J. Field Ornithol. 77(1):21–28, 2006

Effects of a fire on a breeding population of Loggerhead Shrikes in sagebrush steppe habitat

D. L. Humple[1,3] and A. L. Holmes[1,2]

[1] *PRBO Conservation Science, 4990 Shoreline Highway, Stinson Beach, California 94970, USA*
[2] *Oak Creek Lab of Biology, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon 97731, USA*

Received 7 January 2005; accepted 18 May 2005

ABSTRACT. We studied the breeding biology of Loggerhead Shrikes (*Lanius ludovicianus*) in northeastern Oregon from 1995 to 1997 and 2000 to 2001. A wildfire in 1998 burned approximately half the big sagebrush (*Artemisia tridentata*) at this site, permitting comparison of population parameters before and after this event. Shrike density after the fire was half that before the fire, a reduction likely due to loss of suitable nesting habitat. Mayfield estimates of nest survivorship were 39% (range: 30–46%) in the years before and 19% (range: 12–26%) after the fire, among the lowest ever recorded for this species. In 2000, young fledged from only 21% of the territories. Due to persistent renesting, young fledged from 67% of the territories in 2001, a percentage similar to that before the fire. After the fire, shrikes nested more frequently in substrates other than big sagebrush, especially juniper trees (*Juniperus occidentalis*). Clutch size, fledglings per successful nest, and fledgling survival were similar in both periods of the study. Poor nesting success across all years suggests that productivity may play a role in regional declines of shrike populations, and that the loss and fragmentation of nesting habitat due to fire may further reduce productivity. Given the threats facing remaining sagebrush habitat, as well as Loggerhead Shrike population declines, we recommend aggressive fire control measures and further protection for remaining tall sagebrush communities.

SINOPSIS. **Efecto de un fuego en una población de *Lanius ludovicianus*, en un hábitat de artemisa**

Estudiamos la biología reproductiva de *Lanius ludovicianus* en la parte noreste de Oregón de 1995–1997 y de 2000–2001. Un fuego ocurrido en el 1998, destruyó casi la mitad del hábitat formado por artemisa (*Artemisa tridentata*), lo que permitió la comparación de parámetros poblacionales previo y posterior al fuego. La densidad de aves se redujo a la mitad, de la documentada durante el primer periodo de estudio, atribuido a la pérdida de hábitat y de sustrato adecuado. El estimado de Mayfield de supervivencia de nidos antes del fuego fue de 39% (fluctuando de 30 a 46%) y de 19% (fluctuando de 12 a 26%) luego del evento; entre los más bajos informados para la especie. En el 2000, tan solo 21% de los territorios produjeron juveniles, sin embargo debido a la persistencia de reanidamiento, el 67% de los territorios fueron exitosos, lo que resultó en un porcentaje similar al encontrado previo al fuego. Luego del fuego las aves anidaron con más frecuencia en sustratos diferentes a la artemisa, particularmente en árboles de *Juniperus occidentalis*. El tamaño de la camada, volantones por nido exitoso y la supervivencia de volantones fue similar en ambos periodos del estudio. El pobre éxito de anidamiento durante todo el periodo de estudio sugiere que la productividad pudiera tener un rol importante en la reducción regional en las poblaciones del ave y que la pérdida y fragmentación de hábitat de anidamiento por fuegos muy bien pudiera reducir aun más la productividad del pájaro. Dada la aparente importancia de grandes parches de artemisa para *Lanius*, recomendamos medidas agresivas de control de fuegos y la protección de comunidades restantes de artemisa.

Key words: Common Raven, fire fledgling survival, Loggerhead Shrike, nest success, predation, sagebrush

Fire regimes in sagebrush steppe ecosystems of the West have been severely altered, resulting in dramatic shifts in plant communities. In particular, the invasion of introduced annual grasses, especially cheatgrass (*Bromus tectorum*), has changed understory fuel conditions, resulting in larger and more frequent fires and conversion to annual grassland (Whisenant 1990, Pellant and Hall 1994, Pyke 2000, West 2000). Much of the sagebrush steppe habitat that remains is degraded and fragmented (Sands et al. 2000, West 2000). At sites where cheatgrass has been established and has altered fire cycles, the result is often a near-complete loss of sagebrush (Young 1994, Brooks and Pyke 2001). This loss may be permanent due to the ability of cheatgrass to preclude re-establishment of sagebrush through competition and by fostering more frequent fires (Whisenant 1990, West 2000). As a result, shrubland bird communities face major threats from widespread habitat conversion

[3] Corresponding author. Email: dhumple@prbo.org

(Rotenberry 1998, Knick et al. 2003). Further habitat conversion is of special concern in the Columbia Plateau where much of the area has already been converted to cropland (Quigley and Arbelbide 1997, Wisdom et al. 2000), with sagebrush steppe having incurred the greatest loss of any habitat type (Daubenmire 1970, Saab and Rich 1997). The remaining habitat is generally fragmented or degraded by livestock grazing and invasive weeds.

Loggerhead Shrikes (*Lanius ludovicianus*) are classified as a sensitive species in the state of Oregon (ODFW 1997), and have shown significant population declines in the western United States and Canada (Sauer et al. 2004). On our study site, they nested almost exclusively in areas with stands of big sagebrush (*Artemisia tridentata*). This breeding population was studied for three years (1995–1997), with a focus on their local distribution and productivity. A wildfire ignited by lightning in August 1998 burned approximately half the sagebrush habitat, including a substantial portion of the area occupied by shrikes from 1995 through 1997. We returned in 2000 and 2001 to document changes in shrike distribution and nesting success resulting from the fire.

STUDY AREA

The Naval Weapons Systems Training Facility Boardman (NWSTF) is a 19,020 ha bombing range located near the town of Boardman, Morrow County, Oregon, near the Washington border (45°50′N, 119°42′W). The area is characterized by hot, dry summers and cold, wetter winters. The average annual precipitation for Boardman is 22 cm and elevation on the NWSTF ranges from 122 to 274 m (McClelland and Bedell 1987). The facility encompasses one of the few remaining areas of sagebrush steppe within this ecoregion of Oregon. The NWSTF has been historically used for grazing livestock, and during our study portions of the study area were grazed by both cattle and sheep.

We restricted our investigation to the shrike's primary breeding habitat in the southern portion of the facility, an area of about 2550 ha dominated by basin big sagebrush (*A. t. tridentata*) or a mix of basin and Wyoming (*A. t. wyomingensis*) big sagebrush. Dominant grasses varied from cheatgrass to mixed stands of cheatgrass, Sandberg bluegrass (*Poa secunda*), and lesser amounts of bottlebrush squirreltail (*Elymus elymoides*). In some areas, relic stands of native perennial bunchgrasses were present, including bluebunch wheatgrass (*Pseudoroegnaria spicata*) and needle-and-thread grass (*Hesperostipa comata*). The 1998 fire burned about 1700 ha of sagebrush habitat (with some small patches left intact within the burned area), plus 8000 ha of adjacent grassland and rabbitbrush (*Chrysothamnus* spp.) shrublands.

METHODS

In 1995–1997 and 2000–2001, we censused approximately 2550 ha for shrikes, covering nearly all suitable breeding habitat in the southern portion of the facility. Up to 200 ha were censused in a morning, during the first 5–6 h after sunrise. Censuses consisted of one to two observers walking slowly, stopping frequently to scan for shrikes, and then doubling back along a parallel line located 150–250 m from the original line, with distance dependent upon shrub density and terrain. The entire area was censused twice each year between mid-April and late May.

Once shrike territories were identified, observers located and monitored nests using behavioral cues and systematic searches as described by Martin and Geupel (1993). Nest searching began in late March or early April and continued through mid- to late-July. Nests were checked every 2–4 d until the outcome was determined, with increased frequency of visits around predicted hatching and fledging dates. After nest failure or early to mid-season fledging, territories were monitored for additional nesting attempts. In 1997, 2000, and 2001, we monitored post-fledging survival to approximately two weeks. Broods were located and observed for a minimum of 30 min and, if all fledglings were not located, we approached areas where adults delivered food to flush potentially hidden young. If the entire brood was not located, we repeated the process either later that day or the next day. Due to logistical constraints, brood counts occurred at 13–16 d post-fledging, instead of always on day 14.

Shrub cover was measured at 84 sampling stations distributed systematically within eight randomly selected study plots in the sagebrush habitat of our study area. Six plots were 36 ha in size, consisted of nine sampling stations each, and were in areas dominated by basin big sagebrush; two plots were 72 ha in size, consisted of 15 sampling station each, and were in Wyoming big sagebrush. Shrub cover was measured using 200 m of line intercept (Canfield 1941) at each sampling station. Each site was sampled once prior to the fire in either 1996 or 1997, and once after the fire in 2000. We provide that data to help quantify sagebrush loss on the NWSTF. We also digitized a fire perimeter map and compared it to a pre-fire vegetation map to estimate how much overall sagebrush habitat was lost.

STATISTICAL ANALYSIS

We generated multiple indices of productivity: (1) Mayfield estimates of daily and total nest survivorship (Mayfield 1961, 1975), annually and for cumulative pre- and post-fire periods, (2) the annual proportion of territories on which young were successfully produced, (3) the average number of fledglings produced per territory annually, and (4) the average number of fledglings produced per successful nest, annually and for cumulative pre- and post-fire periods.

Mayfield estimates consider the number of days each nest was under observation, eliminating potential underestimation of losses, and allowing for the inclusion of nests that have undetermined fate. We defined the entire nesting period as beginning on the day the first egg was laid and ending on the day of nest failure or departure of the first nestling. We used period lengths that were based on our data from this site: 5.5 d for laying, 16.5 d for incubation, and 16.5 d for the nestling period. These differ slightly from the durations provided by Yosef (1996), with 4.5 d for laying, 16 for incubation, and 16–20 for the nestling period. We used the program CONTRAST (Hines and Sauer 1989) to compare daily nest survival rates among years, and between the years preceding the fire and those following it.

We estimated the proportion of territories that produced young in every year except 1995, when monitoring of individual pairs was less intensive, and for only 14 of 17 territories in 2000 because our field season ended while three pairs still had active nests and the outcomes were not determined. Territories known to have fledged young, even if we had not located the nest, were included. We estimated the average number of fledglings produced per territory for 3 yr (excluding 1995 and 2000 for the reasons stated above) using the number of nestlings observed on the last check prior to fledging. We used the young fledged per territory rather than the young fledged per female because female Loggerhead Shrikes may desert mates between nesting attempts (Haas and Sloane 1989). Because shrikes were not individually marked, we could not determine if the same female occupied a territory throughout the breeding season. We also estimated the number of young fledged per successful nest, including only nests for which we had high confidence in the number of young fledged.

We used a χ^2 likelihood ratio test to compare fledgling survival to two weeks out of the nest between 1997 and 2001. We were unable to make comparisons with survival in 2000 because young fledged from only two nests that year. We tested for differences in the number of nesting attempts per territory (excluding 1995) and clutch size per nest among years and between treatments using two-way ANOVA. We used a χ^2 likelihood ratio test to examine differences in use of sagebrush as a nesting substrate before and after the fire. We tested for a difference in sagebrush cover before and after the fire at the 84 sampling points using a paired *t*-test.

RESULTS

The number of Loggerhead Shrike pairs breeding within the study area ranged from 35 to 38 before the fire and 17 to 21 after (Table 1). Daily nest survival did not differ significantly among years from 1995 to 1997 ($x^2{}_2 = 1.82$, $P = 0.40$), or between 2000 and 2001 ($x^2{}_1 = 2.5$, $P = 0.11$). Overall, daily nest survivorship was lower in the post-fire years ($x^2{}_1 = 7.96$, $P = 0.005$), and the corresponding total nest survivorship dropped from 39.1 before the fire to 19.0 (Table 1). The proportion of territories producing young was lower in 2000, but was similar to the years preceding the fire in 2001 (Table 1). The number of fledglings produced per territory was similar for all 3 yr, ranging from 2.97 to 3.35, and the average number of fledglings per successful nest ranged from 4.69 to 5.63 (Table 1). Observed fledgling survival to two weeks post-fledging was 60% in 1997 and 54% in 2001 (Table 1), and these rates did not differ significantly between the two years (likelihood ratio $x^2{}_1 = 0.55$, $P = 0.46$).

Table 1. Reproductive and demographic parameters of Loggerhead Shrikes on the Naval Weapons Systems Training Facility (NWSTF) in Boardman, Oregon, before and after the 1998 fire.

	Pre-fire					Post-fire			
	1995	1996	1997	Mean 1995–1997	Totals 1995–1997	2000	2001	Mean 2000–2001	Totals 2000–2001
No. of territories	35	36	38	36.3	n/a	17	21	19	n/a
No. of territories producing young	n/a[1]	23	25	n/a	n/a	3[2]	14	n/a	n/a
Proportion of territories producing young	n/a[1]	0.63	0.66	0.65	n/a	0.21[2]	0.67	0.44[2]	n/a
Mean number of fledglings per territory	n/a[1]	3.24	2.97	3.11	n/a	n/a[2]	3.35	–	n/a
Mean number of fledglings per successful nest	4.69 ($N = 13$)	4.78 ($N = 23$)	5.63 ($N = 27$)	5.13 ($N = 63$)	n/a	5.50 ($N = 2$)[2]	5.15 ($N = 13$)	5.20 ($N = 15$)	n/a
Mayfield Analysis									
No. of nests	39	47	61	n/a	147	34	38	n/a	73
Observation days	687	1116.5	1362	n/a	3165	510	754.5	n/a	1264.5
Total nest survival	29.7	45.6	39.7	n/a	39.1	11.9	26.1	n/a	19.0
Daily nest survival (SE)	0.969 (0.007)	0.980 (0.004)	0.976 (0.004)	n/a	0.976 (0.003)	0.946 (0.010)	0.965 (0.007)	n/a	0.958 (0.006)
Fledgling Survival[3]									
No. of young fledged	–	–	139	–	–	11	61	n/a	n/a
No. of fledglings alive at 2 weeks	–	–	83	–	–	10	33	n/a	n/a
Proportion surviving at 2 weeks	–	–	0.60	–	–	0.91	0.54	n/a	n/a

[1] Pairs were not monitored as closely this year as in subsequent years.

[2] Three late-season nests in 2000 that remained active at cessation of monitoring are excluded due to unknown outcomes. If all three produced young, the proportion of territories producing young in 2000 would be 35%.

[3] These data were only collected in 1997, 2000, and 2001. Because of a low sample size in 2000 (only two nests fledged), we did not combine these data with the survival rate from the other post-fire year.

Clutch size ranged from 4 (four of 169 nests) to 8 (three of 169 nests) eggs, with one outlier that had a single egg. Mean clutch size was 6.16 eggs both before (N = 109 nests) and after (N = 57) the fire. There was no significant effect of treatment ($F_{1,161}$ = 0.22, P = 0.64) or year ($F_{3,161}$ = 0.27, P = 0.85) on clutch size ($F_{4,161}$ = 0.20, P = 0.94). The mean number of nests built per territory increased from 1.5 before the fire to 2.2 after due to higher failure rates and more renesting attempts. The main effect of treatment was marginally significant ($F_{1,104}$ = 3.72, P = 0.056), while year was not ($F_{2,104}$ = 2.17, P = 0.12).

In 1996 and 1997, 34% of the nests were renesting attempts, including second (19% of total) and third (1%) attempts at raising a first brood, and first (13%) and second (2%) attempts at raising a second brood. After the fire, 54% of the nests were renesting attempts, including second (31%), third (12%), fourth (4%), and fifth (1%) attempts at a first brood, and first (3%) and second (3%) attempts at raising a second brood. Double brooding was attempted on 29% of territories before the fire and 20% afterward (27% across all years). Five (36%) of the double brooding attempts were successful before the fire, and none after the fire.

We monitored 155 nests before the fire, with 144 (92.9%) in big sagebrush, four (2.6%) in western juniper (*Juniperus occidentalis*), three (1.9%) in dead Russian thistle (*Sasola kali*), three (1.9%) in the ornamental matrimony vine (*Lycium chinense*), and one (0.6%) in accumulated dead tumble mustard (*Sysymbrium altissimum*). After the fire, significantly fewer nests were in sagebrush (likelihood ratio $x^2{}_1$ = 10.69, P = 0.001), with 58 of 75 nests (77.3%) in sagebrush, 10 (13.3%) in western juniper, five (6.7%) in matrimony vine, one (1.3%) in dead Russian thistle, and one (1.3%) in greasewood (*Sarcobatus vermiculatus*). Eighty-six percent of nests placed in juniper trees during all years of the study were renesting attempts. Two nests were in dead sagebrush killed by the fire. At least three nests had inactive Black-billed Magpie (*Pica hudsonia*) nests as a part of their structure, with shrikes building their nest in, beneath, or on top of the old dome nest.

The map of the fire perimeter revealed that approximately half the area that had contained sagebrush was burned. At the 84 points where shrub cover was quantified, mean sagebrush cover decreased from 19.2% to 4.2% (t = 12.37, P < 0.0001). Sagebrush occurred at 94% of the sampling points prior to the fire and 57% afterward, and the number of sites with less than 5% sagebrush canopy cover increased from 20% of the sampling points to 77%.

DISCUSSION

Surveys on the NWSTF in 2000–2001 showed that the number of Loggerhead Shrike pairs breeding at our site was about half of that before the fire. Despite our lack of an unburned control site, we attribute this decline in population size to the loss of nesting habitat resulting from the fire. Many areas that had shrike territories before the fire no longer contained live sagebrush after the fire. In other burned areas, small patches of sagebrush remained. Few areas of continuous sagebrush greater than 100 ha remained after the fire, and in many of the areas with fragmented shrub cover where shrikes persisted, they placed nests in the remaining small patches of live shrubs, foraged in the burned open areas, and perched on burnt snags. Overall, changes in the distribution of nesting territories corresponded with spatial changes in sagebrush cover.

Loggerhead Shrike nest survivorship was also lower following the fire (19% vs. 39%). Although unable to attribute this change directly to the fire, we suspect that the reduction in sagebrush cover and reduced patch size increased the ability of predators, specifically corvids, to find shrike nests. Common Ravens (*Corvus corax*) were a confirmed predator of shrike nests at our site based on multiple failed nests that were torn up and bearing evidence in the form of a raven feather, or feathers, in or beneath the nest shrub. Vander Haegen et al. (2002) examined fragmentation in an agricultural landscape and found that artificial nests in fragmented sagebrush steppe were about nine times more likely to be depredated than those in continuous habitat, and that differences were largely due to predation by corvids. We suspect that the variation in nesting success between the two post-fire years in our study may be related to differences in the numbers of Common Ravens foraging in the area. In 2000, as before the fire, we observed groups of up to 100–200 birds foraging in our study area. However, numbers were much reduced in 2001, always below 100 and rarely more than 20. We suspect that this may have been a factor in the higher nest success for shrikes in 2001 compared to 2000. Understanding how key nest predators respond to fire and resultant changes in vegetation structure and landscape configuration should be a priority for future research.

As with nest success, we found that the proportion of territories producing young in 2000 was lower than before the fire. In 2001, due to persistent nesting attempts, the proportion of territories producing young was comparable to the pre-fire years. However, more nesting attempts and fledging later in the season may affect adult or fledgling survival (Sæther 1988, Visser and Verboven 1999, Dhondt 2001). Possible reductions in survival could result from increased energetic expenditures and stress to adults resulting from multiple nesting attempts, conflicts between late season reproductive efforts and timing of late summer molt having negative impacts on either, or conditions less favorable to raising nestlings and fledglings late in the season (Morton et al. 2004).

Post-fledging survival rates to two weeks out of the nest were comparable before and after the fire (60% and 54%, respectively). The post-fledging period may be critical for shrikes and other passerines, but few data are available. The only other estimate we found for Loggerhead Shrikes in sagebrush habitats was 45% survival to three weeks post-fledging (Poole 1992). Clutch size and fledged brood size were also similar between the pre- and post-fire sampling periods, indicating that the reduced productivity in 2000 was attributable to the reduction in nesting success alone.

In 2000–2001, shrikes increased their use of nesting substrates other than sagebrush, especially juniper trees. This might be due to the tendency for shrikes to place later nests higher (Kridelbaugh 1982, Luukkonen 1987, Woods and Cade 1996), and the greater number of attempts initiated later in the season after the fire due to increased renesting following failure. Indeed, 86% of the nests in juniper trees were renesting attempts. This variation in substrate selection following the fire may also be due to the reduction in overall sagebrush cover and reduced suitability of the remaining patches. Nur et al. (2004), using data gathered as part of this study, found lower survival in later nests, but did not find higher nests to have lower survival after controlling for date.

Populations of Loggerhead Shrikes in the western United States have declined by 3.82% per year since 1966 (Sauer et al. 2004). Reduction and fragmentation of sagebrush habitat after the fire in our study resulted in a corresponding decline in the Loggerhead Shrike population. Habitat loss and fragmentation play an important part in the decline of sagebrush bird communities (Knick et al. 2003), and are likely among the factors contributing to declines of shrike population in parts of the intermountain west. Poor productivity in small remnant patches of sagebrush habitat may be an additional factor in the declines. In the numerous studies summarized by Pruitt (2000) and Yosef (1996), nest success for Loggerhead Shrikes was generally greater than 50%, with the lowest reported at 25% (Collins 1996). Our pre-fire nest success (39%) is among the lowest reported, and the post-fire nest success at our site (19%) is, to our knowledge, the lowest. Our results suggest that efforts to mitigate the deleterious effects of cheatgrass on the fire regime and quality of sagebrush steppe habitats should be continued (Brooks et al. 2004), and efforts should attempt to protect and restore large patches of big sagebrush habitats should be initiated.

ACKNOWLEDGMENTS

Funding for data collection came from the United States Navy agricultural outlease funds handled through the Oregon Department of Fish and Wildlife. In particular, we thank R. Morgan, K. Livezey, J. Phillips, and G. Geupel for providing support for this work. We are indebted to numerous seasonal biologists for their time spent gathering data in the wind and heat, especially J. Durbin, J. Kurant, J. Philipsborn, and B. J. Davis. We are grateful to V. Marr for sharing with us his wildlife observations and fire perimeter map. In addition, we thank R. Burnett, T. Rich, and an anonymous reviewer for helpful comments on early versions of this manuscript. This is PRBO contribution number 1248.

LITERATURE CITED

Brooks, M. L., and D. A. Pyke. 2001. Invasive plants and fire in the deserts of North America. In: Proceedings of the invasive species workshop: the role of fire in the control and spread of invasive species (K. E. M. Galley and T. P. Wilson, eds.), pp. 1–14. Fire Conference 2000: the First National Congress on Fire Ecology, Prevention, and Management. Tall Timbers Research Station, Tallahassee, FL.

———, C. M. D'Antonio, D. M. Richardson, J. B. Grace, J. E. Keeley, J. M. DiTomaso, R. J. Hobbs, M. Pellant, and D. Pyke. 2004. Effects of invasive alien plants on fire regimes. BioScience 54: 677–688.

CANFIELD, R. H. 1941. Application of the line interception method in sampling range vegetation. Journal of Forestry 39: 388–394.

COLLINS, J. A. 1996. Breeding and wintering ecology of the Loggerhead Shrike in southern Illinois. M.S. thesis, Southern Illinois University, Carbondale, IL.

DAUBENMIRE, R. 1970. Steppe vegetation of Washington. Washington Agricultural Experiment Station Technical Bulletin 62, Washington State University, Pullman, WA.

DHONDT, A. A. 2001. Trade-offs between reproduction and survival in tits. Ardea 89: 155–166.

HAAS, C. A., AND S. SLOANE. 1989. Low return rates of migratory Loggerhead Shrikes: winter mortality or low site fidelity. Wilson Bulletin 101: 458–460.

HINES, J. F., 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, Washington, D.C.

KNICK, S. T., D. S. DOBKIN, J. T. ROTENBERRY, M. A. SCHROEDER, W. M. VANDER HAEGEN, AND C. VAN RIPER III. 2003. Teetering on the edge or too late? Conservation and research issues for avifauna of sagebrush habitats. Condor 105: 611–634.

KRIDELBAUGH, A. L. 1982. An ecological study of Loggerhead Shrikes in central Missouri. M.S. thesis, University of Missouri, Columbia, MO.

LUUKKONEN, D. R. 1987. Status and breeding ecology of the Loggerhead Shrike in Virginia. M.S. thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA.

MARTIN, T. E., AND G. R. GEUPEL. 1993. Nest monitoring plots: methods for locating nests and monitoring success. Journal of Field Ornithology 63: 507–519.

MAYFIELD, H. F. 1961. Nesting success calculated from exposure. Wilson Bulletin 73: 255–261.

———. 1975. Suggestions for calculating nest success. Wilson Bulletin 87: 456–466.

MCCLELLAND, S., AND T. BEDELL. 1987. Natural resource management plan Naval Weapons Systems Training Facility, Boardman, OR. Naval Facilities Engineering Command, San Bruno, CA.

MORTON, M. L., M. E. PEREYRA, J. D. CRANDALL, E. A. MACDOUGALL-SHACKLETON, AND T. P. HAHN. 2004. Reproductive effort and return rates in the Mountain White-crowned Sparrow. Condor 106: 131–138.

NUR, N., A. L. HOLMES, AND G. R. GEUPEL. 2004. Use of "survival time analysis" to estimate nesting success in birds. Condor 106: 457–471.

ODFW (OREGON DEPARTMENT OF FISH AND WILDLIFE). 1997. Oregon Department of Fish and Wildlife Sensitive Species. Oregon Department of Fish and Wildlife, Salem, OR.

PELLANT, M., AND C. HALL. 1994. Distribution of two exotic grasses on intermountain rangelands: status in 1992. In: Proceedings: ecology and management of annual rangelands. USDA Forest Service General Technical Report INT-GTR-313, Ogden, UT.

POOLE, L. 1992. Reproductive success and nesting habitat of Loggerhead Shrikes in a shrubsteppe communities. M.S. thesis, Oregon State University, Corvallis, OR.

PRUITT, L. 2000. Loggerhead Shrike status assessment. United States Fish and Wildlife Service, Bloomington, IN.

PYKE, D. A. 2000. Invasive exotic plants of sagebrush ecosystems of the intermountain west. In: Proceedings: Sagebrush steppe ecosystems symposium (P. G. Entwistle, A. M. DeBolt, J. H. Kaltenecker, and K. Steenhof, compilers), pp. 43–54. Bureau of Land Management Publication No. BLM/ID/PT-001001+1150, Boise, ID.

QUIGLEY, T. M., AND S. J. ARBELBIDE. 1997. An assessment of ecosystem components in the interior Columbia Basin and portions of the Klamath and Great basins. General Technical Report PNW-GTR-405. USDA Forest Service Pacific Northwest Research Station, Portland, OR.

ROTENBERRY, J. T. 1998. Avian conservation research needs in western shrublands: exotic invaders and the alteration of ecosystem processes. In: Avian conservation, research, and management (J. M. Marzluff and R. Sallabanks, eds), pp. 262–272. Island Press, Washington, D.C.

SAAB, V. A., AND T. D. RICH. 1997. Large-scale conservation assessment for Neotropical migratory land birds in the interior Columbia River Basin. In: Interior Columbia Basin ecosystem management project: scientific assessment (T. M. Quigley, ed.). USDA Forest Service General Technical Report PNW-GTR-399, Portland, OR.

SÆTHER, B.-E. 1988. Pattern of covariation between life-history traits of European birds. Nature 331: 616–617.

SANDS, A. R., S. SATHER-BLAIR, AND V. SAAB. 2000. Sagebrush steppe wildlife: historical and current perspectives. In: Proceedings: Sagebrush steppe ecosystems symposium (P. G. Entwistle, A. M. DeBolt, J. H. Kaltenecker, and K. Steenhof, eds.). Bureau of Land Management Publication No. BLM/ID/PT-001001+1150, Boise, ID.

SAUER, J. R., J. E. HINES, AND J. FALLON. 2004. The North American breeding bird survey, results and analysis 1966–2003. Version 2004.1. USGS Patuxent Wildlife Research Center, Laurel, MD.

VANDER HAEGEN, W. M., M. A. SCHROEDER, AND R. M. DEGRAAF. 2002. Predation on real and artificial nests in shrubsteppe landscapes fragmented by agriculture. Condor 104: 496–506.

VISSER, M. E., AND N. VERBOVEN. 1999. Long-term fitness effects of fledging date in Great Tits. Oikos 85: 445–450.

WEST, N. E. 2000. Synecology and disturbance regimes of sagebrush steppe ecosystems. In: Proceedings: Sagebrush steppe ecosystems symposium (P. G. Entwistle, A. M. DeBolt, J. H. Kaltenecker, and K. Steenhof, eds). Bureau of Land Management Publication No. BLM/ID/PT-001001+1150, Boise, ID.

WHISENANT, S. G. 1990. Changing fire frequencies on Idaho's Snake River Plains: ecological management implications. In: Proceedings of the symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management (E. E. McArthur, E. M. Romney, and P. T. Tueller, eds.), pp. 4–10. USDA Forest Service General Technical Report INT-276, Intermountain Research Station, Ogden, UT.

WISDOM, M. J., R. S. HOLTHAUSEN, B. C. WALES, C. D. HARGIS, V. A. SAAB, D. C. LEE, W. J. HANN, T. D. RICH, M. M. ROWLAND, W. J. MURPHY, AND M. R. EAMES. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale trends and management implications. General Technical Report PNW-GTR-485. U.S. Forest Service, Pacific Northwest Research Station, Portland, OR.

WOODS, C. P., AND T. J. CADE. 1996. Nesting habits of the Loggerhead Shrike in sagebrush. Condor 98: 75–81.

YOSEF, R. 1996. Loggerhead Shrike (*Lanius ludovicianus*). In: The birds of North America, no. 231 (A. Poole and F. Gill, eds.). Academy of Natural Sciences, Philadelphia, PA, and American Ornithologists' Union, Washington, D.C.

YOUNG, J. A. 1994. History and use of semiarid plant communities – changes in vegetation. In: Proceedings – ecology and management of annual rangelands (S. B. Monsen and S. G. Kitchen, compilers), pp. 5–11. USDA Forest Service General Technical Report INT-GTR-313, Intermountain Research Station, Ogden, UT.

J. Field Ornithol. 77(2):1, 2006 DOI: 10.1111/j.1557-9263.2006.00047.x

Erratum

The final sentence of the Discussion in the article by Humple and Holmes (2006) was incompletely corrected, and should have read:

"Our results suggest that efforts to mitigate the deleterious effects of cheatgrass on the fire regime and quality of sagebrush steppe habitats should be continued (Brooks et al. 2004), and efforts should attempt to protect and restore large patches of big sagebrush habitats."

We apologize for this error.

LITERATURE CITED

Humple, D. L., and A. L. Holmes. 2006. Effects of a fire on a breeding population of Loggerhead Shrikes in sagebrush steppe habitat. Journal of Field Ornithology 77: 21–28.