Are Nest Predators Absent from Noisy Areas or Unable to Locate Nests?

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CHAPTER 9

ARE NEST PREDATORS ABSENT FROM NOISY AREAS OR UNABLE TO LOCATE NESTS?

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Abstract.—Increases in anthropogenic noise (hereafter "noise") exposure may negatively affect reproductive success for breeding birds because noise may mask sounds of approaching predators. However, we recently found that increases in noise amplitude positively influenced nest survival through a decrease in nest predation. On the basis of this result, we hypothesized that noise may result in (1) a numerical decrease in predators in noisy areas or (2) a functional predator response, in which predators are present but noise interferes with their ability to locate nests. We separated the effects of nest predation risk due to a numerical decrease in predators and risk associated with activity at the nest using artificial-nest experiments on control and noisy treatment sites and within a broad range of noise exposure. Our results concurred with results from natural nests regarding patterns of predation, which suggests that common predators may be less abundant in areas with increased noise exposure. Additionally, cameras paired with artificial nests photographed Western Scrub-Jays (*Aphelocoma californica*) depredating nest contents mainly on control sites, which is consistent with evidence that Western Scrub-Jays have lower occupancy in noisy areas. Our findings suggest that breeding birds in areas with high amplitudes of anthropogenic noise may benefit from increased nest success. However, this benefit should be viewed in the context of changes to avian nesting community diversity when exposed to anthropogenic noise; only those species tolerant of noise may persist.

Key words: artificial nests, compressor noise, gas wells, nest predation, New Mexico, quail eggs.

¿Están los Depredadores de Nidos Ausentes de Zonas Ruidosas o son Incapaces de Localizar los Nidos?

Resumen.—El incremento en la exposición al ruido antropogénico (en adelante llamado "ruido") podría afectar negativamente el éxito de las aves reproductoras debido a que el ruido puede enmascarar los sonidos de un depredador acercándose. Sin embargo, recientemente encontramos que el incremento en la amplitud del ruido afecta positivamente la supervivencia de los nidos mediante una disminución de su depredación. Con base en este resultado, postulamos las hipótesis de que el ruido puede resultar en (1) una disminución numérica de los depredadores en áreas ruidosas o (2) una respuesta funcional de los depredadores tal que éstos están presentes pero el ruido interfiere con su habilidad para localizar los nidos. Separamos

los efectos del riesgo de depredación de los nidos debido a una disminución numérica de los depredadores y del riesgo asociado con la actividad en los nidos mediante experimentos con nidos artificiales en sitios con tratamientos control y ruidoso, y dentro de un amplio rango de exposición al ruido. Nuestros resultados coincidieron con los resultados de nidos naturales con respecto a los patrones de depredación, lo que sugiere que los depredadores comunes podrían ser menos abundantes en áreas con mayor exposición al ruido. Además, las cámaras asociadas con los nidos artificiales fotografiaron a *Aphelocoma californica* depredando los contenidos de los nidos principalmente en sitios control, lo que concuerda con evidencia de que *A. californica* presenta menor ocupación de áreas ruidosas. Nuestros resultados sugieren que las aves que se reproducen en áreas con grandes amplitudes de ruido antropogénico se podrían beneficiar de un incremento en el éxito de sus nidos. Sin embargo, este beneficio debe ser observado en el contexto de los cambios en la diversidad de la comunidad de aves anidantes que se producen cuando éstas se exponen al ruido antropogénico; sólo las especies tolerantes podrían persistir.

ANTHROPOGENIC NOISE (HEREAFTER "noise") is pervasive in urban areas, along roadways, and even in rural areas influenced by industrial activities and intensive agriculture (Bayne et al. 2008, Francis et al. 2009, Barber et al. 2010). Noise has been implicated in the decline of bird densities (Reijnen et al. 1995, Kuitunen et al. 1998, Canaday and Rivadeneyra 2001, Forman et al. 2002, Bayne et al. 2008) and shown to negatively influence avian community diversity (Francis et al. 2009). These patterns may be due to species-specific intolerances to anthropogenic noise (Patricelli and Blickley 2006, Warren et al. 2006, Slabbekoorn and Ripmeester 2008, Francis et al. 2009) but may also be due to demographic processes, such as reduced reproductive success for individuals nesting in noisy areas. Nest predation risk may be especially high in noisy areas because noise may mask sounds of approaching predators (Warren et al. 2006, Slabbekoorn and Ripmeester 2008, Brumm 2010). By contrast, noise may impair the ability of opportunistic avian and mammalian nest predators to locate nests, which could result in lower predation risk in noisy areas. Because nest predation is often the primary cause of nest failure for many birds (Ricklefs 1969, Wilcove 1985, Martin 1993, Haskell 1995) and is an important force influencing local population viability (Sherry and Holmes 1992), it is critical to understand whether nests in noisy landscapes have altered predation risk because of noise exposure.

Contrary to conservation concerns that noise may decrease nesting success, we recently found that nest predation decreased with increased noise for the avian community as a whole and for individual species nesting within piñon (*Pinus edulis*)–juniper (*Juniperus osteosperma*) woodlands (Francis et al. 2009). This finding suggested that nest predators may also be negatively affected by noise, but this effect could reflect differences in predator behavior in areas with and without noise exposure (functional responses) or a difference in the relative abundance of predators in noisy versus less noisy areas (numerical response; Chalfoun et al. 2002). For functional responses, noise may negatively affect predators' abilities to locate nests by (1) masking cues used to located nests or (2) increasing predator vigilance through perceived predation risk (Quinn et al. 2006). By contrast, noise may cause a numerical response by predators through a decrease in predator abundances in noisy areas.

Predators are known to use activity near the nest to locate prey nests (e.g., Martin 1993, Martin and Ghalambor 1999, Martin et al. 2000, Fontaine et al. 2007), and acoustic cues, such as nestling begging calls (Haskell 1994) or parent vocalizations (Major and Kendal 1996), may draw predator attention to activity at or near the nest. Noise may mask these acoustic cues and interfere with predators' abilities to locate nests, resulting in higher nest success in noisy areas. In effect, this functional predator response could have a similar positive effect on nest survival as would a numerical decrease of nest predators in noisy areas. A numerical decrease in predators in response to noise may occur because noise is perceived as a threat, disrupts foraging abilities (Quinn et al. 2006, Schaub et al. 2008), or interferes with communication among conspecifics (Slabbekoorn and Ripmeester 2008, Brumm 2010). Here, we examine numerical and functional nest-predator responses to noise exposure by using artificial nests, which control for the influence of parent and nestling activity on predation risk.

Artificial nests lack parent and nestling activity; therefore, predation outcomes are independent of activity at the nest that can influence predation risk (Fontaine et al. 2007) and can provide insight on the relative contributions of functional

and numerical predator responses to nest predation risk. If predation on artificial nests increases with noise exposure, as was observed with natural nests (Francis et al. 2009), it may indicate a numerical predator response (i.e., a reduction) to noise. By contrast, if artificial-nest predation rates are unrelated to noise exposure, unlike that of natural nests, it may indicate a functional predator response to noise. That is, nest predators may exist in noisy areas but experience a reduced ability to locate natural nests due to effects of noise. Numerical and functional predator responses are not mutually exclusive; higher artificial-nest predation on control sites would indicate a numerical response but does not exclude the possibility that a functional response may also contribute to the pattern of increased nest success in noisy areas. Thus, in the present study we (1) examine the effects of the presence and intensity of gas-well compressor noise and nest-site features on survival of artificial nests, (2) compare predation rates of artificial nests with those of natural nests reported in Francis et al. (2009), and (3) identify predators of artificial nests in the piñon–juniper woodland community with artificial nests paired with motion-triggered cameras.

METHODS

In 2006 and 2007, we conducted artificial-nest experiments at the Rattlesnake Canyon Habitat Management Area (RCHMA), San Juan County, New Mexico, which is managed by the Bureau of Land Management (BLM). The RCHMA is dominated by piñon–juniper woodlands and open sagebrush (*Artemisia tridentata*) grasslands and, like other regions of the San Juan Basin, is an extensively developed energy-producing area. In 2003, the San Juan Basin had ~18,000 active oil and gas wells (BLM 2003), and well density has increased markedly since that time (C. D. Francis pers. obs.).

Throughout the RCHMA, gas wells are often coupled with compressors, which generate noise amplitudes that are hazardous to humans (>90 dB[A]; Habib et al. 2007, Occupational Safety and Health Administration 2009). These compressors aid in the transportation of gas through pipelines and run 24 h a day, 365 days a year, aside from periodic maintenance. Because noisy compressors in the RCHMA are present on some well pads (treatment sites) and absent on others (control sites), the area provides a unique opportunity to determine how noise influences natural populations and communities. At our study sites, human activity and vegetation do not differ on or around well pads with and without noisy compressors (for additional details, see Francis et al. 2009); thus, effects of noise are separated from other confounding variables.

We placed artificial nests on treatment and control sites in May 2006 and 2007. In ARCGIS, version 9.2 (ESRI, Redlands, California), we generated 25 random artificial-nest points within two concentric circles at 50 and 150 m from the study-site center (compressor exhaust pipe for treatment sites or gas well head for control sites). In 2006, we used two treatment and two control sites with 25 nests per site, for a total of 100 nests. In 2007, we used three treatment and three control sites, each with 25 nests for a total of 150 nests.

At each artificial nest point, we wired a nest ~2 m high in the nearest appropriate juniper tree. We placed nests near a branching point from the trunk or in a fork of a main branch, mimicking nest placement by the Gray Flycatcher (*Empidonax wrightii*) in our study area. We mimicked Gray Flycatcher nests because it is common to our study area and because its typical nest height (≈2 m) easily accessible. Artificial nests were canary nests manufactured with bamboo wicker (no. B-1980; Rolf C. Hagen, Montreal, Canada). We covered the inside and outside of the nest with wood excelsior (Western Excelsior, Mancos, Colorado) to mimic Gray Flycatcher nests, which are constructed with shredded juniper bark (Sterling 1999, C. D. Francis pers. obs.). The mean outer diameter of the canary nests was 10.0 ± 04 cm ($n = 15$) and, with the wood excelsior covering, was within the reported diameter range of natural Gray Flycatcher nests (outside diameter reported as 12.1 ± 1.43 [SD] cm in Sterling 1999).

Three Japanese Quail (*Coturnix japonica*) eggs (obtained from B & D Game Farm, Harrah, Oklahoma) were placed in each nest. We used quail eggs produced by young hens that were smaller than typical quail eggs; the mean size was 20.1 ± 0.6 mm × 26.2 ± 1.1 mm ($n = 20$), but still larger than the size of Gray Flycatcher eggs (13.7 × 17.7 mm; Sterling 1999). We used the smallest quail eggs available because some important predators are unable to break open quail eggs with a mean width of 23.5 mm (Haskell 1995) and average length of 30 mm (Roper 1992). We placed eggs in nests on 13 May and 22 May in 2006 and 2007, respectively. Although leaving human scent on

eggs may not affect predation or abandonment of American Robin (*Turdus migratorius*) nests (Ortega et al. 1997), we wore latex gloves while handing nests and eggs (Whelan et al. 1994). In 2006, we checked nest contents every 5 days for a total of 15 days, and in 2007, we checked nest contents every 4 days for a total of 12 days (3 visits each year). Accordingly, nests on control and experimental sites were visited with the same frequency.

In 2006, we recorded nest height, nest tree diameter at breast height (DBH), and distances to the nearest tree, snag, and study plot center. We also measured sound pressure levels (SPL) using A- and C-weighted amplitude measurements for 30 s on 3 separate days and times at each artificial nest to control for the effects of atmospheric variability on sound propagation from the compressors. We measured SPL as the equivalent continuous noise level (L_{eq}, fast response time) with Casella convertible sound dosimeters and sound pressure meters (models CEL 320 and CEL 1002 converter) that were certified with National Institute of Standards and Technology traceable certification. We used 95-mm acoustical windscreens, and we did not take SPL measurements when wind conditions were category 3 or above on the Beaufort Wind Scale ($\approx$ 13–18 km h^{-1}). Noise generated from compressors contains considerable energy as high as 5 kHz but had substantial acoustic energy at very low frequencies (see Francis et al. 2009: fig. S2). For this reason, we used A-weighted SPL values (dB[A]) because A-weighting filters much of the low-frequency compressor noise (<0.5 kHz) that most birds hear poorly (Dooling and Popper 2007).

In 2007, at each nest, we measured SPL as in 2006, but because of the lack or small effect of other variables on nest success (see below), we measured only the distance of each nest to the study-site center. To document diurnal predator identity on treatment and control sites, we placed 10 motion-triggered digital cameras (Wildview Xtreme II) on treatment nests and 10 on control nests. We mounted each camera on a branch in an adjacent tree. When an appropriate adjacent tree was unavailable, the camera was mounted in the nest tree. All cameras were positioned within 1–3 m from nests to get clear views, but we also placed cameras in low and relatively inconspicuous locations to avoid drawing additional attention to nests. Artificial nests paired with cameras were selected randomly at each site, with three cameras on two treatment and two control sites and four cameras at one treatment and one control site. Additionally, flashes were turned off on all cameras.

Analysis.—To determine whether noise exposure influenced artificial-nest success, we used generalized linear mixed models (GLMMs) with binomial errors, where removal or damage to any of the eggs was considered to be nest failure (0) and no damage or removal of eggs was treated as nest success (1). We treated year as a random effect to account for yearly variation in predation risk and different exposure lengths between years. Site was also treated as a random effect to account for the fact that nests located at each site were not entirely independent. Nest presence on a treatment or control site (site-type), SPL, and distance to the site center were all treated as fixed effects.

To make comparisons with natural nests from our previous study (Francis et al. 2009), and to evaluate the influence of additional predictor variables on nest success, we modeled daily nest survival (DNS) using the logistic-exposure method (Rotella et al. 2004, Shaffer 2004). This method employs a modified logit-link function to account for the number of days a nest was observed. The method we employed used generalized linear models (GLMs) and did not account for the nested nature of our study design, but we view it as a valuable complement to the GLMM analyses that accounts for this design in the model structure. Because predictor variables under consideration differed between years, we treated nests from 2006 and 2007 separately to estimate DNS. In 2006, we examined the influence of the following variables on DNS: nest location on a treatment or control site (site-type), SPL, nest height, DBH, and distances to the nearest tree, snag, and study-site center. In 2007, we examined the influence of site-type, SPL, camera presence, and distance to study-site center. Predictions of the expected effect on nest success and DNS for each variable are provided in Table 1.

For all analyses, we used an information-theoretic approach to evaluate support for competing candidate models (Burnham and Anderson 2002) with Akaike's information criterion corrected for small sample sizes (AIC$_c$). We ranked models on the basis of differences in AIC$_c$ scores (ΔAIC$_c$). For DNS models, we calculated AIC$_c$ scores using the number of known nest survival days plus all intervals ending in nest failure as the effective sample size (N$_{eff}$; Rotella et al. 2004). Models with

TABLE 1. Variables included in mixed-effect nest survival model and daily nest survival (DNS) models for artificial nests on treatment and control sites in the Rattlesnake Canyon Habitat Management Area, northwest New Mexico, 2006–2007. Predicted effect direction is provided for each.

Variable	Abbreviation	Direction of predicted effect
2006–2007 mixed-effect and DNS models		
Nest located on a treatment or control site	Site-type	+ [a]
Distance of nest to study-site center	Dist	–
Sound pressure level at nest, dB(A)	SPL	+
2006 DNS models only		
Nest substrate diameter at breast height	DBH	+
Nest height	Nht	–
Distance to nearest snag	Dsnag	–
Distance to nearest live tree	Dtree	–
2007 DNS models only		
Camera presence	CamY	+ / –

[a]Nest presence on a treatment site expected to positively influence success.

ΔAIC_c scores within 2 of the best model were considered to have strong support and were assigned Akaike weights (w_i) to quantify the degree of support for each. We used all candidate models with Akaike weights to calculate model-averaged variable coefficients and unconditional 95% confidence intervals (CIs). We calculated odds ratios for the model-averaged coefficients and 95% CIs, and we concluded that there was little evidence for the effect of a predictor variable on DNS when the odds ratios of the 95% CIs overlapped 1.0. All analyses were completed in R (R Development Core Team 2009), and all means are reported ± SE unless otherwise indicated.

RESULTS

Mean SPL values at artificial nests were significantly different between treatment (50.2 ± 0.5 dB[A]) and control sites (37.6 ± 0.5 dB[A], t = 18.32, df = 248, P < 0.001) and ranged from 31.3 to 47.4 dB(A) on control sites and 41.2 to 61.2 dB(A) on treatment sites. Of the GLMM candidate models, the top model for nest success included distance to the site center and SPL as fixed effects (Table 2), and this model fit the data (Hosmer-Lemeshow goodness-of-fit test, χ^2 = 7.62, P = 0.47). Two other models also received strong support (ΔAIC_c < 2); however, following model-averaging procedures,

only SPL had a strong, positive effect on nest success (odds ratio for the 95% CI did not overlap 1.0; Table 3), supporting results observed in natural nests (Francis et al. 2009). Nest success estimates increased with SPL, with ~20% of nests surviving at low SPL values around 30 dB(A) to >80% surviving at high SPL values >60 dB(A) (Fig. 1).

DNS models.—In 2006, one hundred artificial nests had an effective sample size of 806; the 150 artificial nests used in 2007 had an effective sample size of 1,482. For both years, several models had strong support (ΔAIC_c < 2) and the top models fit the data (Hosmer-Lemeshow goodness-of-fit tests: 2006, χ^2 = 4.96, P = 0.76; 2007, χ^2 = 4.16, P = 0.84; Table 4). Following model averaging, DNS was strongly influenced by site-type and nest substrate DBH in 2006 and SPL in 2007 (Table 5). All other model-averaged variable coefficients did not influence DNS because odds ratios for the 95% CIs overlapped 1.0 for each (Table 5).

In 2006, DNS decreased with substrate DBH, though the effect was small (β_{DBH} = –0.02 ± 0.01). The influence of site-type was much stronger ($\beta_{Treatment}$ = 1.04 ± 0.44), where DNS on treatment sites (0.75 ± 0.04) was 17% higher than DNS on control sites (0.58 ± 0.05; Fig. 2). In 2007, SPL positively affected DNS (β_{SPL} = 0.32 ± 0.11). For instance, DNS rates ranged from 0.21 at low SPL values to >0.99 at SPL values of 47 dB(A) and above (Fig. 2). For

Table 2. All mixed-effect models, plus nulls based on 250 artificial nests located in the Rattlesnake Canyon Habitat Management Area, northwest New Mexico, 2006–2007. K is the number of parameters in the model, AIC_c is Akaike's information criterion corrected for small sample size, ΔAIC_c is the difference in AIC_c values from the top-ranking model, and w_i is the Akaike weight, calculated for all models with strong support ($\Delta AIC_c < 2$). All models contained year and site as random effects.

Model[a]	K	AIC_c	ΔAIC_c	w_i
Dist, SPL	5	301.80	0.00	0.53
Dist, SPL, Site-type	6	303.36	1.56	0.24
SPL	4	303.41	1.61	0.23
SPL, Site-type	5	304.87	3.07	
Dist, Site-type	5	305.03	3.23	
Site-type	4	306.30	4.50	
Dist	4	306.45	4.65	
Null—random effects only	3	307.11	5.31	

[a]Abbreviations of variables are defined in Table 1.

Table 3. Mixed-effect model-averaged effect sizes (± SE) and odds ratios with 95% confidence intervals (CIs) for all variables present in supported models (ΔAIC_c < 2) for artificial nests in the Rattlesnake Canyon Habitat Management Area, northwest New Mexico, 2006–2007. Bold denotes variables considered to have a strong effect.

Variable[a]	Effect size and direction	Odds ratio	95% CI
Dist	–0.01 ± 0.01	0.99	0.97–1.01
SPL	**0.11 ± 0.05**	**1.12**	**1.01–1.23**
Site-typeT[b]	–0.20 ± 0.44	0.82	0.35–1.93

[a]Abbreviations of variables are defined in Table 1.
[b]Nest presence on a treatment site.

both years, DNS estimates were lower than estimates for natural nests (treatment sites, 0.99, 95% CI: 0.98–0.99; control sites, 0.97, 95% CI: 0.97–0.98; Francis et al. 2009), though 2007 DNS estimates for nests exposed to SPL values >47 dB(A) were similar to DNS values for natural nests on treatment sites.

Cameras and nest predators.—Cameras at artificial nests photographed predators at 6 of 11 depredated artificial nests. Because flashes were turned off during this experiment, it is probable that some of the undocumented predation events occurred at night. Additionally, at least one camera on a control site failed to document a predation event because of low batteries. Of the artificial nests with cameras, 8 of 10 on control sites were preyed upon, and only 3 of 10 on treatment sites were preyed upon. Western Scrub-Jays (*Aphelocoma californica*) accounted for four of the six photographed predation events, with
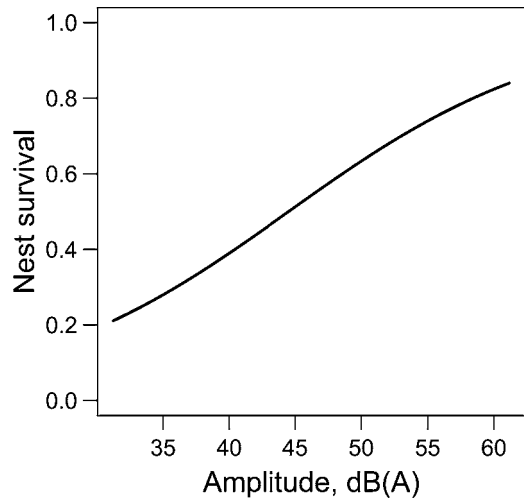

Fig. 1. Artificial-nest survival estimates increased with noise exposure (increased sound pressure level) for artificial nests located in the Rattlesnake Canyon Habitat Management Area, northwest New Mexico, 2006–2007. Estimates are based on model-averaged coefficients from all generalized linear mixed models with strong support ($\Delta AIC_c < 2$).

one on a treatment site and three on control sites. We also documented a Least Chipmunk (*Tamias minimus*) and a Steller's Jay (*Cyanocitta stelleri*) depredating artificial nests at a treatment site and a control site, respectively.

Discussion

Our results demonstrate that artificial-nest success increases with increased SPLs of gas-well compressor noise, which is consistent with results from natural nests (Francis et al. 2009). The DNS results for each year also support this finding. Because nests that lacked activity at the nest did not result in equivalent nest predation rates on treatment and control sites or with increases in SPL, these results suggest that predators may have lower abundances in noisy areas and provide evidence for a numerical predator response. We did not find strong support for a functional predator response due to the effects of noise; however, we cannot conclude that a numerical response is not coupled with a functional response. Of course, it is possible that reduced foraging efficiency (i.e., a functional response) may be a mechanism that causes predators to abandon noisy areas. A numerical reduction in predators with increased noise exposure may also be due to reduced number of prey. However, density of natural bird nests does not differ between treatment and

TABLE 4. All daily nest survival (DNS) models with $\Delta AIC_c < 4$, plus null models for artificial nest DNS in the Rattlesnake Canyon Habitat Management Area, northwest New Mexico. In 2006, one hundred artificial nests had an effective sample size of 806; in 2007, one hundred and fifty artificial nests had an effective sample size of 1,482. K is the number of parameters in the model, AIC_c is Akaike's information criterion corrected for small sample size, ΔAIC_c is the difference in AIC_c values from the top-ranking model, and w_i is the Akaike weight, calculated for all models with strong support ($\Delta AIC_c < 2$).

Model[a]	K	AIC_c	ΔAIC_c	w_i
2006				
DBH, Site-type	3	255.60	0.00	0.32
DBH, Site-type, SPL	4	256.53	0.93	0.20
DBH, Dsnag, Site-type	4	256.64	1.04	0.19
DBH, Dist, Site-type	4	256.98	1.38	0.16
DBH, Dsnag, Site-type, SPL	5	257.49	1.89	0.13
DBH, Nht, Site-type	4	257.68	2.08	
DBH, Dtree, Site-type	4	257.68	2.08	
DBH, Dist, Dsnag, Site-type	5	258.16	2.56	
DBH, Dist, Site-type, SPL	5	258.46	2.86	
DBH, Dtree, Site-type, SPL	5	258.60	3.00	
DBH, Nht, Site-type, SPL	5	258.62	3.02	
DBH, Dsnag, Nht, Site-type	5	258.72	3.12	
DBH, Dsnag, Dtree, Site-type	5	258.74	3.14	
DBH, Dist, Dtree, Site-type	5	259.03	3.43	
DBH, Dist, Nht, Site-type	5	259.08	3.48	
DBH, Dist, Dsnag, Site-type, SPL	6	259.52	3.92	
DBH, Dsnag, Dtree, Site-type, SPL	6	259.54	3.94	
Null	1	264.80	9.20	
2007				
Camera, Dist, Site-type, SPL	5	270.70	0.00	0.49
Dist, Site-type, SPL	4	271.60	0.90	0.31
Camera, Site-type, SPL	4	272.41	1.71	0.21
Site-type, SPL	3	272.87	2.17	
Camera, Dist, SPL	4	274.39	3.69	
Null	1	288.70	18.00	

[a] Abbreviations of variables are defined in Table 1.

control sites, though the composition of nesting species does (Francis et al. 2009). Because Western Scrub-Jays and other opportunistic predators prey upon nest contents from many species, this change in composition is unlikely to cause a numerical reduction in nest predators.

Artificial nest studies have been used in many vegetation types to identify predation pressures for nesting birds, yet they have some drawbacks, including different rates of nest predation than natural nests (Storaas 1988, Weidinger 2001, Pärt and Wretenberg 2002, Faaborg 2004, Villard and Pärt 2004). These differences have been attributed to lack of parental activity, which is precisely why we used artificial nests in the present study, and to differences in nest placement, nest material, and the size of eggs used as bait (Buler and

Hamilton 2000, Davison and Bollinger 2000). In our study, DNS estimates for artificial nests were lower than DNS estimates for natural nests, yet DNS estimates were also different for artificial nests between years, potentially reflecting the use of different sites in 2006 and 2007 or a longer and earlier (9 calendar days) exposure period for nests in 2006 than in 2007. Nevertheless, the pattern of higher predation on control compared with treatment sites and the increase in nest success with increased SPL was consistent between artificial and natural nests (Francis et al. 2009).

Motion-triggered cameras documented Western Scrub-Jays preying upon eggs in artificial nests in four of six photographed predation events, and three of these four events were at artificial nests on control sites. This limited sample is consistent

TABLE 5. Model-averaged effect sizes (± SE) and odds ratios with 95% confidence intervals (CIs) for all variables present in supported models (ΔAIC_c < 2) for daily nest survival of artificial nests in the Rattlesnake Canyon Habitat Management Area, northwest New Mexico, 2006–2007. Bold denotes variables considered to have a strong effect.

Variable[a]	Effect size and direction	Odds ratio	95% CI
2006			
DBH	**−0.02 ± 0.01**	**0.98**	**0.96–0.99**
Dist	0.00 ± 0.00	1.00	1.00–1.00
SPL	−0.02 ± 0.03	0.98	0.92–1.05
Dsnag	−0.01 ± 0.01	0.99	0.97–1.02
Site-typeT[b]	**0.88 ± 0.33**	**2.41**	**1.27–4.57**
2007			
CameraY	−0.45 ± 0.43	0.64	0.28–1.48
Dist	−0.01 ± 0.01	0.99	0.97–1.01
SPL	**0.32 ± 0.11**	**1.38**	**1.11–1.73**
Site-typeT[b]	−3.41 ± 2.44	0.03	0.00–3.94

[a] Abbreviations of variables are defined in Table 1.
[b] Nest presence on a treatment site.

with expectations, given the pattern of significantly lower Western Scrub-Jay occupancy on treatment sites than on control sites (Francis et al. 2009, Ortega and Francis 2012). However, our cameras did not photograph all predation events. Some undocumented events may have occurred at night and were not captured because flashes were turned off, but we cannot rule out the possibility that some of the cameras failed to trigger during diurnal predation events. Regardless, the majority of undocumented predation events at artificial nests paired with cameras occurred on control sites (4 of 5).

Our experiments showed decreased nest predation with increased noise exposure, independent of activity at the nest. Whether this pattern holds across other landscapes is unknown, yet because species' responses to noise can differ, nest predators in other landscapes may not respond negatively to noise, potentially leading to different nest predation patterns, such as higher nest predation in noisy areas. This possibility highlights the continued need for thorough field research at the community level when attempting to characterize the cumulative effects of anthropogenic noise or other factors that constitute human disturbance.
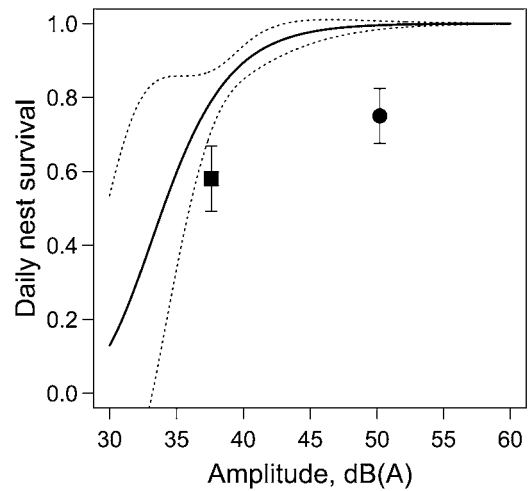
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FIG. 2. In 2006, the daily nest survival (DNS) estimate was lower for control sites (square) than for treatment sites (circle). The symbols are displayed at the mean sound pressure level (SPL) per site-type, and bars denote 95% confidence intervals (CIs) of DNS estimates. In 2007, SPL positively influenced DNS estimates for artificial nests. Dashed lines denote 95% CI bounds. Estimates were based on model-averaged parameter estimates from all models with strong support (ΔAIC_c < 2) for DNS models of artificial-nest success in the Rattlesnake Canyon Habitat Management Area, northwest New Mexico.

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