 25800 Carlos Bee Boulevard, Hayward, CA 94542

ABSTRACT: Monitoring canaries in coal mines, and other bird populations, can uncover limits in habitat management. Over 14 years, a breeding bird assemblage showed substantial declines at a suburban wetland park in Central California. Of the seventy bird species observed here, twenty-five species were known to breed, and four are classified as riparian focal species for conservation. Species richness *(S)*, species diversity *(H')* and species evenness *(J')* showed little variability among years, however total individuals of all species territories combined *(N)* showed statistically significant declines. Breeding bird censuses conducted from 1994 to 1998 and 2004 to 2008 showed substantial declines in eleven out of twenty-five species, those of notable conservation interest include common yellowthroat (*Geothlypis trichas*), Wilson's warbler (*Wilsonia pusilla*), and song sparrow (*Melospiza melodia*). These changes were not related to any measurable alteration in vegetation on the plot, or precipitation/climate, but may be related to changes in habitat surrounding the site. To our knowledge, this is the first long-term breeding bird census of a riparian habitat along the eastern shoreline of San Francisco Bay, California. Management recommendations to benefit the avifauna include adaptive management during monitoring, and expansion of the park's riparian habitat by enhancing plants in surrounding area restorations.

Key words: California, riparian habitat, monitoring breeding birds, baseline data for restoration.

TRANSACTIONS OF THE WESTERN SECTION OF THE WILDLIFE SOCIETY 46:7-20

Riparian ecosystems are among the highest priorities for assessment, improved management, and restoration (Krueper 1993). Wetland and riparian areas comprise less than 1% of the total land area in western United States, yet more than any other habitat type, riparian vegetation is used by wildlife (Thomas et al. 1979). In western United States, 77 breeding bird species are identified as obligate or riparian dependent, and their occurrence serves as the standard to which areas can be compared (Rich 2002). Over 75% of all terrestrial species in Oregon and Wyoming depend on riparian areas during some portion of their life cycle (Chaney et al. 1990). In Arizona and New Mexico, at least 80% of all vertebrates use riparian areas, and more than 50% of those are considered to be riparian obligates (Chaney et al. 1990). More than 225 species of birds, mammals, reptiles, and amphibians depend on California's riparian habitats (Riparian Habitat Joint Venture 2004).

Many breeding and other bird populations depend on riparian habitat. In the southwestern United States, riparian areas support a higher diversity of breeding birds than do all other habitats combined (Anderson and Ohmart 1977, Johnson et al 1977, Johnson and Haight 1985). Over 60% of the species identified as Neotropical migrants by Partners In Flight used riparian areas in the western United States during the breeding season or as migratory stopover sites (Krueper 1993). Riparian areas may be the most important habitat for landbird species in California (Manley and Davidson, 1993). Yet riparian systems are degraded throughout much of the western United States (Thomas et al. 1979, Knopf et al. 1988, Chaney et al. 1990, Saab et al. 1995).

Natural riparian systems are critical to wildlife and are disappearing, in response to human demands on these areas for water and recreation (Merola-Zwartjes and DeLong 2005), as well as degradation

from other factors such as flood control efforts, improper grazing practices (e.g., Krueper 1993, Fleischner 1994, Ohmart 1994), intensive agriculture where streamside habitat is depleted (Stauffer and Best 1980), and water diversions (Rich 2002). Over the past century, estimates are that up to 95% of western riparian vegetation communities have been lost or degraded, and many of the bird species associated with these systems have been extirpated or have experienced sever declines (DeSante and George 1994, Hunter et al. 1987, Krueper 2000). Depending on the bioregion in California, riparian habitat only covers 2% to 15% of its historic range (Katibah 1984, Dawdy 1989).

It often is unclear whether local population changes in resident and migrant breeding birds are primarily the result of habitat alteration within a site (Canterbury and Blockstein 1997; Massey and Evans 1994), broad-scale effects on the breeding grounds, changes in winter habitat, annual variations in precipitation and temperature (Verner, Purcell and Turner, 1996), or other factors. Long-term monitoring of bird populations and habitat structure is useful for detecting local population trends and suggesting the degree to which changes can be attributed to local factors. This study was conducted in a suburban wetland park where the area was sampled quantitatively (Riensche 1993) and showed no detectable change in vegetation during the study.

The objectives of our study were to (1) document the yearly trends in the avian populations and community structure in a riparian habitat, (2) describe and monitor the vegetation, (3) establish a baseline density of the breeding bird assemblages for comparison purposes, and (4) develop adaptive management recommendations for the enhancement of existing riparian habitat in this suburban wetland park.

Study Area

We conducted this study at Coyote Hills Regional Park (hereafter: "Coyote Hills") in Fremont, California (37.556481 N Lat., 122.077052 W Long.). Coyote Hills is 3.5 km long, almost 405 hectares in size, and contains one of the largest willow-dominated riparian woodlands, 8.5 hectares, remaining along the eastern shore of San Francisco Bay. This Willow Grove (name of riparian site in the park) is only a remnant of its former size being dramatically reduced in size due to agriculture and urban development. Arroyo willows *(Salix lasiolepis)* dominate this woodland with occasional, scattered box elders (*Acer negundo californicum*) and western sycamores *(Plantanus racemosa)*. Coyote Hills is part of the East Bay Regional Park District, a two-county special district with about 38,850 ha in Alameda and Contra Costa Counties.

Methods

In 1994, we established a Breeding Bird Census (BBC) plot in the park. Censuses were conducted from 1994 to 1998 and 2004 to 2008. The census plots consisted of a rectangular grid with stations 50 m apart. A team of two or three individuals conducted the census following standard BBC procedures (Van Velzen 1972), recording all birds seen and heard. All counts were made in the early morning, starting about 0.5 hr before sunrise and ending 2.5-3 hr later, and were not conducted on days with heavy rain or strong winds. Sixteen visits were made during each breeding season (March to mid June), in which the team walked the grid lines and recorded all birds seen and heard, giving a total of 96 BBC censuses during this study. Starting direction of travel for each visit on the plot was random. Territory boundaries were determined based on repeated behavioral occurrences (male singing and/or displays) and simultaneous singing. In addition, detection of nests, the carrying of nest material, and/or the feeding of offspring was used as evidence to confirm and support the number of territory boundaries. The number of bird territories provided a measure of breeding population density. Standardized methodology of BBC allows density estimates to be compared among different sites and among different years at the same site. To minimize variation among observers and to reduce any biases in census results, at least two authors worked together while censusing the plot and determining territory boundaries. Gaps in the research years are due to lack of time and funds, making annual censuses of the plot impractical, but provided two distinct blocks of data to compare, a decade apart.

Species included here are limited to those with small (<2 ha), well-defined territories that can be easily delineated. Birds that were excluded included species with largely poorly defined territories (e.g. some hawks) and non-territorial species (e.g. finches). Differences in population densities between 1994 – 1998 and 2004 -2008 were expressed as percentage change (after Canterbury and Blockstein 1997). The

Mann-Whitney U statistical test was used to compare the degree of individual species change at the 90% (marginally significant) and 95% (statistically significant) confidence levels.

Using the methods described by Yahner (1983) and Roffflinke et al. (1990), four measures of avian community structure were computed per year. These measures included mean species richness *(S)*, species diversity *(H')*, species evenness *(J')*, and total number of individual territories *(N*, for separate or combined species*)*. *S* is the total number of species; *H'* is based on the Shannon index = $-\sum p_i \log_e p_i$, where *p* is the proportion of individuals represented by the *i*th species; and *J'= H'*/log *S* (after Dickson 1978). These measures of community structure for all years were compared using nonparametric Mann-Whitney U tests, at the 95% confidence level.

Vegetation was surveyed quantitatively using the methods of James and Shugart (1970) and James (1980). Ten randomly placed 0.04-ha circular plots were used to evaluate ground and canopy cover using an ocular tube. Shrub density was estimated from two transects across the plot. All trees with a dbh of at least 7.6 cm were recorded by species and diameter (size) within the plot.

Results

Riensche (1993 and 1994) qualitatively described our willow-dominated riparian vegetation structure, and our analogous observations detected no major change here over the course of this study. Willow riparian woodland comprised 82% of the plot, permanent and seasonal wetland comprised 13%, and herb and grassland mix comprised the remaining 5%. Up to 50% of the surface was covered by standing water during the breeding season.

Bird community – Seventy bird species were observed during this 14-year study period, of which forty-six species are known to nest within Coyote Hills and twenty-five species attempted to breed on the site (Table 1). Based on relative population densities, the six most common species on the plot were, in decreasing order of abundance: song sparrow (*Melospiza melodia*) averaging 12 territories/8.5 ha, marsh wren *(Cistothorus palustris)* averaging 6 territories/8.5 ha, common yellowthroat *(Geothlypis trichas)* averaging 4.5 territories/8.5 ha; Bewick's wren *(Thryomanes bewickii)*, mourning dove *(Zenaida macroura)*, and bushtit *(Psaltriprus minimus)* each at 3 territories/8.5 ha (Table 2). Those species showing statistically ($p<0.05$) and marginally significant declines ($p<0.10$) on the plot were as follows: Virginia rail (*Rallus limicola*), American coot (*Fulica americana*), bushtit (*Psaltripus minimus*), marsh wren (*Cistothorus palustris*), European starling (*Sturnus vulgaris*), common yellowthroat (*Geothlypis trichas*) ($p<0.07$), Wilson's warbler (*Wilsonia pusilla*), spotted towhee (*Pipilo maculates*) ($p<0.07$), California towhee (*Pipilo crissalis*), song sparrow (*Melospiza melodia*), and brown-headed cowbird (*Molothrus ater*) (see Table 2). The entire breeding bird assemblage showed a markedly decrease in population density during this 14-year study period (Figure 1). In addition, three out of four of the highly important, Riparian Focal species (Figure 2) showed significant ($p<0.05$) and marginally significant ($p<0.10$) territory density declines. Throughout this study, the song sparrow remained the predominant species. The four variables describing the structure of the avian community in all six years (Table 3) showed little variability among years with the exception of individual species' territories, which showed a significant decline between the first and last three years.

Discussion

Many studies indicate long-term declines in songbird populations (Faagborg and Arendt 1992, Gauthreaux 1992, Saurer and Droege 1992), and most of the species involved are Neotropical migrants (Robbins et al. 1989, Rappole and MacDonald 1994) . Factors that limit songbird populations include: habitat loss or degradation on breeding, wintering, and migratory stopover areas, suppression of natural disturbance processes, increased cowbird parasitism, pesticide influences, changes in predation rates and food availability, and other factors brought about by weather or climate change (Sherry and Holmes 1995, Rotenberry et al. 1995, Robinson 1997, Askins 2000).

While a number of riparian breeding bird species on our plots declined dramatically, no current evidence suggests an overall bird population decline in the park. The array of bird species richness (*S*), diversity (*H'*) and evenness (*J'*) within the 8.5-ha mature riparian plot was generally similar, showing no statistically significant difference among years. However, eleven of the twenty-five breeding bird species did show statistically significant or nearly significant declines (see Table 2). Riparian Focal species (song sparrow, Wilson's warbler, and common yellowthroat) in particular showed evidence

Table 1. Bird species that were observed at Coyote Hills Regional Park, Willow Grove plot (8.5 ha). Endangered, threatened and special status species are in bold. Status as a resident breeder within the park boundaries is signified as (b), all others are visitors.

Canada Goose (b)	*Branta canadensis*	Warbling Vireo	*Vireo gilvus*
Gadwall (b)	*Anas strepera*	Western Scrub-Jay (b)	*Aphelocoma californica*
Mallard (b)	*Anas platyrhynchos*	Tree Swallow (b)	*Tachycineta bicolor*
Ring-necked Pheasant (b)	*Phasianus colchicus*	Cliff Swallow (b)	*Hirundo pyrrhonota*
Pied-billed Grebe (b)	*Podilymbus podiceps*	Barn Swallow (b)	*Hirundo rustica*
Great Blue Heron	*Ardea herodias*	Chestnut-backed Chickadee (b)	*Poecile rufescens*
Great Egret	*Casmerodius albus*	Bushtit (b)	*Psaltriparus minimus*
Green Heron	*Butorides striatus*	Bewick's Wren (b)	*Thryomanes bewickii*
Black-crowned Night Heron	*Nycticorax nycticorax*	Marsh Wren (b)	*Cistothorus palustris*
Turkey Vulture	*Cathartes aura*	Ruby-crowned Kinglet	*Regulus calendula*
White-tailed Kite (b)	***Elanus leucurus***	Swainson's Thrush	*Catharus ustulatus*
Northern Harrier (b)	***Circus cyaneus***	Hermit Thrush	*Catharus guttatus*
Sharp-shinned Hawk	***Accipiter striatus***	American Robin (b)	*Turdus migratorius*
Cooper's Hawk (b)	***Accipiter cooperii***	Northern Mockingbird (b)	*Mimus polyglottos*
Red-shouldered Hawk (b)	*Buteo lineatus*	European Starling (b)	*Sturnus vulgaris*
American Kestrel (b)	*Falco sparverius*	Orange-crowned Warbler	*Vermivora celata*
Peregrine Falcon	***Falco peregrinus***	**Yellow Warbler**	***Dendroica petechia brewsteri***
California Black Rail	***Laterallus jamaicensis coturniculus***	Common Yellowthroat (b)	*Geothlypis trichas*
Virginia Rail (b)	*Rallus limicola*	Wilson's Warbler (b)	*Wilsonia pusilla*
Common Moorhen (b)	*Gallinula chloropus*	**Yellow-breasted Chat**	***Icteria virens***
American Coot (b)	*Fulica americana*	Western Tanager	*Piranga ludoviciana*
Killdeer (b)	*Charadrius vociferus*	Spotted Towhee (b)	*Pipilo maculatus*
Mourning Dove (b)	*Zenaida macroura*	California Towhee (b)	*Pipilo fuscus*
Barn Owl	*Tyto alba*	Fox Sparrow	*Passerella iliaca*
Great Horned Owl (b)	*Bubo virginianus*	Song Sparrow (b)	*Melospiza melodia*
Long-eared Owl	***Asio otus***	White-crowned Sparrow	*Zonotrichia leucophrys*
White-throated Swift	*Aeronautes saxatalis*	Golden-crowned Sparrow	*Zonotrichia atricapilla*
Anna's Hummingbird (b)	*Calypte anna*	Black-headed Grosbeak	*Pheucticus melanocephalus*
Nuttall's Woodpecker (b)	*Picoides nuttallii*	Red-winged Blackbird (b)	*Agelaius phoeniceus*
Downy Woodpecker (b)	*Picoides pubescens*	Western Meadowlark (b)	*Sturnella neglecta*
Northern Flicker (b)	*Colaptes auratus*	Brown-headed Cowbird (b)	*Molothrus ater*
Olive-sided Flycatcher	*Contopus borealis*	Hooded Oriole (b)	*Icterus cucullatus*
Pacific-sloped Flycatcher (b)	*Empidonax difficilis*	Bullock's Oriole (b)	*Icterus bullockii*
Black Phoebe (b)	*Sayornis nigricans*	Lesser Goldfinch (b)	*Carduelis psaltria*
Loggerhead Shrike (b)	***Lanius ludovicianus***	American Goldfinch (b)	*Carduelis tristis*

Table 2. Population Densities of breeding bird species at Coyote Hills Regional Park, Willow Grove plot (8.5 ha). Focal species for the Riparian Bird Conservation Plan are in italic/bold. The Mann-Whitney U-test revealed that eleven out of twenty-five species showed statistically (tied $p < 0.05$) and marginally significant (tied $p < 0.07$) declines. Species with < 2 territories found in six seasons are excluded.

Species	Mean Territories for 94 -98	Mean Territories for 04 -08	% Change in Population Density 94-98 to 04-08	Level of Significance
Pied-Billed Grebe	1.00	0.67	-34%	none
Mallard	1.33	0.83	-37%	none
White-tailed Kite	0.83	0.67	-20%	none
Virginia Rail	1.00	0.17	-84%	p<0.05
American Coot	1.00	0.00	-100%	p<0.05
Mourning Dove	2.83	3.50	23%	none
Anna's Hummingbird	1.00	1.00	no change	none
Downy Woodpecker	1.00	0.83	-17%	none
Black Phoebe	0.83	0.33	-152%	none
Tree Swallow	0.67	1.00	33%	none
Scrub Jay	1.50	1.00	-50%	none
Chestnut-backed Chickadee	1.67	1.33	-20%	none
Bushtit	4.33	2.00	-116%	p<0.05
Bewick's Wren	3.33	3.00	-10%	none
Marsh Wren	7.00	5.17	-31%	p<0.05
European Starling	1.83	0.00	-100%	p<0.05
Common Yellowthroat	5.33	3.67	-31%	p<0.07
Wilson's Warbler	2.50	0.83	-200%	p<0.05
Rufous-sided Towhee	1.67	0.33	-400%	p<0.07
California Towhee	2.50	1.00	-150%	p<0.05
Song Sparrow	15.00	8.67	-42%	p<0.05
Brown-headed Cowbird	2.67	1.00	-160%	p<0.05

of a decline. Songbird densities comparisons (as with riparian breeding territories) between the years of 1994, 1995, 1998 vs. 2004, 2005, 2008 showed statistically significant declines. The local drop in their population densities might be linked to broad-scale regional habitat changes, or might simply be the result of decadal fluctuations (while chance is ruled out by our statistics). In a 21-year, constant-effort, mist-netting study at Point Reyes Bird Observatory, northwest of our study area, all bird groups underwent significant declines, although high nesters, common cowbird hosts, and Neotropical migrants declined faster than their respective counterparts (Ballard et al. 2003). In contrast, no decade-long, linear trends were evident in species diversity, evenness or richness for either Neotropical migrants or winter residents at Coyote Creek Field Station (Jaramillo et al. 1996), south of our study area. Tree swallow (*Tachycineta bicolor*) and mourning dove (*Zenaida macroura*), showed no dramatic local population declines, and are typical of late-successional habitats and may have simply taken advantage of the available forage and nest sites provided by several scattered mature trees on the plot.

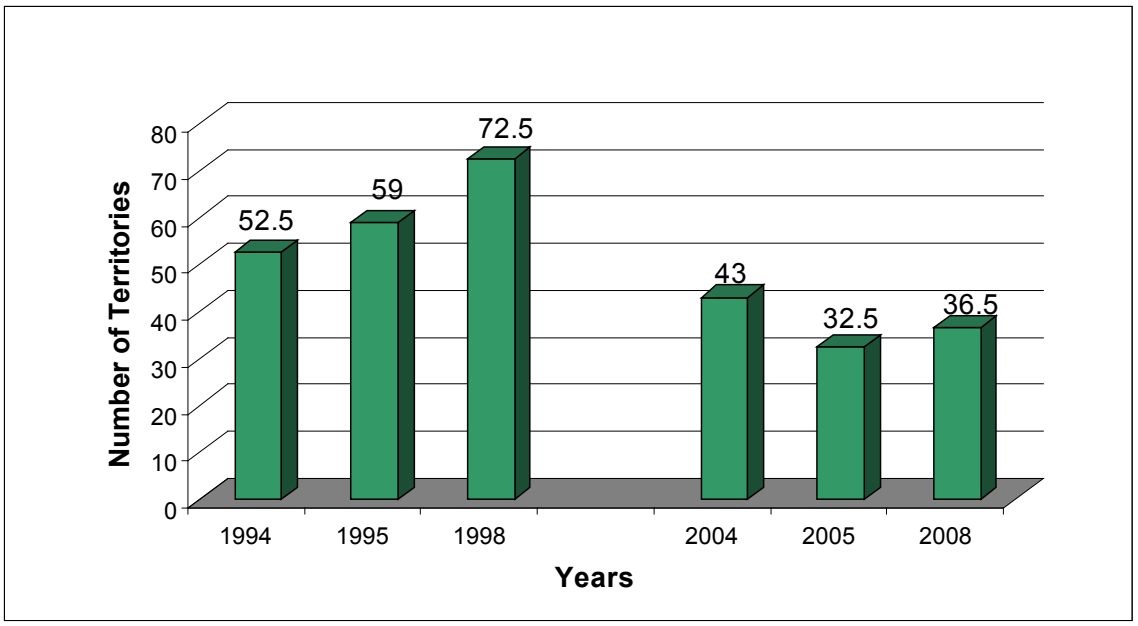

Figure 1. The number of breeding bird territories at Coyote Hills Regional Park, Willow Grove plot (8.5 ha). The breeding bird population shows a significant decrease in density (Mann-Whitney U-test, n = 296 among six years, tied $p < 0.05$).

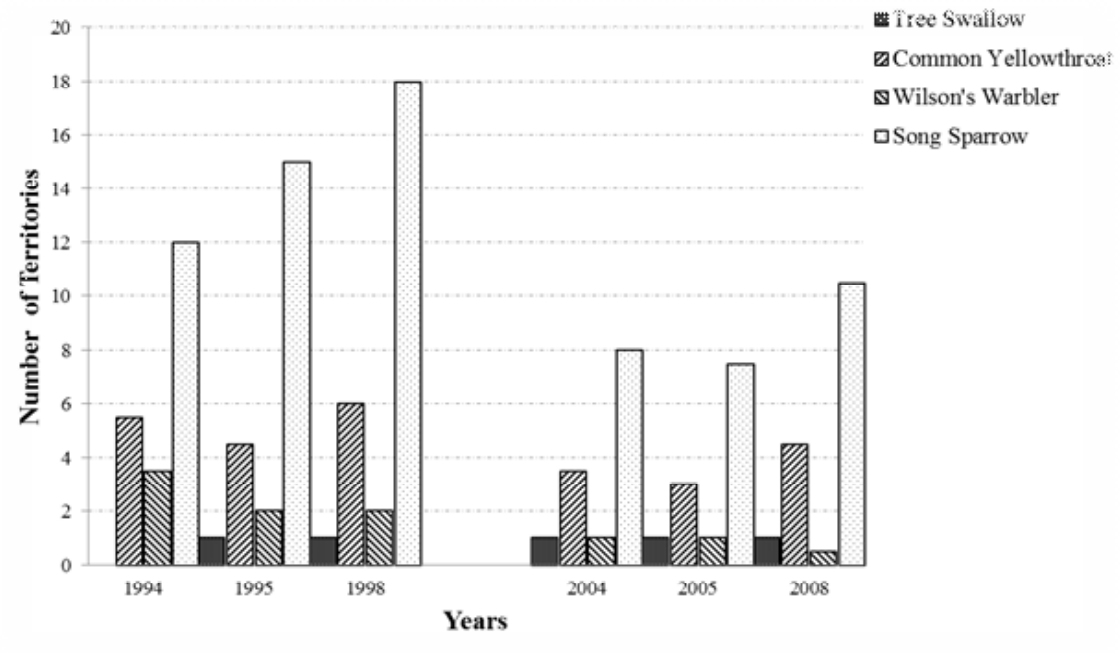

Figure 2. The number of riparian focal species breeding bird territories at Coyote Hills Regional Park, Willow Grove plot (8.5 ha). The Mann-Whitney U-test revealed a significant difference for the Wilson's warbler and the song sparrow (tied $p < 0.05$) and marginally significant (tied $p < 0.07$) for the common yellowthroat.

Table 3. Avian community variables by year at Coyote Hills Regional Park, Willow Grove plot (8.5 ha) 1994 – 2008. Statistical Alpha (tied p) based on Mann-Whitney U-test (significant change when tied $p < 0.05$)

Years	Richness (S)	Diversity (H')	Evenness (J')	Individuals (N)
1994	19	2.31	1.81	52.5
1995	21	2.58	1.91	58.5
1998	22	2.43	1.81	71.5
2004	18	2.49	1.99	42
2005	16	2.48	2.06	32.5
2008	17	1.77	1.43	36.5
Level of Significance	0.18	0.83	0.51	0.049

Birds have many features that make them especially valuable as indicators of habitat conditions (Hutto 1998, O'Connell et al. 2000). Birds that require understory vegetation are especially valuable when conducting riparian assessment, as many of these species will not occur without dense understories that characterize western riparian areas with high biotic integrity. Among the best of these are song sparrow *(Melospiza melodia)*, common yellowthroat *(Geothlypis trichas)*, yellow-breasted chat *(Icteria virens)*, and house wren *(Troglodytes aedon)*; Wilson's warbler *(Wilsonia pusilla)* is not only an understory obligate but also requires mid-story vegetation (Rich, 2002). Yellowthroats nest and forage in areas of dense low vegetation, which is typical of moist habitats (Stewart 1953, Yahner 1987). Sedgwick and Knopf (1987) suggested that yellowthroat populations can serve as ecological indicators of the quality of ground/shrub vegetation. Similarly, song sparrows are ground/shrub-foragers associated with dense brushy vegetation and usually are absent from closed-canopy forests (DeGraaf et al. 1980, Maurer et al. 1981, Kahl et al. 1985). Song sparrow was the most common riparian obligate on the site, demonstrating that the required dense understory vegetation was present.

The negative trend of Neotropical songbird species is a conservation concern, and habitat fragmentation of temperate breeding habitat is hypothesized to be a major factor underlining these declines (Patton 1994, Robinson and Wilcove 1994). Why eleven out of twenty-five breeding bird species declined on the site is open to speculation. A common justification for missing bird species in western riparian systems is that some component of the vegetation is missing (e.g., grass, shrubs, small or large trees; Krueper 1993, Saab et al. 1995, Dobkin et al. 1998, Krueper 2003). Some other possible explanations for the decline might be inadequate surrounding riparian vegetation, human disturbance due to recreational activities, and the common occurrence of nest predators (American crow, *Corvus brachyrhynchos*, and domestic cats). Nest predation is an important factor diminishing the breeding success of passerine birds (Martin 1993), and appears to increase with habitat fragmentation (Andren et al. 1984, Wilcove 1985, Small and Hinter 1988, Yahner and Scott 1988). In eastern Pennsylvania, raccoons (*Procyon lotor*) were the most commonly photographed nest visitor at the forest edge (Zegers et al. 2000). Songbird nest predators and the abundance of brown-headed cowbirds in the forest edge within a fragmented, agriculture landscape in central Missouri were significantly more abundant than the forest interior (Chalfoun, 2000). Prior to 2002, an active predator management strategy was implemented in the park to remove non-native red foxes (*Vulpes fulva*), over abundant raccoons (*Procyon lotor*) and feral cats in support of the California quail reintroduction program (Riensche, 2003). This intensive predator management effort was stopped once the quail were well established in 2001, and may have had an indirect benefit to the breeding bird assemblage on the study plot prior to 2004 by reducing the potential impacts of nest predators.

Other plausible explanations for the decline of expected species should be considered. First, bird populations are notoriously variable (Rotenberry and Wiens 1980), even in undisturbed habitats (Holmes and Sherry 2001). Second, the occurrence of species could be affected by events off-site during the nonbreeding

season (Rich, 2002). And third, differences in bird species diversity have been shown to fluctuate due to a large edge effect of cottonwood groves adjacent to agricultural lands, which contributed to higher bird species diversity values, in contrast to lower bird species diversity values in habitats with flooding or a low water table (Bottorff 1974, Carothers et al. 1974). The eastern portion of our plot was within 200 meters of agricultural lands that stopped active production in the late 1990s and may have also been an indirect benefit to the breeding bird assemblage on the study plot prior to 2000.

Another reason for the decline may include observer effects. Several studies have shown that territorial defense and advertisement, especially singing, are more intense at high densities than at low densities (LaPerrier and Haugen 1972; Marion 1974; Sorola 1984). It has been suspected that the density of a breeding population itself may result in biased counts that tend to amplify the real swings in abundance noted in populations that could lead to double counting of some individuals during population highs and to missing individuals at population lows (Verner, Purcell and Turner, 1996). Additionally, errors due to observer variation (Ralph and Scott 1981, Ralph et al. 1995) can be large, but can be reduced by appropriate training and by minimizing the number of individuals sampling, as in our study. In our study, the same persons on the census teams over the series of years recorded the same patterns shown by all observers combined.

Avian species richness (*S*) often declines in stressed or disturbed ecosystems (Adams and Barrett 1976). Evenness (*J'*), on the other hand, is relatively stable and usually does not fluctuate markedly in response to habitat changes (Kricher 1972, Adams and Barrett 1976). Especially in summer, species diversity (*H'*) varies primarily as a function of species richness and is influenced minimally by species evenness (Rotenberry et al. 1979). Patten and Rotenberry (1998) pointed out that it is possible for a breeding bird community composition to change little in terms of predominate species, but change greatly in terms of overall richness depending on measurement techniques used. Thus, use of an index that emphasizes species dominance (e.g., the Simpson diversity index) could yield quantitatively different conclusions than use of a measure that emphasizes rare species (e.g., the Shannon diversity index). In our study, we used the Shannon diversity index to emphasize rare species. The species diversity (*H'*) decline we observed was not because of a decrease in species richness (*S*).

One would expect the park's avian fauna to remain relatively stable even if fluctuations occurred, because smaller populations will abandon marginal fragmented habitats before disappearing from high-quality habitats. However, continued significant declines in Riparian Focal species within the park would indicate a serious problem, and the continued monitoring of the plot to detect such declines and identify the factors would be beneficial. As pointed out by Verner et al. (1996), the fundamental need of any monitoring program is sufficient knowledge about the typical baseline level of a population against which any observed future trends can be interpreted.

In general, it is reasonable to attribute the changes in the riparian bird community at Coyote Hills over our 14-year period to broad landscape scale patterns rather than population fluctuations due to local habitat changes. No noticeable change in the local habitat was detected. Likewise, the environment sampled by Verner, Purcell and Turner, (1996) did not undergo evidence of habitat change during their eleven-year study, so the observed variations in species abundance were thought to be the result of other factors (primarily variation in precipitation and secondarily variations in temperature). We did not detect any significant change in precipitation and temperature during the two study periods. In a similar long-term study, many riparian bird residents showed fairly wide fluctuations in numbers over the eight years of study, implying that these fluctuations reflect a cyclic nature of breeding success (Massey and Evans, 1994). Ballard et al. (2003) implied that the accelerating declines in songbirds since 1990 may reflect the effects of large-scale climate cycles, particularly on long-distance migrants. Furthermore, Ballard et al. (2003) suggests that long-term population trajectories of songbird populations across North America may be better understood in the context of the Pacific Decadal Oscillation.

California's riparian habitat provides important breeding and over winter grounds, migratory stopover areas and corridors for dispersal (Cogswell 1962, Gaines 1977, Ralph 1998, Humple and Geupel 2002, Flannery et al. 2004). Through improved management, riparian vegetation and breeding bird populations in the western United States can respond rapidly and increase by orders of magnitude where vegetation cover is increased (Krueper 1993, Krueper et al. 2003). This fact, coupled with the recognized

widespread degradation of these systems, requires that environmental practitioners continue to not only employ current methodologies but also to develop new habitat enhancement approaches with broader biological diversity goals. The starting point to any management plan is an inventory that includes a list of plant and animal species, their populations, distribution patterns, habitat affinities, and documentation of occurrences (Scout et al. 1995). By comparing existing and historical conditions, managers can make quantitative assessments. The restoration of unique and ecologically important communities such as riparian areas and the reintroduction of extirpated species are appropriate approaches to conserving biological diversity (Scout et al. 1995). Bird species diversity is correlated with habitat diversity (Willson 1974, Balda 1975), and manipulation increasing the structural diversity of habitat can benefit the greatest number of species. It is reported that recovery and new growth of vegetation along stream courses paralleled an increase in variety and numbers of breeding bird species (Massey and Evans, 1994). Additionally, Stauffer and Best (1980) indicated that bird species richness increased with the width of wooded riparian habitats. Others have shown that irrigated forests have taller and lusher herbaceous vegetation than non-irrigated forests (Sopper and Kardos 1973). Furthermore, food resources, such as berries, seeds, and invertebrates, are more abundant in irrigated than in non-irrigated forests (Lewis 1977, Greenwald 1981). Rollfinke et al. (1990) showed that lush growth of herbaceous vegetation and formation of ponds associated with the installation and operation of a wastewater irrigation system provided suitable habitat for yellowthroats and song sparrows. Research comparing the importance of different habitat attributes to avian community has shown that individual bird species respond with greater frequency to the number of particular species of riparian trees than to any other habitat structure variable (Rice et al. 1984).

In riparian systems, broadleaf trees provide secure, suitable nest platforms for raptors. Additionally, woodpeckers excavate the larger dead, softwood limbs to create cavities which are subsequently used by other species. Mature and structurally complex stands of broadleaf trees may also provide thermal protection for mid-summer breeders (Hunter et al. 1984). The need for mature broadleaf trees in riparian areas is unequivocal and the most effective conservation action for riparian-obligate species. To maximize the growth of broadleaf trees in riparian areas, natural regeneration should be encouraged, large scale revegetation efforts should be initiated, and non-native plants should be controlled (Hunter et al. 1984). Restoration and improved management are the best means to increase the amount and quality of riparian habitat and should be directed at increasing understory cover; particularly forbs and maintaining deadwood at restoration sites (see Riparian Habitat Joint Venture 2004 and references).

Due to their biological wealth and sever degradation, riparian areas are the most critical for conservation of Neotropical migrants and resident birds in the West (Miller 1951, Gaines 1974, Manely and Davidson 1993, Rich 1998, Dovovan et al. 2002). And although the riparian habitat in the area of Coyote Hills in Fremont is much reduced from its historic size, it could be enhanced to fit a number of criteria that Diamond and May (1976) deemed essential for a natural reserve. First the surrounding area east of the plot could be planted with local stock to create a circular shape (the current shape is somewhat triangular), which would maximize the area-to-perimeter ratio, thus minimizing dispersal distances within the riparian habitat. Secondly, this circular configuration would avoid the peninsular effects in which dispersal rates to outlying locations would be low thereby diminishing the reserve's effectiveness. Lastly, these restoration efforts would create easily accessible stepping-stone habitat patches, which could lead to other similar habitat patches, thereby creating corridors of movement.

Coyote Hills Willow Grove may be the last representative habitat of its type found along the highly urbanized, eastern shore of the San Francisco Bay. The park is a popular destination for wildlife watching and is one of the top ten bird watching sites in the San Francisco Bay Area. The riparian breeding bird community decline may be a response to naturally occurring fluctuations reflecting the cyclic nature of breeding success; or caused by other variables such as climatic cycles, disease, nest predation, influences of agricultural practices, wide-spread habitat fragmentation on the landscape scale, the effects of island biogeography, or some combinations of all the above. We encourage additional research that investigates the influences of resource variability and provide some measures of avian densities during both the breeding and nonbreeding season, bird reproductive success, and the genetic structure of this breeding bird community. We encourage

careful consideration and appreciation of what these results mean to riparian bird communities and how practitioners might benefit from such data when planning, implementing and monitoring riparian conservation efforts.

Management Implications

This study achieved several goals: data collected established baseline information on the riparian breeding bird community that may serve as a basis for evaluating future findings, and our study demonstrated that with adequate planning, staff support, and trained volunteers, ongoing long-term surveys can be an integral part of a stewardship program. This study provides the first statistically sound, comprehensive assessment of the East Bay Regional Park District's riparian breeding bird community at Coyote Hills Regional Park and will serve as a basis for developing future park district surveys to assist in conservation and restoration activities. Effective management of riparian vegetation and wildlife in the area can only occur through continued, wider, long-term monitoring to clearly understand physical factors that may be involved in causing the declines we observed.

ACKNOWEDGMENTS

We would like to dedicate this work to our mentor and friend Howard L. Cogswell. Additionally we would like to express our sincere gratitude to the following people that made this work possible: C. Aquilar, K. Bloom, G. Bloom, I Bletz, P. Cross, C. Garcia, C. High, H. High, K. High, S. High, D. Mason, J. Mena, M. Marrow, B. Pinomaki, R. Pinomaki, T. Pinomaki, B. Pinomaki, R. Reid, M. Riensche, S. Riensche , D. Riensche, N. Riensche, R. Riensche, S. Robinson, P. Savage, M. Schynert, B. Scoggins, P. Shawen, A. Shawen, W. Spitler, G. Still, P. Thompson, P. Thompson, S. Wiley, J. Wiley, R Wiley, and P. Zierman.

LITERATURE CITED

Adams, D. L. and G. W. Barrett. 1976. Stress effects on bird-species diversity within mature forest ecosystems. American Midland Naturalist 96: 179-194.

Anderson, B. W., and R. D. Ohmart. 1977. Vegetation structure and bird use in the lower Colorado River Valley. Pages 23-34 *in* R. R. Johnson and D. A. Jones, technical coordinators. Importance, preservation and management of riparian habitat: a symposium. United States Forest Service, General Technical Report RM-GTR-43.

Andren, H. P., Angelstram, E. Lindstrom, and P. Widen. 1984. Differences in predation pressure in relation to habitat fragmentation: an experiment. Oikos 45: 273-277.

Askins, R. A. 2000. Restoring North America's birds: lessons from landscape ecology. Yale University Press, New Haven, CT.

Balda, R.P. 1975. Vegetation structure and breeding bird diversity. Pages 59-80 *in* D. R. Smith, Technical Coordinator. Symposium on management of forest and range habitats for nongame birds. U.S. Department of Agriculture Forest Service General Technical Report WO-1.

Ballard, G., G. R. Geupel, N. Nur and T. Gardali. 2003. Long-term declines and decadal patterns in population trends of songbirds in Western North America, 1979 – 1999. The Condor 105: 737 – 755.

Bottorff, R. L. 1974. Cottonwood habitat for birds in Colorado. American Birds 28: 975-979.

Canterbury, G. E. and D. E. Blockstein. 1997. Local changes in a breeding bird community following forest disturbance. Journal of Field Ornithology 68: 537 – 546.

James, F. C. 1980. On understanding quantitative surveys of vegetation. American Birds 34: 22-23.

Carothers, S. W., R. R. Johnson, and S. W. Aitchison. 1974. Population structure and social organization of southwestern riparian birds. American Zoology 14: 97-108.

Chalfoun, A. D. 2000. The effects of edge and habitat fragmentation on predators of songbird nests. M.S. Thesis, University of Missouri-Columbia, University of Missouri, Columbia, Missouri.

Chaney, E., W. Elmore, and W. S. Platts. 1990. Livestock grazing on western riparian areas. United States Environmental Protection Agency, Washington, D. C., USA.

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

James, F. C. and H. H. Shugart. 1970. A quantitative method of habitat description. Audubon Field Notes 24:727-736.

Dawdy, D. R. 1989. Feasibility of mapping riparian forests under natural conditions in California. Pp 63-68 *in* Proceedings of the California Riparian Systems Conference. GTR PSW-110, Davis, CA.

DeGraaf, R. M., G. M. Witman, J. W. Lanier, B. J. Hill, and J. M. Keniston. 1980. Forest habitat for birds of the northeast. Northeast Forest Experimental Station U.S. Department of Agriculture Forest Service.

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

Diamond, J. M. and R. M. May. 1976. Island biogeography and the design of natural reserves. Pp. 163-186 *in* Theoretical ecology principles and applications (R. M. May, ed.). W. B. Saunders Co., Philadelphia, Pennsylvania.

Dickson, J. G. 1978. Seasonal bird populations in a south central Louisiana bottomland hardwood forest. Journal of Wildlife Management 42: 875-883.

Dobkin, D. S., A. C. Rich, and W. H. Pyle. 1998. Habitat and avifauna recovery from livestock grazing in a riparian meadow system of the northwestern Great Basin. Conservation Biology 12: 2009-221.

Donovan, T. M., C.J. Beardmore, D. N. Bonter, J. D. Brawn, R. J. Cooper, J. A Fitzgerald, R. Ford, S. A. Gauthreaux, T. L. George, W. C. Hunter, T. E. Martin, J. Price, K.V. Rosenberg, P. D. Vickery and T. B Wigley. 2002. Priority research needs for the conservation of Neotropical migrant landbirds. Journal of Field Ornithology 73:329-339.

Faaborg, J., and W.J. Arendt. 1992. Long-term declines of winter resident warblers in a Puerto Rican dry forest: which species are in trouble? Pp. 57-63 *in* J. M. Hagan III, and D. W. Johnston, editors, Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington, DC.

Flannery, M. E., S. L. Guers, T. Gardali, N. Nur and G. R. Guepel. 2004. Landbird migration at the Salton Sea: the importance of desert riparian habitat. Studies in Avian Biology: 27: 106-115.

Fleischner, T. L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8: 629-644.

Gaines, D. 1974. The nesting riparian avifauna of the Sacramento Valley, California and the status of the Yellow-billed Cuckoo. MS Thesis. University of California, Davis CA.

Gaines, D. 1977. The valley riparian forest of California: their importance to bird populations. *In* A. Sands, editor, Riparian Forests in California: their ecology and conservation. Institute of Ecology Publication 15. University of California, Davis CA.

Gauthreaux, S. A., Jr. 1992. The use of weather radar to monitor long-tern patterns of trans-Gulf migration in spring. Pp. 96-100 *in* J. M. Hagan III, and D. W. Johnston, editors, Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington, DC.

Greenwald, C. M. 1981. Prediction of songbird responses to habitat alteration resulting from wastewater irrigation. M.S. thesis, The Pennsylvania State University, University Park, Pennsylvania.

Holmes, R. T., and T. W. Sherry. 2001. Thirty-year bird population trends in an unfragmented temperate deciduous forest: importance of habitat changes. Auk 118: 589-609.

Humple, D. L. and G. R. Geupel. 2002. Autumn populations of birds in riparian habitats of California's central valley. Western Birds 33: 34-50.

Hunter, W. C., R. D. Ohmart, and B. W. Anderson. 1987. Status of breeding riparian-obligate birds in southwestern systems. Western Birds 18:10-18.

Hutto, R. L. 1998. Using landbirds as indicator species group. Pages 75-91 *in* J. M. Marzluff and R, Sallabanks, editors. Avian conservation: research and management. Island Press, Covelo, California, USA.

Jaramillo, A., S. E. Hudson, and C. M. Strong. 1996. Coyote Creek Field Station Ten-Year Report: 1987 – 1996. San Francisco Bay Bird Observatory, 524 Valley Way, Milpitas CA. 95035. http://www.sfbbo.org/docs/CCFS%20Ten-Year%20Report%201987-1996.pdf

Johnson, R. R. and L. T. Haight. 1985. Avian use of exroriparian ecosystems in the North American warm deserts. Pages 156-160 in R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre, technical coordinators. Riparian ecosystems, and their management: reconciling conflicting uses. United States Department of Agriculture, Forest Service, General Technical Report RM-GTR-120.

Johnson, R. R., L. T. Haight and J. M. Simpson. 1977. Endangered species vs. endangered habitats: a concept. Pages 68-74 in R. R. Johnson and D. A. Jones, technical coordinators. Importance, preservation and management of riparian habitat: a symposium. United States Department of Agriculture, Forest Service, General Technical Report RM-GTR-43.

Kahl, R. B., T.S. Baskett, J. A. Ellis and J.N. Burroughs. 1985. Characteristics of summer habitats of selected nongame birds in Missouri Resource Bulletin 1056, Agriculture Experimental Station, University Missouri-Columbia, Columbia, Missouri.

Katibah, E. H. 1984. A brief history of riparian forests in the Central Valley of California. *In* R.E. Warner and K. M. Hendrix, editors. California Riparian Systems: Ecology, Conservation, and Productive Management. University of California Press Ltd. London, England.

Knope, F. L., R. R. Johnson, T. D. Rich, F. B. Samson, and R. C. Szaro. 1988. Conservation of riparian ecosystems in the United States. Wilson Bulletin 100: 272-284.

Kricher, J. C. 1972. Bird Species diversity: the effects of species richness and equitability on the diversity index. Ecology 53: 278-282.

Krupper, D. J. 1993. Effects of land use practices on western riparian ecosystems. Pages 321-330 in D. M. Finch and P. W. Strangel, editors. Status and management of Neotropical migratory birds. United States Department of Agriculture, Forest Service, General Technical Report RM-229.

Krupper, D. J. 2000. Conservation priorities in naturally fragmented and human-altered riparian habitats of the arid West. Pages 88-90 in R. Bonney, D. N. Pashley, R. J. Cooper, and Niles editors. Strategies for bird conservation: the Partners In Flight planning process; Proceedings of the 3rd Partners in Flight Workshop, 1-5 October 1994, Cape May, New Jersey. United States Department of Agriculture Forest Service, Rocky Mountain Research Station Proceedings RMRS-P-16.

Krupper, D. J., J. L. Bart, and T. D. Rich 2003. Response of breeding birds to the removal of cattle on the San Pedro River, Arizona. Conservation Biology 17: 607-615.

LaPerrier, A. J., and A. O. Haugen. 1972. Some factors influencing calling activity of wild mourning doves. Journal of Wildlife Management 36: 1193-1199.

Lewis, S. J. 1977. Avian communities and habitat components in natural and wastewater irrigated environments. M.S. thesis, Pennsylvania State University, University Park, Pennsylvannia.

Manley, P. and C. Davidson. 1993. A risk analysis of Neotropical migrant birds in California, U.S. Forest Service report, Region 5. San Francisco, CA.

Maurer, B. A., L. B. McArthur and R. C. Whitmore. 1981. Effects of logging on guild structure of a forest bird community in West Virginia. American Birds 35: 11-13.

Marion, W. R. 1974. 1974. Ecology of the plain chachalaca in the lower Rio Grande Valley of Texas. Ph.D. dissertation, Texas A&M University, College Station.

Martin, T. E. 1993. Nest predation among vegetation layers and habitat types: revising the dogmas. American Naturalist 141: 897-913.

Massey, B. W. and M. U. Evans. 1994. An eight-year census of birds of Vallecito Creek, Anza-Borrego Desert, California. Western Birds 25: 178-191.

Merola-Zwartjes, M. and J. P. Delong. 2005. Avian species assemblages on New Mexico golf courses: surrogate riparian habitat for birds? Wildlife Society Bulletin 33: 535-447.

Miller, A. H. 1951. An analysis of the distribution of the birds of California. University of California Publication Zoology 50: 531- 643.

O'Connell, T. J., L. E. Jackson, and R. P. Brooks. 2000. Bird guilds as indicators of ecological condition in the central Appalachians. Ecological Applications 10: 1706-1721.

Ohmart, R. D. 1994. The effects of human-induced changes on the avifauna of western riparian habitats. Studies in Avian Biology 15: 273-285.

Paton, P. W. 1994. The effects of edge on avian nesting success: how strong is the evidence? Conservation Biology 8: 17-26.

Patten, M. A. and J.T. Rotenberry. 1998. Post-disturbance changes in a desert breeding bird community. Journal of Field Ornithology 69: 614-625.

Ralph, C. J. 1998. A Comparison of timing, content, and monitoring methods of landbird migration in the Pacific States. Paper presented at the North American Ornithological conference, April 1998. St Louis, MO.

Ralph, C. J., and J. M. Scott, editors. 1981. Estimating numbers of terrestrial birds. Studies in Avian Biology No. 6.

Ralph, C. J., J. R. Sauer and S. Droege, editors. 1995. Monitoring bird populations by point counts. United States Department of Agriculture, Forest Service, General Technical Report PSW-GTR-149.

Rappole, J. H., and M. V. McDonald. 1994. Cause and effect in population dynamics of migratory birds. Auk 111: 652-660.

Rice, J., B. W. Anderson and R. D. Ohmart. 1984. Comparison of the importance of different habitat attributes to avian community organization. Journal of Wildlife Management 48: 895-911.

Rich, T. D. 1998. Guide for assessing the occurrence of breeding birds in western riparian systems. Draft Report, Fish, Wildlife and Forests Group, Bureau of Land Management. Boise, ID.

Rich, T. D. 2002. Using breeding land birds in the assessment of western riparian systems. Wildlife Society Bulletin 30: 1128-1139.

Riensche, D. L. 1993. Birding Bird Census – Willow Riparian Woodland and Edge. Journal of Field Ornithology 64(Supplement):35-36.

Riensche, D. L. 1994. Birding Bird Census – Willow Riparian Woodland and Edge. Journal of Field Ornithology 65(Supplement):46-47.

Riensche, D. L. 2003. Born to be Wild: California Quail Reintroduction, the Coyote Hills Experience. Quail Unlimited, pp: 16 -18.

Riparian Habitat Joint Venture. 2004. Version 2.0. The riparian bird conservation plan: a strategy for reversing the decline of riparian associated birds in California. California Partners in Flight. PRBO Conservation Science, 4990 Shoreline Hwy., Stinson Beach, CA.

Robinson, S. K. and D. S. Wilcove. 1994. Forest fragmentation in the temperate zone and its effects on migratory songbirds. Bird Conservation International 4: 233-249.

Robinson, S. K. 1997. The case of the missing songbirds. Consequences 3: 2 -15.

Robbins, C. S., J. R. Sauer, R. S. Greenberg and S. Droege. 1989. Population declines in North American birds that migrate to the Neotropics. Proceedings of the National Academy of Science 86: 7658-7662.

Rollfinke, B. F., R. H. Richard and J. S. Wakeley. 1990. Effects of forest irrigation on long-term trends in breeding bird communities. Wilson Bulletin 102: 264 – 278.

Rotenberry, J. T., R. E. Fitzner, and W. H. Richard. 1979. Seasonal variation in avian community structure: differences in mechanisms regulating diversity. Auk 96: 499-505.

Rotenberry, J. T., and J. A. Wiens. 1980. Temporal variation in habitat structure and shrubsteppe bird dynamics. Oecologia 47: 1-9.

Rotenberry, J. T., R. J. Cooper, J. M. Wunderle and K. S. Smith. 1995. When and how are populations limited: the roles of insect outbreaks, fires, and other natural disturbances. Pp. 55 – 84 *in* T. E. Martin and D. M. Finch, editors, Ecology and management of Neotropical migratory birds. Oxford University Press, New York.

Saab, V. A., C. E. Bock, T. D. Rich, and D. S. Dobkin. 1995. Livestock grazing effects in western North America. Pages 311-353 *in* T. E. Martin and D. M. Finch, editors. Ecology and management of Neotropical migratory birds. Oxford University, New York.

Sauer, J. R., and S. Droege. 1992. Geographic patterns in population trends of North American Neotropical migrants. Pp. 26 – 42 *in* J. M. Hagan III, and D. W. Johnston, editors, Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington, DC.

Scout, J. M., E. D. Ables, T. C. Edwards, Jr., R. L. Eng, T. A. Gavin, L. D. Harris, J. B. Haufler, W. M. Healy, F. L. Knopf, O. Torgerson and H. P. Weeks, Jr. 1995. Conservation of biological diversity: perspectives and the future for the wildlife professional. Wildlife Society Bulletin 23: 646-657.

Sedgwick, J. A. and F. L. Knopf. 1987. Breeding bird response to cattle grazing of a cottonwood bottomland. Journal of Wildlife Management 51: 230-237.

Sherry, T. W., and R. T. Homes. 1995. Summer versus winter limitation of populations: what are the issues and what is the evidence? Pp. 85 – 120 *in* T. E. Martin and D. M. Finch, editors. Ecology and management of Neotropical migratory birds. Oxford University, New York.

Small, M. F. and M. L. Hunter. 1988. Forest fragmentation and avian nest predation in forested landscapes. Oecologia 76: 62-64.

Sopper, W. E. and L. T. Kardos. 1973. Vegetation responses to irrigation with treated municipal wastewater, Pp. 271-294 *in* W. E. Sopper and L. T. Kardos, editors. Recycling municipal wastewater and sludge through forest and cropland. Pennsylvania State University Press, University Park, Pennsylvania.

Sorola, S. H. 1984. Investigation of Mearn's quail distribution. Texas Parks and Wildlife Department, Federal Aid Performance Report, Project W-108-R-7. Austin, Texas.

Stauffer, D.F. and L. B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. Journal of Wildlife Management 44: 1-15.

Stewart, R. E. 1953. A life history study of the Yellow-throat. Wilson Bulletin 65: 99-115.

Thomas, J. W., C. Maser, and J. E. Rodiek. 1979. Wildlife habitats in managed rangelands: the Great Basin of southeastern Oregon. United States Department of Agriculture, Forest Service, General Technical Report GTR-PNW-80.

Van Velzen, W. T. 1972. Breeding bird census instructions. American Birds. 26: 1007-1010.

Verner, J., K. L. Purcell and J. G. Turner. 1996. Monitoring trends in bird populations: levels of annual variability in counts. Transactions of the Western Section of the Wildlife Society 32: 1-7

Wilcove, D. S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66: 1211-1214.

Willson, M. F. 1974. Avian community organization and habitat structure. Ecology 55: 1017-1029.

Yahner, R. H. 1983. Seasonal dynamics, habitat relationships, and management of avifauna in farmstead shelterbelts. Journal of Wildlife Management 47: 85 – 104.

Yahner, R. H. 1987. Structure, seasonal dynamics, and management of avifauna in small even-aged forest stands. Wilson Bulletin 99: 218-232.

Zegers, D. A., S. May and L. J. Goodrich. 2000. Identification of nest predators at farm/forest edge and forest interior sites. Journal of Field Ornithology71:207-216.