After the Vision Fire: Monitoring Landbirds in the Riparian Zone

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Abstract

We monitored the riparian bird community for two years following the 1995 Vision Fire in the Point Reyes National Seashore (PRNS), Marin County, California. We compare bird and vegetation data on burned and unburned sites within PRNS and the Golden Gate National Recreation Area. Bird abundance, as indexed by fixed-radius point counts, was higher for several shrub-nesting species at burned sites than at unburned sites. For some tree nesting species, however, abundance was lower at burned sites. A comparison of vegetation data collected at the bird survey points showed that burned riparian had significantly less tree cover and had greater shrub and herb cover than unburned sites. Reproductive success and survival may serve as better indicators of habitat quality and population health than abundance of individuals. Therefore, we located and monitored nests of the Song Sparrow (*Melospiza melodia*) – a species whose abundance was greater in the recently burned riparian habitat – to estimate nest survival at one burned site (Muddy Hollow) and two unburned sites (Lagunitas and Olema Creeks). We then built population growth rate models (λ) to determine the relative "source-sink" status of this species by site, to index local population health. Nest survival was significantly higher on the burned site than the unburned sites, and the λ values suggested that the burned site was a population source while the unburned sites were sinks. The fact that abundance and reproductive success were higher at the burned site is intriguing because it suggests that high Song Sparrow abundance can be used to infer habitat quality in coastal riparian areas, but more rigorous studies are needed. Our results provide evidence that fires in riparian zones may benefit breeding populations of songbirds (given the right conditions and timing) and highlight the utility of monitoring programs to land managers.

Song Sparrow. Peter LaTourrette North American Bird Photo Gallery: http://birdphotography.com/

Introduction

On 3 October 1995, an illegal campfire erupted into a wildfire (Vision Fire) that, over the next 12 days, burned more than 12,000 acres of the Point Reyes National Seashore (PRNS) and surrounding land-holdings. Fueled by atypically dry 50-mph winds, the rate of spread of the fire reached 3,100 acres per hour. The fire was classified as low to moderate intensity and several different habitat types burned. We used standardized landbird monitoring methods to assess whether the Vision Fire had any impact on the riparian-breeding songbird community.

We compared bird and vegetation data on burned and unburned sites to: (1) Assess whether the fire influenced abundance of riparian-breeding landbirds. We predicted that species would respond differently to the fire depending upon their particular life-history characteristics. (2) Characterize habitat changes caused by the fire and qualitatively relate them to bird response. For example, a ground-nesting bird may respond differently than a tree-nesting bird due to changes in vegetation caused by the fire. (3) Estimate site-specific population "health" for the Song Sparrow (*Melospiza melodia*) in burned versus unburned sites. We indexed habitat quality by building source-sink models (Pulliam 1988). A *source* population is one in which the production of young surviving to breeding age exceeds adult mortality. These populations will sustain themselves and/or export excess individuals to other populations. A sink population is one in which young are not produced in sufficient numbers to compensate for adult mortality. Sink populations will either go locally extinct or be maintained by individuals produced elsewhere.

Source and sink populations often form networks or landscapes of populations joined by immigrants and emigrants, and a single source population may effectively maintain many sink populations (Pulliam 1988). Thus, population dynamics cannot be understood at the single population level. Sink populations have the potential to drain source populations that, in turn, could lead to widespread population declines, though sinks are not without value (see Howe et al. 1991).

Methods

Study Sites

We used data from an on-going monitoring

program to investigate songbird response to the Vision Fire. All study sites were located within the Point Reyes National Seashore and the Golden Gate National Recreation Area, coastal Marin County, California. A total of six riparian forests made up our study areas, three burned and four unburned (Table 1). Intensity of the fire at our study sites was classified as "low" with the exception of a portion of Muddy Hollow that was "moderate".

Vegetation at all study sites was similar. Trees were mostly Red Alder (*Alnus rubra*) and willow (*Salix* spp.) with lesser amounts of California bay (*Umbellularia californica*), coast live oak (*Quercus agrifolia*), and California buckeye (*Aesculus californica*). The understory included saplings of the tree species as well as California blackberry (*Rubus ursinus*), rush (*Juncus* spp.), hedge nettle (*Stachys* sp.), stinging nettle (*Urtica californica*), and a wide variety of other herbs and grasses. The area surrounding our study sites is mostly a mosaic of coastal scrub and/or mixed evergreen forest typical of the region (Shuford and Timossi 1989).

Relative Abundance

We estimated relative abundance of birds using the point count method (Ralph et al. 1993, 1995). At each study site we established a series of point count survey stations at least 200 m apart. Point count stations were surveyed three times by trained observers, at least 10 days apart, during the summers of 1997 and 1998. The duration of each count was 5 minutes, and all birds seen or heard were recorded. We used only detections within 50 m of the observer and made the assumption that detection probabilities were similar between treatments. All counts began around local sunrise and continued for no more than four hours to restrict the census to peak singing hours. A total of 38 burned points and 49 unburned points (Olema Creek only used for site-specific comparisions, see below) were used in our analyses (Table 1).

Vegetation

We used a 50 m radius plot, or relevé (Ralph et al. 1993) to sample vegetation in burned and unburned forests in summer, 1997. We visually estimated the percent cover of the plot within each of three vegetation strata; tree, shrub and herb. Herbs consisted of both forbs and grasses. Shrubs and trees were distinguished by structure as opposed to by species. Thus a single species could be present as both shrubs and trees depending on size ($\geq$ 5 m = tree). We noted the percent cover of dominant plant species by strata, determined the maximum and minimum heights for each vegetation layer, and the maximum and minimum diameter at breast height of trees within the 50 m radius relevé. Additionally, we noted the width of the riparian zone, slope, aspect (direction of slope), percent cover of closed canopy, running water, bare ground, litter, and wetland vegetation.

Statistical Analyses of Bird Abundance and Vegetation Data

We (1) compared habitat characteristics between burned and unburned vegetation plots and (2) compared bird abundance between burned and unburned sites for 12 bird species that occurred on at least 10% of the point count stations. We also compared Song Sparrow abundance among the nest monitoring sites; Muddy Hollow, Lagunitas Creek, and Olema Creek in 1997 only. For our abundance index, we used the total detections across 3 visits; each survey point was treated as an independent sampling unit. To account for potential site-specific differences unrelated to fire effects, we used 3-way ANOVA that included site as a covariate in all analyses. Data were transformed when necessary (log or square-root) to meet the assumptions of parametric analyses. For one species (Bewick's Wren), we grouped count data into three categories of abundance after transformations failed to normalize residuals of ungrouped data. Significance was assumed at the $P \leq 0.05$ level. All statistical analyses were carried out using the program STATA (STATA Corp. 1997).

Table 1. Names, locations, and number of point count stations in burned and unburned riparian forests. The Olema Creek site was used only in the site-specific comparisons of Song Sparrow abundance (1997).

Study Site	Latitude (N)	Longitude (W)	Number of Point Counts Stations
Burned			
Muddy Hollow	38°02'	122°48'	17
Coast Trail/Laguna	38°02'	122°52'	13
Coast Camp	38°02'	122°85'	8
Unburned			
Bear Valley	38°03'	122°48'	16
Redwood Creek	37°51'	122°34'	20
Lagunitas Creek	38°02'	122°45'	13
Olema Creek	38°06'	122°80'	13

Source-Sink Model

The source-sink model (λ) employed here determines if a population can maintain itself without immigration or emigration (closed population) by estimating a population growth rate (Pulliam 1988). Components (demographic parameters) of the model are adult survival (probability that an adult will survive from one breeding season to the next), juvenile survival (survival from fledgling age to breeding adult), and reproductive success (probability of a nest surviving from egg laying to fledging x number of nesting attempts x average number of young produced per successful nest). We can write the equation for sources and sinks as:

λ = adult survival + (juvenile survival x reproductive success)

A value of 1 indicates that a population is exactly replacing itself, > 1 indicates that a population is increasing or is a source, < 1 indicates that a population is declining or is a sink.

To obtain data necessary to estimate nest survival we located and monitored nests in 1997 at Muddy Hollow, Lagunitas Creek, and Olema Creek. We attempted to replicate the burned treatment by monitoring nests on Laguna Creek, a drainage that runs parallel to Muddy Hollow, but sample sizes were too low at this site to warrant analysis.

Nest searching and monitoring followed standardized procedures described by Martin and Geupel (1993). We attempted to determine the fate of each nest by checking nest status every 1 - 4 days. A nest attempt was considered successful if it fledged at least one Song Sparrow young as evidenced by the presence of one or more of the following; fledglings outside of the nest, nest condition and timing suggested fledging (e.g., fecal matter on and around nest), adults carrying food in immediate vicinity of nest after expected fledge date, young fledged in response to the nest being checked by field biologists. A nest was considered to have failed if it was damaged and inactive, fledged only a cowbird, eggs were damaged, nestling(s) found dead, and nest contents disappeared during egg laying, incubation, or the early nestling stage before fledging would have been possible. Nests where success or failure may have both been possibilities, but none of the criteria for fledge or fail assessment was met, were considered of uncertain fate.

We calculated nest survival using the Mayfield (1975) method as recommended by Johnson (1979) for computing standard errors. We calculated the nest termination date following Manolis et al. (2000). We computed daily nest mortality by dividing total number of nests that failed by total number of exposure days within each site. The number of exposure days at each site were 220.0 from Muddy Hollow, 259.5 from Lagunitas Creek and 147.5 from Olema Creek. Daily nest survival was thus calculated as 1 - daily mortality, and overall nest survival estimates were calculated as a function of this daily survival rate raised to the length of the average nesting cycle (24 days from Chase 2002). For the other components of reproductive success, number of nestlings per successful

Bewick's Wren. Peter LaTourrette North American Bird Photo Gallery: http://birdphotography.com/

Pacific-slope Flycatcher. Peter LaTourrette, North American Bird Photo Gallery: http://birdphotography.com/

nest and number of nesting attempts, we used averages of 2.51 and 2.2, respectively (PRBO, unpublished data). We compared daily nest survival among study sites using the program CONTRAST (Sauer and Williams 1989).

We used an adult survival estimate of 59.9% for Song Sparrow based on capture-recapture analysis using 14 years of mist-net data from the nearby Palomarin Field Station (Nur et al. 2000). Similarly, we used an estimate of Song Sparrow juvenile survival of 38.4% from the Palomarin Field Station (Chase 2001). Survival estimates are probabilities that birds will survive from one year to the next, whether or not they were recaptured.

Results

Abundance varied for several species between burned and unburned sites (Table 2). There were fewer Pacific-slope Flycatchers and Chestnut-backed Chickadees in burned sites, and more Song Sparrows, Allen's Hummingbirds, Orange-crowned Warblers, and Bewick's Wrens in burned sites (see Table 2 for scientific names of species).

Several habitat characteristics differed between burned and unburned vegetation plots (Table 3). Burned plots had significantly greater shrub and herb cover than unburned plots. Unburned plots, however, had significantly greater tree cover, and the tree and shrub communities contained more species of plants than the burned plots (Table 3).

We located and monitored 22 Song Sparrow nests at Muddy Hollow, 23 at Lagunitas Creek, and 15 at Olema Creek (Table 4). Nest survival was 0.64 at Muddy Hollow, 0.29 at Lagunitas Creek and 0.19 at Olema Creek. We found significant differences in nest survival among all sites ($\lambda^2 = 7.20$, df = 2, P = 0.03). Between-site comparisons revealed that Muddy Hollow had higher nest survival than Lagunitas ($\lambda^2 = 3.85$, df = 1, P = 0.05) and Olema ($\lambda^2 = 4.80$, df = 1, P = 0.03) but Lagunitas and Olema did not differ ($\lambda^2 = 0.45$, df = 1, P = 0.5).

In 1997, Song Sparrow abundance was greater at Muddy Hollow than at Lagunitas Creek (F = 14.54, df = 1, P = 0.006) and Olema Creek (F = 7.87, df = 1, P = 0.009), but there were no differences in abundance between Lagunitas and Olema (P = 0.63).

Estimates of λ using the observed nest survival estimate were 1.28 for Muddy Hollow and remained above 1.0 even when using our lowest and most conservative nest survival estimate (i.e., lower bounds of the 95% CI). Estimates of λ were below 1.0 for Lagunitas Creek (0.91) and Olema Creek (0.80). However, when we used our highest estimates (upper bounds of the 95% CI) both Lagunitas and Olema were > 1.0.

Discussion

Variation in abundance between several species in burned versus unburned sites may be attributable to habitat changes caused by the fire. Song Sparrows, Allen's Hummingbirds, Orange-crowned Warblers, Bewick's Wrens, Wilson's Warblers, and American Goldfinches were more abundant at sites that had burned than at the unburned sites (Table 2). These species have an affinity for areas with moderately dense understory for nesting and foraging (reviewed in Shuford 1993) and burned sites had a richer and more abundant shrub layer than did unburned (Table 3). The Song Sparrow, for example, primarily places its nests low (< 1.5 m) in shrubs and herbs and thus may have benefited from the greater amount of understory created by the fire. The American Goldfinch and the

Table 2. Comparison of bird relative abundance (mean number of detections [within 50 m] per survey station) between burned (n = 38) and unburned (n = 49) riparian sites, 1998. Alpha (P) values (burn effect term) are from three-way ANOVA with transect (study site) included as a covariate. NS = non-significant. Table taken from Gardali et al. (2003).

Species	Burned (± SE)	95% CI	Unburned (± SE)	95% CI	P value
Allen's Hummingbird (*Selasphorus sasin*)	1.37 (± 0.19)	0.99-1.75	0.88 (± 0.15)	0.57-1.19	0.03
Pacific-slope Flycatcher (*Empidonax difficilis*)	0.55 (± 0.12)	0.30-0.80	0.61 (± 0.14)	0.33-0.90	0.06
Warbling Vireo (*Vireo gilvus*)	0.37 (± 0.13)	0.11-0.63	1.18 (± 0.17)	0.84-1.53	NS
Chestnut-backed Chickadee (*Poecile rufescens*)	0.47 (± 0.12)	0.22-0.72	1.51 (± 0.24)	1.03-1.99	0.09
Bewick's Wren (*Thryomanes bewickii*)	0.84 (± 0.19)	0.45-1.24	0.24 (± 0.09)	0.07-0.42	< 0.001
Swainson's Thrush (*Catharus ustulatus*)	1.53 (± 0.21)	1.11-1.94	2.14 (± 0.23)	1.69-2.60	NS
American Robin (*Turdus migratorius*)	0.55 (± 0.12)	0.30-0.80	0.49 (± 0.14)	0.21-0.77	NS
Orange-crowned Warbler (*Vermivora celata*)	1.13 (± 0.23)	0.67-1.59	0.31 (± 0.08)	0.15-0.46	0.03
Wilson's Warbler (*Wilsonia pusilla*)	2.5 (± 0.21)	2.08-2.92	2.08 (± 0.24)	1.60-2.56	NS
Song Sparrow (*Melospiza melodia*)	5.29 (± 0.33)	4.61-5.96	3.53 (± 0.29)	2.95-4.11	0.004
Black-headed Grosbeak (*Pheuticus melanocephalus*)	0.55 (± 0.14)	0.26-0.85	0.86 (± 0.13)	0.59-1.13	NS
American Goldfinch (*Carduelis tristis*)	0.87 (± 0.21)	0.45-1.29	0.24 (± 0.10)	0.05-0.44	NS

Allen's Hummingbird, generally placing their nests in understory vegetation, show greater flexibility in nest height placement but may have benefited from an increased supply of their preferred foods. The American Goldfinch has a diet of mostly seeds and, uncommon for non-carduline songbirds, even feeds its nestlings regurgitated seeds (Middleton 1993). Seeds produced by the abundant and rich herb layer probably provided ample foraging opportunities for the goldfinch. Similarly, the Allen's Hummingbird likely benefited from abundant sources of nectar from several plant species common after the fire (e.g., hedge nettle and bee plant [*Srophulania californica*]). For other species however, whose nesting and foraging requirements are met primarily in trees and tree canopy (reviewed in Shuford 1993), abundance was lower at burned sites (Table 2). Loss of trees most likely resulted in a reduction in numbers for most of these species. Other studies have noted reduced abundance of tree and canopy nesting species following a fire (Raphael et al. 1987, Dieni and Anderson 1999).

Abundance data may not act as a proxy to population health (e.g., source-sink status) and it has been suggested that density may in fact be a misleading indicator of habitat quality (Van Horne 1983, Brawn and Robinson 1996, but see Bock and Jones 2004). Does the presence of more Song Sparrows at burned sites equate to higher quality habitat? If so, some effect of the Vision Fire may have been responsible. We inferred habitat quality by estimating reproductive success and then putting it into the context of population health. The demographic components for the source-sink models differed only in reproductive success; specifically nest survival (Table 4). Reproductive success (even our lowest estimate) at Muddy Hollow was sufficiently high enough to offset adult mortality indicating that this site was a population source for the Song Sparrow. By contrast, only the highest estimates of nest survival at Lagunitas and Olema would characterize those sites as population sources (λ values > 1.0).

Populations of sources and sinks are difficult to identify because estimates for the demographic components are generally lacking and difficult to measure (see below). In our case, however, relatively robust estimates (adult and juvenile survival) were available from the long-term monitoring project at the nearby Palomarin Field Station. The parameters used in the model are assumed to be constant (i.e., remain unchanged over time) which is likely an incorrect assumption from an ecological standpoint, as demographic parameters will vary as the environment fluctuates (Nur and Sydeman 1999). Thus, populations may fluctuate between source and sink status. Despite these limitations, we believe that modeling source-sink status is useful as a comparative measure of population health.

The Vision Fire may have created conditions that increased the probability of nest survival at Muddy Hollow. The fire, for example, may have decreased the number of nest predators. Indeed, preliminary results indicate that small mammal numbers were reduced following the Vision Fire (G. Fellers pers. comm.). Additionally, the density of shrubs and herbs may have provided increased nest concealment from predators thereby resulting in higher success. Others have reported higher nest success in relatively well-concealed Song Sparrow nests (Nice 1937:93-94, Chase 2001). We know of only two studies that examined the effect of fire on the reproductive success of songbirds and both found results opposite ours; reproductive success was reduced in burned areas (Rohrbaugh et al. 1999, Aquilani et al. 2000). These studies, however, were conducted in habitats that may not be comparable; grasslands in Oklahoma and oak-hickory forests in Indiana. With prescribed burning and "let-burn" policies growing in popularity, studies examining the effects of fire

Table 3. Comparison of habitat characteristics between burned (n = 38) and unburned (n = 49) riparian sites, 1997. Alpha (P) values from ANOVA with transect (study site) included as a covariate. NS = non-significant. Table taken from Gardali et al. (2003).

Habitat Variable	Burned	Unburned	P value
Shrub cover (%)	52.6	24.9	< 0.001
Herbaceous cover (%)	42.8	28.6	0.001
Tree cover (%)	30.3	47.3	< 0.001
Tree species richness (#)	1.6	3.4	0.003
Shrub species richness (#)	3.8	4.5	< 0.001
Difference in shrub layer height (m)	3.3	3.5	0.003
Maximum tree dbh (cm)	31.7	49.9	NS
High shrub layer height (m)	3.2	3.7	NS
High tree height (m)	21.0	18.2	NS

on reproductive success of songbirds in various habitats and regions are sorely needed.

We acknowledge that a three-site comparison does not a definitive study make. However, our estimate of nest survival from Muddy Hollow (64%) was far higher than those reported for coastal scrub breeding populations at the nearby Palomarin Field Station (23.2 – 32.5%; Chase 2001) as well as three sites in coastal British Columbia (15-42%; Rogers et al. 1997). The question of whether Song Sparrow density was an indicator of habitat quality cannot be answered from our study. Still, it is interesting to note that Muddy Hollow had significantly more Song Sparrows than the unburned sites and also had significantly higher nest survival. Additionally, in a more formal test of the assumption that higher abundance infers greater habitat quality, Sallabanks and Quinn (2000) suggested that habitat quality could be reliably inferred from high abundance for Song Sparrows in Washington. Additionally, a recent literature review concluded that "birds are ususally more abundant in habitats where reproduction is highest, confirming the legitimacy of using bird counts as indicators of breeding habitat quality and as a basis for management decisions" (Bock and Jones 2004).

Conclusions

The impact of the Vision Fire on riparian-breeding landbirds varies by species as expected; abundance for some species was higher on burned sites, lower for others. These results were in concordance with the habitat associations of the individual species. In general, the fire did not appear to strike a catastrophic blow to the birds breeding in the riparian habitat at Muddy Hollow. In fact, the fire may have created conditions that enhanced reproductive success for Song Sparrow and perhaps other species as well.

Long-term monitoring is essential to understanding the effects of episodic events like fire (O'Conner 1991). It is unfortunate that we had no standardized pre-fire data, as these would have provided a more robust picture of the effects of the Vision Fire on landbirds. Still, our results highlight the utility and importance of monitoring programs to inform land managers.

Acknowledgements

We are indebted to the many field biologists who have counted, banded, and located nests of landbirds over the course of the study including, among others, Grant Ballard, Jim DeStaebler, Katie Fehring, and Diana Humple. This manuscript was improved by comments from Mary Chase and two anonymous reviewers. We are grateful to Sarah Allen of the Point Reyes National Seashore and Daphne Hatch of the Golden Gate National Recreation Area for their foresight in supporting songbird monitoring. Many organizations contributed funds: Golden Gate National Recreation Area, Golden Gate National Parks Association, Point Reyes National Seashore, Point Reyes National Seashore Association, National Park Service Recreational Fee Demonstration Project, David and Lucille Packard Foundation, Marin Community Foundation, San Francisco Foundation, Ms. Doris Leonard Conservation Associates, Mrs. Dorothy Hunt, and the Marin Audubon Society. This is PRBO contribution number 1144.

Literature Cited

Aquilani, S. M., D. C. LeBlanc, and T. E. Morrell. 2000. Effects of prescribed surface fires on ground- and shrub-nesting neotropical migratory birds in a mature Indiana oak forest, USA. Natural Areas Journal 20:317-324.

Bock, C. E., and Z. F. Jones. 2004. Avian habitat evaluation: should counting birds count? Frontiers in Ecology and the Environment 2: 403-410.

Brawn, J. D., and S. K. Robinson. 1996. Source-sink population dynamics may complicate the interpretation of long-term census data. Ecology 77:3-12.

Chase, M. K. 2001. Reproductive success, natal dispersal, and recruitment in a Song Sparrow (*Melospiza melodia*) population breeding in

Table 4. Number of Song Sparrow nests monitored, total days of observation, number of nests that failed, were successful, or of uncertain fate, daily nest survival, and cumulative (total) nest survival by site for the entire nesting period[a] (24 days from Chase 2002), 1997.

Site	n	Observer days	Failed	Successful	Uncertain	Daily survival ± SE	Total survival (95% CI)
Muddy Hollow	22	220.0	4	16	2	0.982 ± 0.009	0.64 (0.42-0.99)
Lagunitas Creek	23	259.5	13	9	1	0.950 ± 0.014	0.29 (0.15-0.56)
Olema Creek	15	147.5	10	4	1	0.932 ± 0.029	0.19 (0.06-0.52)

[a] Total nest survival = $(\text{daily survival})^{24}$

California coastal scrub. PhD. Dissertation, University of California, Riverside.

Chase, M. K. 2002. Nest site selection and nest success in a Song Sparrow population: the significance of spatial variation. Condor 104: 103-116.

Dieni, J. S., and S. H. Anderson. 1999. Effects of recent burning on breeding bird community structure in aspen forests. Journal of Field Ornithology 70:491-503.

Gardali, T., G. R. Geupel, A. L. Holmes, and D. L. Humple. 2003. Songbird response to wildfire in a coastal riparian system. In California Riparian Systems: Processes and Floodplain Management, Ecology, and Restoration (Faber, P.M. ed.). 2001 Riparian Habitat and Floodplains Conference Proceedings, Riparian Habitat Joint Venture, Sacramento, CA.

Howe, R. W., G. J. Davis, and V. Mosca. 1991. The demographic significance of 'sink' populations. Biological Conservation 57:239-255.

Johnson, D. H. 1979. Estimating nest success: the Mayfield method and an alternative. Auk 96: 651-661.

Manolis, J. C., D. E. Anderson, and F. J. Cuthbert. 2000. Uncertain nest fates in songbird studies and variation in Mayfield estimation. Auk 117: 615-626.

Martin, T. E. and G. R. Geupel. 1993. Nest monitoring plots: methods for locating nests and monitoring success. Journal of Field Ornithology 64:507-519.

Mayfield, H. 1975. Suggestions for calculating nest success. Wilson Bulletin 87:456-466.

Middleton, A. L. A. 1993. American Goldfinch (*Carduelis tristis*). In The Birds of North America, No. 80, A. Poole and F. Gill (Editors). Philadelphia: The Academy of Natural Sciences; Washington D.C.: The American Ornithologists Union.

Nice, M. M. 1937. Studies in the life history of the Song Sparrow. Trans. Linn. Soc. NY 4:1-246.

Nur, N., Geupel, G. R., and Ballard, G. 2000. The use of constant-effort mist-netting to monitor demographic processes in passerine birds: annual variation in survival, productivity, and floaters, in Strategies for bird conservation: The partners in flight planning process. Proceedings of 3rd Partners in Flight Workshop, Oct. 1-5 1995, Cape May, NJ. Proceedings RMRS-P-16 (R. Bonney, D. N. Pashley, R. J. Cooper, and L. Niles, eds.), p. 185-194. U.S. Dept. Agri., Forest Serv., Rocky Mountain Research Station, Ogden, UT.

Nur, N., and W. J. Sydeman. 1999. Demographic processes and population dynamic models of seabirds: implications for conservation restoration. Current Ornithology 15:149-188.

O'Conner, R. J. 1991. Long-term population studies in the United States. Ibis 133:36-48.

Pulliam, H. R. 1988. Sources, sinks, and population regulation. American Naturalist 132: 652-661.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Field Methods for Monitoring Landbirds. General Technical Report PSW-GTR 144. USDA Forest Service.

Ralph, C. J., J. R. Sauer, and S. Droege. 1995. Monitoring Bird Populations by Point Counts. General Technical Report PSW-GTR 149. USDA Forest Service. 181 pp.

Raphael, M. G., M. L. Morrison, and M. P. Yoder-Williams. 1987. Breeding bird populations during twenty-five years of post fire succession in the Sierra Nevada. Condor 89:614-626.

Rogers, C. M., M. J. Taitt, J. N. M. Smith, and G. Jongejan. 1997. Nest predation and cowbird parasitism create a demographic sink in wetland-breeding Song Sparrows. Condor 99:622-633.

Rohrbaugh, Jr. R. W., D. L. Reinking, D. H. Wolfe, S. K. Sherrod, and M. A. Jenkins. 1999. Effects of prescribed burning and grazing on nesting and reproductive success of three grassland passerine species in tallgrass prairie. Studies in Avian Biology 19:165-170.

Sallabanks, R., and T.Quinn. 2000. Can we infer habitat quality from the results of wildlife surveys? Final report to Washington State Department of Natural Resources, Olympia, WA.

Sauer, J. R., and B. K. Williams. 1989. Generalized procedures for testing hypotheses about survival or recovery rates. Journal of Wildlife Management 53:137-142.

Shuford, W. D. 1993. The Marin County Breeding Bird Atlas: a Distributional and Natural History of Coastal California Birds. California Avifauna Series 1. Bushtit Books, Bolinas, CA.

Shuford, W. D., and I. C. Timossi. 1989. Plant communities of Marin County. California Native Plant Society. Special Publication 10.

Stata Corp. 1997. STATA, Release 5.0 Stata Corp., College Station, TX.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47: 893-901.