An evaluation of powerline rights-of-way as habitat for early-successional shrubland birds

David I. King and Bruce E. Byers

Abstract Recent population declines among bird species that breed in early-successional shrubland habitats in the eastern United States have been associated with declines in habitat availability. Forest succession has eliminated shrublands in many locations, but powerline rights-of-way constitute a potential reservoir of shrubland habitat for birds. We studied 2 populations of an early-successional shrubland bird, the chestnut-sided warbler (*Dendroica pensylvanica*), in powerline rights-of-way in western Massachusetts over five breeding seasons to evaluate the potential conservation value of these habitats. Our goals were to 1) measure reproductive success and adult survival of birds nesting in powerline rights-of-way, 2) test for edge-related increases in nest predation that might compromise the health of bird populations in powerline rights-of-way, and 3) evaluate whether reproductive success and adult survival rates of birds nesting in powerline rights-of-way were sufficient to maintain these populations. Our results indicated that nesting and fledging success in these populations were high, but nest success was marginally lower ($P=0.09$) near edges in 1 of 2 years for which distances from nests to edge were measured. Also, reproductive success and adult survival were sufficient at both sites to balance losses from mortality, suggesting that powerline rights-of-way can support populations of early-successional shrubland birds.

Key words birds, chestnut-sided warbler, *Dendroica pensylvanica*, nesting, powerline, right-of-way, survival

Conservationists have long been concerned about evidence of population declines in Neotropical migrant birds in the eastern United States (Aldrich and Robbins 1970, Briggs and Criswell 1978). However, most studies have focused primarily on birds that breed in mature forest (Askins et al. 1990). Only recently have researchers become concerned about birds that breed in early-successional shrubland habitats, a group that in the eastern United States is exhibiting more consistent declines than species that breed in mature forest (Askins 1993, Hagan 1993).

The decline of early-successional shrubland birds has been widely attributed to loss of suitable habitat resulting from diminished agricultural and silvicultural activity (Askins 1993, Litvaitis 1993, DeGraaf and Miller 1996). Restoration of shrublands through deliberate, large-scale creation of early-successional habitat is expensive (Askins 1994), so management of shrubland species may best be accomplished by taking advantage of human activities that inadvertently create or maintain early-successional habitat (Thompson and DeGraaf 2001).

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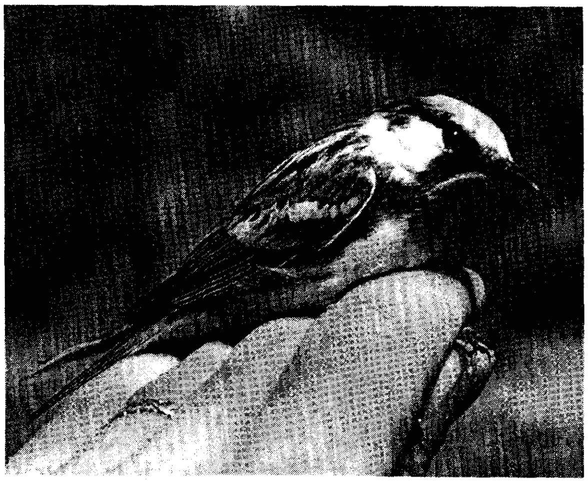
Powerline rights-of-way are potentially important habitats for early-successional shrubland birds because these rights-of-way are constantly maintained in an early stage of succession (Askins 1994). However, to evaluate the importance of these habitats to bird conservation, it is critical to determine whether powerline rights-of-way represent "source" habitats (habitats where reproductive output exceeds losses to the population from mortality) or "sink" habitats (habitats in which reproduction is insufficient to balance losses from mortality and populations are maintained by immigration from source habitats, Pulliam 1988). Powerline rights-of-way are typically narrow (<100 m), so all available nesting habitat is near edges. Thus, these habitats might be sinks if the increased rates of edge-related nest predation reported in other early-successional habitats such as regenerating clearcuts (Rudnicky and Hunter 1993, Vander Haegen and DeGraaf 1996) and grasslands (Johnson and Temple 1990, Winter and Faaborg 1999) are also present within rights-of-way. To address this issue we studied chestnut-sided warblers (*Dendroica pensylvanica*), an early-successional shrub-nesting species. The chestnut-sided warbler, which nests in powerline rights-of-way in western Massachusetts, has been undergoing a significant ($P<0.001$) long-term decline in Massachusetts (-1.3%/yr since 1966, Sauer et al. 1997).

Study area

Our study was conducted in Savoy State Forest, Berkshire County, Massachusetts (42°40´N, 73° 3´W). Elevation was 600–760 m, and the area was extensively (>90%) forested. We studied birds in powerline rights-of-way at two sites 0.5 km apart. We banded birds at "site A" starting in 1986 and collected data on reproductive success during the spring and summer of 1988–1990 and 1999–2000. We banded birds at "site B" from 1987–1989 and collected data on reproductive success during the spring and summer of 1989. The forest in the study area was dominated by red maple (*Acer rubrum*) and eastern hemlock (*Tsuga canadensis*), with an understory consisting primarily of mountain laurel (*Kalmia latifolia*). Vegetation within the powerline rights-of-way consisted primarily of meadowsweet (*Spiraea* spp.), azalea (*Rhododendron* spp.), viburnum (*Viburnum* spp.), and brambles (*Rubus* spp.), along with saplings of tree species from the surrounding forest. Both powerline rights-of-way extended through mature forest approximately 20–25 m tall, and each site comprised all habitat within a segment of the powerline right-of-way. The two segments were 1,032 m (site A) and 1,548 m (site B) long. The width of both segments was approximately 35 m. Both sites were maintained in a state of early-successional shrub habitat during the study by foliar application of glyphosate herbicides in 1989, 1994, and 1999.



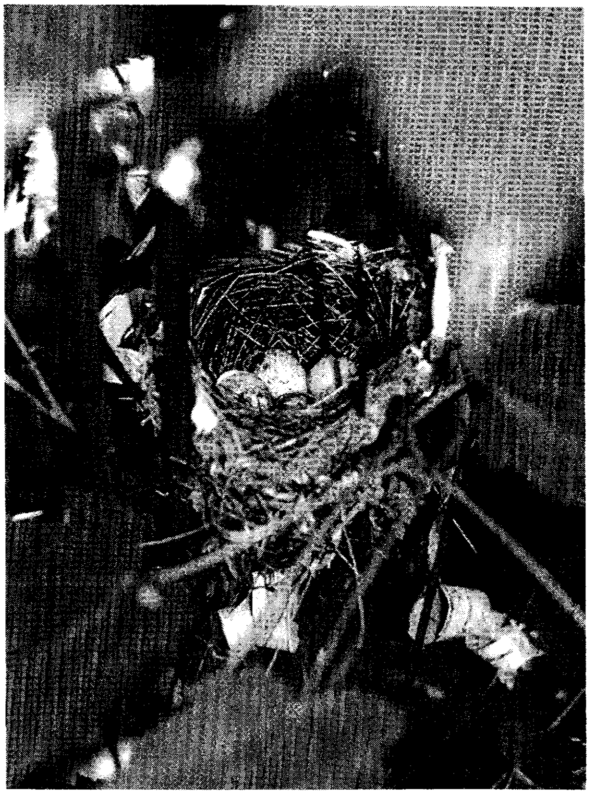
A male chestnut-sided warbler.

Methods

We visited both sites daily from mid-May to late August during each year of the study. We used tape-recorded chestnut-sided warbler songs and mist nets to capture males as they arrived in early May and marked each bird with a unique color-band combination. Capture effort for males was similar among years, and banding activities continued through the season until all males were marked. We captured fewer females than males, but the proportion of males to females in the sample remained constant among years.

We located nests by following adult birds carrying nesting material or food, or by systematic searching. We marked nests with a short piece of red flagging placed 3–5 m away, checked them daily, and recorded their contents. We considered a nest to have been depredated if it was found empty before the predicted fledging date and the adults were not subsequently observed feeding young. We considered a nest to have been abandoned if eggs had been laid in the nest and either the clutch was not completed or there was no further evidence of adult activity at the nest. The number of young present in the nest during the visit prior to fledging was used as the number of young fledged. Intensive monitoring of territories continued throughout the breeding season, and we are confident that few, if any, breeding attempts were overlooked.

To determine whether the rights-of-way at our study sites were source or sink habitats, we calculated the finite rate of increase of each population using the formula $\lambda = P_A + P_J\beta_I$, where P_A was the survival rate of adult chestnut-sided warblers during the nonbreeding season, P_J was the survival rate of juvenile chestnut-sided warblers during the nonbreeding season, and β_I was the number of juvenile females produced/breeding female (Pulliam 1988). For our estimate of β_I, we used the total number of young fledged/female/season (including renests and second broods) divided by 2 (we assumed a 1:1 sex ratio for nestlings, in keeping with sex ratios revealed by laparotomy in field studies of other small passerines [Howe 1977, Morton 1984]). Values of $\lambda<1$ indicated that reproduction in that habitat was insufficient to balance mortality (i.e., it was a sink habitat), values of $\lambda>1$ indicated that reproduction in that habitat was more than sufficient to balance mortality (i.e., it was a source habitat), and $\lambda=1$ indicated that reproduction was equal to mortality. We calculated 95% confidence intervals for λ using the combined standard errors for adult survival and productivity.



A typical chestnut-sided warbler nest.

We used adult survival rates calculated from birds marked and resighted at site A from 1986–1990 and site B from 1987–1989 using a time-independent Jolly-Seber model (we did not model survival or recapture probabilities as a function of year because of small sample sizes) with the computer program JOLLY (Pollock et al. 1990). Only birds that occupied territories on our sites, based on our intensive monitoring efforts, were included in the survival analyses. We did not capture enough females for separate analysis of males and females. Because of the low rate of return of juvenile chestnut-sided warblers to our study sites, we were unable to calculate juvenile survival rates directly, so we used 0.31 (the overwintering survival rate for juvenile Neotropical migrant passerines employed by Donovan et al. [1995] and others).

We compared the proportion of nests failing from all causes, as well as the proportion of nests depredated, among years and between sites using *G*-tests. In addition, we compared nest survival rates (calculated following Mayfield [1975]) among years and between sites using program CONTRAST (Hines and Sauer 1989). Finally, we compared the number of fledglings/nesting attempt and the number of fledglings/pair among years and between sites using one-way analysis of variance (ANOVA) and Tukey-Kramer post hoc comparisons.

For the 1999 and 2000 nests, we divided nests into 4 classes, based on their distance from the forest edge (0–5, >5–10, >10–15, and >15 m from the edge). We then compared the proportion of nests depredated among distance classes using *G*-tests, nest survival among distance classes using program CONTRAST, and number of fledglings/nesting attempt among distance classes using one-way ANOVA and Tukey-Kramer post hoc comparisons. We restricted our analyses of edge effects to losses from predation because predation was the primary cause of nest loss in this and other migrant passerine populations and was known to vary as a function of distance to edges (King et al. 1996, Manolis et al. 2000, Flaspohler et al. 2001).

Results

Reproductive success

Over the entire study period, 82.6% of 86 nests fledged at least 1 young. Of the 15 nests that failed, 10 (66.7%) were caused by predation and 5 (33.3%) by abandonment. Only 2 (2.3%) nests were parasitized by brown-headed cowbirds (*Molothrus ater*)—both at site A and both with a single cowbird egg. One of these nests fledged 2 warblers and 1 cowbird, and the other was depredated. Overall, the daily survival rate of nests was 0.989 (SE = 0.003, n=86), 88% of 77 pairs fledged at least 1 young, and the average number of fledglings/pair including renests and second broods was 2.86 (SE = 0.17, n=77). Only 2 pairs initiated a second nesting attempt after the initial successful attempt.

There was some variation in reproductive success among years (Table 1). The proportion of nests failing from all causes was higher (G_4=8.79, P= 0.09) and the proportion of depredated nests was higher (G_4= 9.37, P=0.05) in 2000 than in other years. Daily survival of nests was lower in 2000 than in other years (χ^2_4=9.94, P=0.04, Table 1), and this difference persisted when only losses to predation were considered (χ^2_4=15.1, P=0.004). The number of fledglings/nesting attempt was lower in 1989 and 2000 than in other years ($F_{4,73}$=3.44, P= 0.01, Tukey-Kramer HSD post-hoc comparisons), but the average number of young fledged/pair did not differ among years ($F_{4,65}$=1.42, P=0.23).

We also detected some differences in reproductive success among sites (Table 1). Fewer nests were depredated at site A than site B in 1989, the only year in which we studied both sites (G_1=2.97, P=0.08), although this was not reflected in a difference in nest survival between sites (χ^2_1=0.11, P= 0.91). Fewer young were fledged/pair at site A than at site B in 1989 ($t_{1,20}$=2.05, P=0.05).

Edge effects

There were no differences among distance classes in the proportion of nests that were depredated (G_3=0.00, P=1.00, Figure 1) in 1999; however, slightly more nests were depredated near edges in 2000 (G_3=6.62, P=0.09). There were no differences in nest survival among distance classes in 1999 (χ^2_3=0.04, P=0.99, Figure 1) or 2000 (χ^2_3= 6.10, P=0.11). The average number of young fledged/nest did not differ among distance classes in either year (1999: $F_{3,10}$=0.76, P=0.54; 2000: $F_{3,22}$ =2.21, P=0.12; Figure 1).

Table 1. Reproductive success of chestnut-sided warblers breeding in powerline rights-of-way in western Massachusetts, 1988–2000.

Year	Percent successful	Daily nest survival ± SE	*n* (nests)	pair±SE	Fledglings/ *n* (pairs)
Site A					
1988	100	1.00 ± 0.000	10	3.50 ± 0.22	10
1989	80.0	0.988 ± 0.008	15	2.50 ± 0.38	14
1990	83.3	0.990 ± 0.007	12	2.67 ± 0.47	12
1999	92.9	0.995 ± 0.005	14	3.23 ± 0.23	13
2000	66.7	0.978 ± 0.007	27	2.33 ± 0.311	21
Site B					
1989	100	1.00 ± 0.000	8	3.38 ± 0.26	8

Rate of population increase

Sixty-nine adult chestnut-sided warblers were banded at site A between 1986 and 1990, and 28

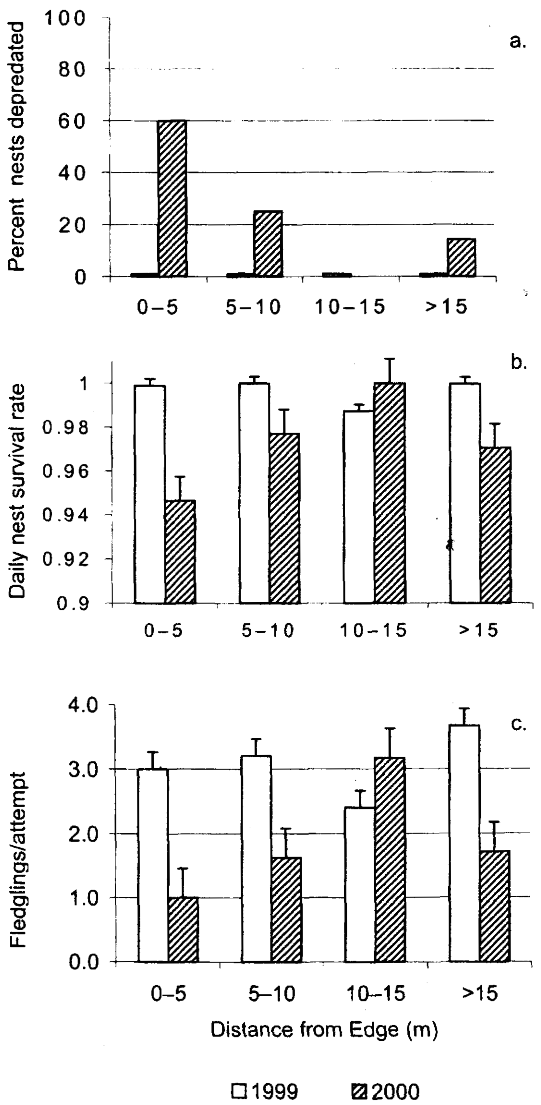


Figure 1. Reproductive success [a) percent nests depredated, b) daily nest survival rate, c) fledglings per attempt] of chestnut-sided warblers breeding in a powerline right-of-way in western Massachusetts in relation to the forest edge, 1999–2000.

adult chestnut-sided warblers were banded at site B between 1987 and 1989. Adult survival was 0.814 (SE=0.029) at site A and 0.648 (SE=0.364) at site B. The estimate of recapture (resighting) probability for both sites was 1.00. Using these values for adult survival (P_A), and our estimates for productivity (β_I) at site A (2.76±0.17 SE) and site B (3.38±0.26 SE) and juvenile survival (P_J) from the literature, we calculated $\lambda=1.26$ for site A (95% confidence interval=1.02-1.50) and $\lambda=1.23$ for site B (95% confidence interval=0.52-1.94).

Discussion

Our results indicated that chestnut-sided warblers at our sites produced more than enough young to balance losses from mortality; therefore, these powerline rights-of-way were source habitats. Furthermore, the average daily nest survival rates we observed in these narrow habitat patches were similar to those recorded for chestnut-sided warblers in extensive (6-19 ha) patches of regenerating forest in remote areas of New Hampshire (0.981-1.00, King et al. 2001). Our findings are important for two reasons. First, although it is known that many shrubland bird species use powerline rights-of-way (Anderson et al. 1977; Kroodsma 1982, 1984; Bramble et al. 1992; Meehan and Haas 1997), this study is the first to indicate that powerline rights-of-way are source habitats. This was contrary to our expectation, based on studies of edge-related nest predation in similar habitats, that edge-related nest predation might compromise the viability of bird populations nesting in these narrow habitat patches. Second, the activities that historically have fostered and maintained early-successional habitat are in decline, but the extent of habitat created by powerline rights-of-way is likely to persist and probably increase with increasing human populations.

Although we presented data on only one species, Dececco et al. (2000) found that predation rates were similar among years and sites for four species of Neotropical migrants in the middle Appalachians. Furthermore, Manolis et al. (2000) and Flaspohler et al. (2001) reported that patterns of nest predation rates relative to clearcut borders were similar for several species of ground-nesting migrant passerines. Thus, our results likely apply to other early-successional species with similar life-history attributes (Dececco et al. 2000).

Our assessment of the viability of these populations was dependent on the survival rates we used. For example, we included both males and females in our survival analyses, and because male survival is generally higher than that of females (Breitwisch 1989), this might have inflated our survival estimates. Populations at our study areas, however, would be stable ($\lambda=1$) even if we used values for adult survival as low as 0.58 and 0.48 for sites A and B, respectively, which indicated that our conclusions were robust to substantial overestimates of female survival rates. Similarly, populations at our sites would be stable ($\lambda=1$) even if we used values for juvenile survival as low as 0.13 and 0.21 for sites A and B, respectively, substantially lower than other published estimates for juvenile Neotropical migrant passerines of 0.31 and 0.42 (Anders et al. 1997 and Donovan et al. 1995, respectively).

We did not observe any differences in fledging success between years in which herbicides were applied and other years, suggesting that the application of glyphosate herbicides did not have any direct effects on bird productivity at our sites. This was consistent with research indicating that the acute toxicity of these chemicals on birds is low (Kidd and James 1991). The release of low herbaceous vegetation in the year following herbicide application, however, might have allowed predators in adjacent forests to extend their foraging activities into the corridor (Schreiber et al. 1976), which could be associated with the increased rates of nest predation we observed near edges in 2000 (Chasko and Gates 1982).

Other studies have reported increases in nest predation near edges in shrublands in regenerating clearcuts (Rudnicky and Hunter 1993, Vander Haegen and DeGraaf 1996). Although our comparison of nest predation rates among distance classes was not significant at the conventionally used *P*-value of 0.05, the marginally significant increase in nest predation near edges we observed in 2000 was consistent with the results of these other studies. Our observation that overall productivity was lowest in the year in which we observed slightly higher predation near edges (2000) suggested that increased rates of nest predation near edges could potentially affect the viability of bird populations in powerline rights-of-way in cases where rights-of-way are not wide enough to provide sufficient interior habitat. In fact, if we calculate the finite rate of increase using only fledging data for 2000, site A would become a sink habitat ($\lambda=0.92$). In contrast to our results, Chasko and Gates (1982) observed lower predation rates near edges than in interior areas of powerline rights-of-way in Maryland. Further studies of avian survival and reproductive success in powerline rights-of-way in different regions, of different widths, and perhaps using additional focal species, would help determine the generality of our conclusions and would help further define the role of these habitats in the conservation of early-successional shrubland birds.

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Literature cited

ALDRICH, J. W., AND C. S. ROBBINS. 1970. Changing abundance of migratory birds in North America. Smithsonian Contributions to Zoology 26:17-26.

ANDERS, A. D., D. C. DEARBORN, J. FAABORG, AND F. R. THOMPSON, III. 1997. Juvenile survival in a population of Neotropical migrant birds. Conservation Biology 11:698-707.

ANDERSON, S. H., K. MANN, AND H. H. SHUGART. 1977. The effect of transmission-line corridors on bird populations. American Midland Naturalist 79:216-221.

ASKINS, R. A. 1993. Population trends in grassland, shrubland, and forest birds in eastern North America. Current Ornithology 11:1-34.

ASKINS, R. A. 1994. Open corridors in a heavily forest landscape: Impact on shrubland and forest-interior birds. Wildlife Society Bulletin 22:339-347.

ASKINS, R. A., J. F. LYNCH, AND R. GREENBERG. 1990. Population declines in migratory birds in eastern North America. Current Ornithology 7:1-57.

BRAMBLE, W. C., R. H. YAHNER, AND W. R. BYRNES. 1992. Breeding-bird population changes following right-of-way maintenance treatments. Journal of Arboriculture 18:23-32.

BREITWISCH, R. 1989. Mortality patterns, sex ratios, and parental investment in monogamous birds. Current Ornithology 6: 1-50.

BRIGGS, S. A., AND J. H. CRISWELL. 1978. Gradual silencing of spring in Washington: selective reduction of species of birds found in three woodland areas over the past 30 years. Atlantic Naturalist 32:19-26.

CHASKO, C. G., AND J. E. GATES. 1982. Avian habitat suitability along a transmission line corridor in an oak-hickory forest region. Wildlife Monographs 82.

DECECCO, J. A., M. R. MARSHALL, A. B. WILLIAMS, G. A. GALE, AND R. J. COOPER. 2000. Comparative seasonal fecundity of four Neotropical migrants in middle Appalachia. Condor 102: 653-663.

DEGRAAF, R. M, AND R. I. MILLER. 1996. The importance of disturbance and land-use history in New England: implications for forested landscapes and wildlife conservation. Pages 3-35 *in* R. M. DeGraaf and R. I. Miller, editors. Conservation of faunal diversity in forested landscapes. Chapman and Hall, New York, New York, USA.

DONOVAN, T. M., F. R. THOMPSON, III, J. FAABORG, AND J. R. PROBST. 1995. Reproductive success of migratory birds in habitat sources and sinks. Conservation Biology 9:1380-1395.

FLASPOHLER, D. J., S. A. TEMPLE, AND R. N. ROSENFIELD. 2001. Species-specific edge effects on nest success and breeding bird density in a forested landscape. Ecological Applications 11:32-46.

HAGAN, J. M. 1993. Decline of the rufous-sided towhee in the eastern United States. Auk 110:863-874.

HINES, J. E., AND J. R. SAUER. 1989. Program CONTRAST: a general program for the analysis of several survival or recovery rate estimates. United States Fish and Wildlife Service Technical Report 24:1-7.

HOWE, H. F. 1977. Nestling sex ratio adjustment among common grackles. Science 198:744-746.

JOHNSON, R. G., AND S. A. TEMPLE. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management 54:106-111.

KIDD, H., AND D. R. JAMES. 1991. The agrochemicals handbook. Third edition. Royal Society of Chemistry Information Services, Cambridge, United Kingdom.

KING, D. I., R. M. DEGRAAF, AND C. R. GRIFFIN. 2001. Productivity of early successional birds in clearcuts and groupcuts in an eastern deciduous forest. Journal of Wildlife Management 65: 345-350.

KING, D. I., C. R. GRIFFIN, AND R. M. DEGRAAF. 1996. Effect of clearcutting on habitat use and reproductive success of the Ovenbird in forested landscapes. Conservation Biology 10: 1380-1386.

KROODSMA, R. L. 1982. Bird community ecology on power-line corridors in east Tennessee. Biological Conservation 23: 79-94.

KROODSMA, R. L. 1984. Ecological factors associated with degree of edge effect in breeding birds. Journal of Wildlife Management 48:418-425.

LITVAITIS, J. A. 1993. Response of early successional vertebrates to historic changes in land use. Conservation Biology 7: 866-873.

MANOLIS, J. C., D. E. ANDERSON, AND F. J. CUTHBERT. 2000. Patterns of edge and fragmentation studies in northern hardwood-conifer landscapes: retrospective power analysis and Minnesota results. Wildlife Society Bulletin 28:1088-1101.

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

MEEHAN, A. L., AND C. A. HAAS. 1997. Use of a powerline corridor by breeding and wintering birds in Giles county, Virginia. Virginia Journal of Science 48:259-264.

MORTON, M. L. 1984. Sex and age ratios in wintering White-crowned Sparrows. Condor 86:85-87.

POLLOCK, K. H., J. D. NICHOLS, C. BROWNIE, AND J. E. HINES. 1990. Statistical inference for capture-recapture experiments. Wildlife Monographs 107.

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

RUDNICKY, T. C., AND M. L. HUNTER JR. 1993. Avian nest predation in clearcuts, forests, and edges in a forest-dominated landscape. Journal of Wildlife Management 57:358-364.

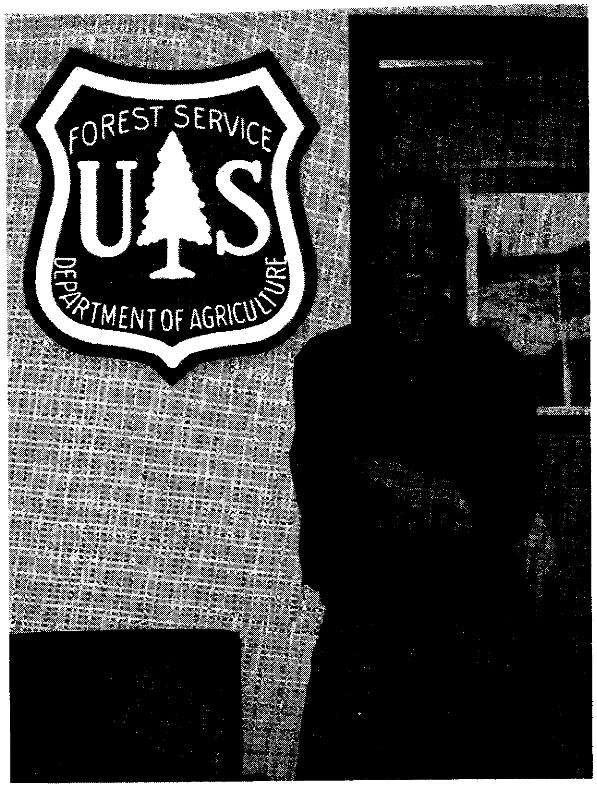
SAUER, J. R., J. E. HINES, G. GOUGH, I. THOMAS, AND B. G. PETERJOHN. 1997. The North American Breeding Bird Survey results and analysis. Version 96.4. Patuxent Wildlife Research Center, Laurel, Maryland, USA.

SCHREIBER, R. K., W. C. JOHNSON, J. D. STORY, C. WENZEL, AND J. T. KITCHINGS. 1976. Effects of powerline rights-of-way on small nongame mammal community structure. Pages 264-273 *in* R. Tillman, editor, Proceedings of the First National Symposium on Environmental Concerns in Rights-of-Way Management, 6-8 January, 1976. Mississippi State University, Starkville, USA.

THOMSPON, F. R., III, AND R. M. DEGRAAF. 2001. Conservation approaches for woody, early successional communities in the eastern United States. Wildlife Society Bulletin 29: 483-494.

VANDER HAEGEN, W. M., AND R. M. DEGRAAF. 1996. Predation rates in an industrial forest landscape. Forest Ecology and Management 86: 171-179.

WINTER, M., AND J. FAABORG. 1999. Patterns of area sensitivity in grassland nesting birds. Conservation Biology 13: 1424-1436.



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