Research Note

Off-Highway Vehicle Trail Impacts on Breeding Songbirds in Northeastern California

DANIEL C. BARTON,[1,2] *PRBO Conservation Science, 4990 Shoreline Highway, Stinson Beach, CA 94970, USA*

AARON L. HOLMES,[3] *PRBO Conservation Science, 4990 Shoreline Highway, Stinson Beach, CA 94970, USA*

ABSTRACT Rapid growth in off-highway vehicle (OHV) use in North America leads to concerns about potential impacts on wildlife populations. We studied the relationship between distance to active OHV trail and songbird nesting success and abundance in northeastern California, USA, from 2002 to 2004. We found evidence of greater nest desertion and abandonment and reduced predation on shrub nests <100 m from OHV trails than at nests >100 m from OHV trails. Two of 18 species studied were less abundant at sites on trails than at sites 250 m from trails, and no species were more abundant on trails. Management of OHV trail development should consider possible negative impacts on nesting success and abundance of breeding birds. (JOURNAL OF WILDLIFE MANAGEMENT 71(5):1617–1620; 2007)

DOI: 10.2193/2006-026

KEY WORDS off-highway vehicle impacts, road effects, shrubsteppe songbirds, songbird abundance, songbird nesting success, trail effects.

Rapid growth in off-highway vehicle (OHV) use (Bowker et al. 1999) in North America leads to concerns about potential impacts on wildlife populations. The few previous studies on the impacts of OHV on wildlife populations or habitats compared abundance of plants or wildlife between used and unused areas on large spatial scales (e.g., Luckenbach and Bury 1983, Brooks 1999) or studied the impacts of beach OHV use on shorebirds (e.g., Buick and Paton 1989). These studies generally indicate that disturbance or habitat alteration associated with OHV use causes reduction in wildlife populations (Luckenbach and Bury 1983, Lovich and Bainbridge 1999).

Researchers could use results from more in-depth studies on roads and recreational (hiking) trails to predict the impacts of OHV trails on wildlife. Possible mechanisms of demographic change identified in studies of the effects of roads or recreational (hiking) trails on wildlife are mortality from collisions, altered movement patterns, altered reproductive success, and decreases in populations due to loss of habitat (Rich et al. 1994, Forman and Alexander 1998, Miller and Hobbs 1998, Forman et al. 2003). Off-highway vehicle trails could affect wildlife in similar ways. However, seasonal and temporal use patterns, types of vehicles used, and areas developed differ between OHV trails and roads or recreational trails. Therefore, results from studies of the effects of roads and recreational trails on wildlife can only be applied to OHV trails with caution. Direct study is required to understand the effects of OHV trails on wildlife.

We performed a 3-year study to assess effects of active OHV trails on songbird abundance and nesting success at a publicly developed and maintained OHV recreation area. We measured nesting success because it is an important deterministic component of seasonal fecundity (Jones et al. 2005), which in turn influences population growth rate (Saether and Bakke 2000). We present results on the effects of proximity to OHV trails for songbird nest predation, abandonment, and desertion rates. We also present count-based relative abundance indices of common songbird species in relation to proximity to OHV trails.

[1] *E-mail: daniel.barton@umontana.edu*
[2] *Present address: Program in Organismal Biology and Ecology & Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT 59812, USA*
[3] *Present address: Oak Creek Lab of Biology, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331, USA*

STUDY AREA

From April to July 2002–2004 we conducted research at the Fort Sage Mountains OHV Area, 3 km northeast of Doyle, California, USA, which is managed by the Bureau of Land Management. In 2002, we established a nest-monitoring plot near the primary OHV trailhead and campground and 70 point count stations in the OHV area. The OHV area consisted of 8,900 ha located at the northern end of the Fort Sage Mountains, and was characterized by a mosaic of vegetation types dominated by big sagebrush (*Artemisia tridentata*), bitterbrush (*Purshia tridentata*), western juniper (*Juniperus occidentalis*), green rabbitbrush (*Chrysothamnus viscidiflorus*), gray rabbitbrush (*C. nauseosus*), and greasewood (*Sarcobatus vermiculatus*). The OHV trail network included narrow (0.5 m) motorcycle trails to wide (3 m) dirt roads. The area received approximately 9,000 visitor-days of use per year during 2002–2004, with most use in March–May and September–November (D. Jackson, Bureau of Land Management Susanville Field Office, personal communication).

METHODS

We located and monitored bird nests to estimate rates of predation, abandonment, desertion, and success using methods described by Martin and Geupel (1993). We recorded locations of nests using a handheld Global Positioning System device and calculated the distance to the nearest OHV trail using the Nearest Features 3.8 extension (Jenness 2004) in ArcView Geographic Information System (GIS) 3.2a. We grouped nests by those close to

(<100 m) and far from (>100 m) OHV trails to evaluate the effects of trail distance on nesting success because we were constrained by small sample sizes. Splitting nests into these 2 distance categories created 2 groups of approximately equal sizes.

We calculated daily abandonment rates, daily desertion rates, and daily predation rates for nests close to and far from active trails using the Mayfield method (Mayfield 1975) and standard errors following Johnson (1979). We excluded nests that were parasitized by brown-headed cowbirds (*Molothrus ater*) from analyses (n = 3). We defined abandonment as cessation of a nesting attempt prior to egg laying, and we defined desertion as cessation of a nesting attempt when the nest contained either eggs or young. To calculate predation rates, we pooled nests into ground and shrub open cup-nesting species because within these groups, predation rates tend to be similar (Martin 1993), thus reducing the problems created by pooling heterogeneous species. We used the chi-square test as implemented by Program CONTRAST (Hines and Sauer 1989) to test for an effect of distance to active OHV trail on Mayfield estimates of predation, abandonment, and desertion rates.

We used a GIS coverage of trail locations superimposed on a United States Geological Survey Digital Raster Graphic of the Fort Sage Mountains to select 35 on-trail stations and pair them with 35 off-trail stations with regards to slope and elevation. We located off-trail stations 250 m away from their paired on-trail station and we located all off-trail sites between 200 m and 250 m away from the nearest active OHV trail. We visited all paired sites to assess comparability of vegetation cover. In 2 cases we relocated point count station on- and off-trail pairs because of disparate habitat types. We estimated relative bird abundances at these locations using 100-m fixed-radius 5-minute point counts (Ralph et al. 1993). Thus, on-trail station surveys included individuals detected within 100 m of trails, and off-trail station surveys included individuals 100–350 m from trails. We conducted point count surveys at each station twice per year from 2002 to 2004 for a total of 6 visits to each of the 70 stations. All surveys occurred between 0530 hours and 0900 hours on 17 May–25 June.

We measured habitat variables at each station using a 100-m line-intercept transect to estimate shrub cover, and 20 0.1-m^2 sampling plots spaced evenly along the length of the 100-m transect to estimate coverage of grasses, forbs, and bare ground. In addition, we counted trees within a 100-m radius.

We used 2-tailed paired t-tests to compare the mean number of detections per year of 18 bird species detected more than once at both on- and off-trail points, and to compare on- and off-trail vegetation variables. We used mean number of detections per year because of low annual variation and small sample size. We examined the strength of relationships between bird species abundance and 8 vegetation variables (total shrub cover, big sagebrush cover, bitterbrush cover, combined saltbush [*Atriplex* spp.] and greasewood shrub cover, western juniper density, perennial grass cover, annual grass cover, and forb cover) using Spearman correlations. When bird species abundance varied significantly between on- and off-trail points we used analysis of covariance (ANCOVA) to test whether vegetation differences between on- and off-trail points explained variation in bird species abundance, or whether the trail result was independent of measured vegetation attributes. Except where noted previously, we conducted all analyses using Stata 8.0 (StataCorp, College Station, TX). We defined significance at $\alpha = 0.10$ in order to reduce the risk of making a type 2 error due to small sample sizes and associated limited power. Further, we discuss nonsignificant effects as suggestive of possible biological effects (Robinson and Wainer 2002).

RESULTS

We used pooled data from 113 nests of 20 small songbird species to calculate daily desertion rates, 38 nests of 12 species found during building for daily abandonment rates, and 105 nests of 16 open-cup nesting species for daily predation rates. Daily abandonment rate of nests was 4 times higher at nests <100 m from a trail than those >100 m, but this difference was not statistically significant ($\chi^2 = 2.38$, 1 df, $P = 0.12$; Table 1). We only observed desertion within 21 m of trails, and daily desertion rate was significantly greater at nests <100 m from trails than those >100 m from trails ($\chi^2 = 4.02$, 1 df, $P = 0.04$; Table 1). Daily predation rates were approximately 2 times higher in ground-nesting birds than in shrub-nesting birds ($\chi^2 = 3.304$, 1 df, $P = 0.069$; Table 1), and thus separating these categories for analysis of the effect of trails on predation rate is appropriate. Daily predation rate of shrub nests <100 m from trails was approximately half that of nests >100 m from trails, but this difference was not statistically significant ($\chi^2 = 2.62$, 1 df, $P = 0.11$; Table 1). Daily predation rate (Table 1) of ground nests was not different <100 m from trails than >100 m ($\chi^2 = 0.14$, 1 df, $P = 0.91$; Table 1).

Spotted towhee (*Pipilo erythrophthalmus*) and western scrub-jay (*Aphelocoma coerulescens*) were somewhat less abundant at on-trail points (Table 2). Bitterbrush cover differed between on- and off-trail stations ($P < 0.04$), and was weakly correlated with spotted towhee abundance ($r = 0.19$, $P < 0.05$). Big sagebrush cover did not differ significantly between on- and off-trail stations ($P = 0.16$), but was correlated with both spotted towhee ($r = 0.46$, $P < 0.05$) and western scrub-jay abundance ($r = 0.26$, $P < 0.05$). Spotted towhee abundance was 9.33% lower (90% CI: –2.04%, –16.62%) at on-trail sites after accounting for the effects of vegetation (main effect of trail in ANCOVA, $F_{1,32} = 4.62$, $P = 0.039$, partial $R^2 = 0.038$) in a model that included the effects of trail, site pair, sagebrush cover, and bitterbrush cover (ANCOVA, $F_{37,32} = 7.63$, $P < 0.001$). Western scrub-jay abundance was 45.13% lower (90% CI: –3.69%, –86.56%) at on-trail sites after accounting for the effects of vegetation (main effect of trail in ANCOVA, $F_{1,33} = 3.44$, $P = 0.073$, partial $R^2 = 0.069$) in a model that

Table 1. Mayfield daily nest abandonment, desertion, and predation rates by off-highway vehicle (OHV) trail distance at the Fort Sage OHV Area, Lassen County, California, USA, 2002–2004.[a]

	Nests <100 m from trails					Nests >100 m from trails						
	Daily failure rate			Trail distance (m)		Daily failure rate			Trail distance (m)			
Failure cause	Estimate	SE	n[b]	$\bar{x}$	SD	Estimate	SE	n[b]	$\bar{x}$	SD	χ^2	P
Abandonment	0.066	0.029	23	43.7	30.3	0.016	0.016	15	189.3	47.5	2.376	0.123
Desertion	0.006	0.003	62	37.1	27.9	0.000	0.000	51	204.4	64.0	4.024	0.045
Shrub predation	0.031	0.008	38	31.1	27.7	0.058	0.015	32	198.3	68.4	2.618	0.106
Ground predation	0.071	0.018	24	46.7	25.9	0.067	0.022	19	214.9	56.2	0.135	0.908

[a] χ^2 and P values are comparisons of daily rates close to and far from trails using Program CONTRAST (Hines and Sauer 1989).
[b] We pooled species to achieve sample sizes large enough for comparisons between distance categories.

included the effects of trail, site pair, and sagebrush cover (ANCOVA, $F_{36,33} = 7.63$, $P < 0.001$).

DISCUSSION

Our results suggest a positive effect of proximity to OHV trail on nest desertion and abandonment and a negative relationship of proximity to OHV trail on predation rates of nests built in shrubs (Table 1). These effects have opposite net effects on nesting success, making interpretation difficult. However, our results suggest that species that are prone to nest abandonment or desertion, or that do not renest after failure, will be negatively affected by OHV trails. Conversely, some shrub-nesting species may benefit from reduced predation rates. However, because we pooled species for analysis due to small sample sizes, we are unable to infer which species may benefit or suffer due to these particular effects.

We found a tendency for lower predation rates (Table 1) at shrub nests <100 m from trails, counter to the frequently predicted positive effect of habitat edges on predation rates (Paton 1994). The OHV traffic on these trails could have frightened away predators, thus causing reduced predator densities in proximity to OHV trails. This hypothesis is echoed in a study of the effect of recreational hiking trails on songbird nest predation, which found lower predation rates near trails, ostensibly due to a reduced number of predators near trails (Merkle 2002). Conversely, all 5 desertion events observed were very close (<21 m) to trails and abandonment rate was 4 times higher close to trails (Table 1). Because we did not study OHV traffic directly, we are unable to determine whether OHV trails or OHV traffic influenced abandonment, desertion, or predation.

We found a negative effect of OHV trail on the abundance of 2 of 18 species studied, but the effect of OHV trail accounted for little of this variation after controlling for the effect of vegetation among sites. A negative effect of trails on spotted towhee is consistent with another study of this species that shows it avoids recreational trails (Holmes and Geupel 2005). It is unclear from our results whether these 2 species were less abundant on trails

Table 2. Comparison of on- and off-trail abundance ($\bar{x}$ detections/station/yr) of the 18 most common species at 35 pairs of point count stations at the Fort Sage Off-Highway Vehicle Area, Lassen County, California, USA, 2002–2004.

Species		On-trail abundance		Off-trail abundance		
		$\bar{x}$	SE	$\bar{x}$	SE	P[a]
Spotted towhee	*Pipilo maculatus*	1.00	0.22	1.32	0.25	0.099
Black-throated sparrow	*Amphispiza bilineata*	0.99	0.13	1.10	0.15	0.530
Western meadowlark	*Sturnella neglecta*	0.92	0.12	0.86	0.11	0.576
Pinyon jay	*Gymnorhinus cyanocephalus*	0.17	0.08	1.14	0.96	0.324
Lark sparrow	*Chondestes grammacus*	0.63	0.12	0.53	0.12	0.485
Brewer's sparrow	*Spizella breweri*	0.68	0.18	0.37	0.11	0.122
Blue-gray gnatcatcher	*Polioptila caerulea*	0.46	0.11	0.41	0.11	0.678
Bewick's wren	*Thryomanes bewickii*	0.30	0.08	0.31	0.08	0.818
Sage sparrow	*Amphispiza belli*	0.30	0.10	0.26	0.09	0.676
Brown-headed cowbird	*Molothrus ater*	0.17	0.06	0.33	0.11	0.170
Ash-throated flycatcher	*Myiarchus cinerascens*	0.18	0.06	0.28	0.07	0.169
Mourning dove	*Zenaida macroura*	0.24	0.06	0.21	0.05	0.697
Horned lark	*Eremophila alpestris*	0.21	0.09	0.19	0.11	0.790
Western scrub-jay	*Aphelocoma californica*	0.11	0.04	0.20	0.06	0.059
Bushtit	*Psaltriparus minimus*	0.21	0.07	0.10	0.05	0.202
Chipping sparrow	*Spizella passerina*	0.16	0.06	0.12	0.05	0.600
Loggerhead shrike	*Lanius ludovicianus*	0.13	0.06	0.15	0.04	0.676
Gray flycatcher	*Empidonax wrightii*	0.15	0.06	0.11	0.05	0.635
Juniper titmouse	*Baeolophus ridgwayi*	0.08	0.03	0.08	0.04	1.000
Red-shafted flicker	*Colaptes auratus*	0.05	0.02	0.10	0.03	0.117

[a] P values from paired t-tests.

because they avoided trails, or because trails reduced the amount of available habitat. We were unable to quantify such effects because no nearby site comparable to the Fort Sage Mountains OHV area exists to serve as a proper control.

We suggest future studies focus on replication across multiple OHV areas and matched control sites. Larger sample sizes would provide greater power to detect hypothesized effects for which we provide only suggestive results. Future studies should consider that effects of OHV trails or OHV use on the abundance of songbirds might occur at scales >250 m (e.g., Brooks 1999). Approximately 24% of the 8,900-ha study area was within 100 m of an active OHV trail, which suggests that the observed local effects could scale to landscape-level effects. Determining the scale at which disturbances such as OHV trail development and use affect wildlife demography is critical to effective management. Additionally, selection of focal species for demographic research would reduce the analytic and inferential issues created by pooling nest data across species. However, if pooling is necessary, our results highlight the need to control for nest strata in analyses.

MANAGEMENT IMPLICATIONS

Management of OHV trail development should consider possible negative impacts on nesting success and abundance of breeding birds. Areas within 100 m of OHV trails may provide reduced-quality habitat to nesting songbirds, particularly for species that suffer significant losses of annual fecundity due to abandonment or desertion of individual breeding attempts. Limitation of OHV trail development in breeding areas of rare or endangered birds could minimize conflicts over land use between recreation and wildlife conservation.

ACKNOWLEDGMENTS

We are grateful for assistance provided by the Bureau of Land Management, particularly D. Armentrout, J. Sippel, and B. Corbin. California Department of Fish and Game provided housing and office space and we especially thank F. Hall and P. Cherney for their support. We are indebted to D. Humple, A. Campomizzi, C. Kennedy, T. Corriel, and T. Rahmig for assistance with data collection. Funding for this research was provided through the Bureau of Land Management from the California Off-Highway-Vehicle Commission. W. D. Robinson and T. E. Martin provided helpful comments. This is PRBO contribution number 1518.

LITERATURE CITED

Bowker, J. M., D. B. K. English, and H. K. Cordell. 1999. Projections of outdoor recreation participation to 2050. Pages 449–480 *in* H. K. Cordell, C. J. Betz, J. M. Bowker, D. B. K. English, S. H. Mou, J. C. Bergstrom, R. J. Teasley, and M. A. Tarrant, editors. Outdoor recreation in American life: a national assessment of demand and supply trends. Sagamore, Champaign, Illinois, USA.

Brooks, M. 1999. Effects of protective fencing on birds, lizards, and black-tailed hares in the western Mojave Desert. Environmental Management 23:387–400.

Buick, A. M., and D. C. Paton. 1989. Impact of off-road vehicles on the nesting success of hooded plovers *Charadrius rubricollis* in the Coorong region of South Australia. Emu 89:159–172.

Forman, C. J., and L. E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207–231.

Forman, R. T, D. Sperling, J. A. Bissonette, A. P. Clevenger, C. D. Cutshall, V. H. Dale, L. Fahrig, R. France, C. R. Goldman, K. Heanue, J. A. Jones, F. J. Swanson, T. Turrentine, and T. C. Winter. 2003. Road ecology. Island Press, Washington D.C., USA.

Hines, J. E., and J. R. Sauer. 1989. Program CONTRAST: a general program for the analysis of several survival or recovery rate estimates. U.S. Fish and Wildlife Service Fish and Wildlife Technical Report 24, Washington, D.C., USA.

Holmes, A. H., and G. R. Geupel. 2005. Effects of trail width on the densities of four species of breeding birds in chaparral. *In* C. J. Ralph, J. R. Sauer, and S. Droege, technical editors. Proceedings of the Third International Partners in Flight Conference. U.S. Forest Service General Technical Report PSW-GTR-191. Albany, California, USA.

Jenness, J. 2004. Nearest features (nearfeat.avx) extension for ArcView 3.x, v. 3.8a. Jenness Enterprises, Flagstaff, Arizona, USA.

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

Jones, J., P. J. Doran, L. R. Nagy, and R. T. Holmes. 2005. Relationship between Mayfield nest-survival estimates and seasonal fecundity: a cautionary note. Auk 122:306–312.

Lovich, J. E., and D. Bainbridge. 1999. Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration. Environmental Management 24:309–326.

Luckenbach, R. A., and R. B. Bury. 1983. Effects of off-road vehicles on the biota of the Algodones Dunes, Imperial County, California. Journal of Applied Ecology 20:265–286.

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

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

Merkle, W. W. 2002. Recreational trail-use effects on American robin (*Turdus migratorius*) and yellow warbler (*Dendroica petechia*) nesting ecology and behavior. Dissertation, University of Colorado, Boulder, USA.

Miller, J. R., and N. T. Hobbs. 1998. Recreational trails, human activity, and nest predation in lowland riparian areas. Landscape and Urban Planning 50:227–236.

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

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. U.S. Forest Service General Technical Report PSW-GTR-144. Albany, California, USA.

Rich, A. C., D. S. Dobkin, and L. J. Niles. 1994. Defining forest fragmentation by corridor width: the influence of narrow forest-dividing corridors on forest-nesting birds in southern New Jersey. Conservation Biology 8:1109–1121.

Robinson, D. H., and H. Wainer. 2002. On the past and future of null hypothesis significance testing. Journal of Wildlife Management 66:263–271.

Saether, B. E., and O. Bakke. 2000. Avian life history variation and contribution of demographic traits to the population growth rate. Ecology 81:642–653.

Associate Editor: Kus.