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Habitat Relations

Nesting Characteristics Of Mourning Doves in Central New Mexico: Response to Riparian Forest Change

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ABSTRACT Riparian forests of the American Southwest are especially prone to changes in composition and structure due to natural and anthropogenic factors. To determine how breeding mourning doves (*Zenaida macroura*) respond to these changes, we examined nest site use and nest survival in control plots, fuel reduction plots before and after mechanical thinning, and post-wildfire sites. The greatest number of nests (50%) were located in post-wildfire sites where resprouted vegetation and woody debris provided numerous nest sites in the understory. We found fewer nests in post-treatment fuel reduction plots (17%), where most were constructed in cottonwoods, and an intermediate number of nests in control and pre-treatment plots (33%), where most were constructed in exotic plants. The best-supported logistic-exposure nest survival model indicated that survival varied among years and with date. Models containing effects of forest type, study block, and nest site selection received little support, suggesting that survival was constant among plot locations, disturbance types, and nest sites. Our nest survival estimates were low relative to those from other studies, but productivity could offset mortality if adults make numerous nest attempts each year. Our results highlight the utility of woody vegetation and debris as understory nest sites for mourning doves and other riparian birds. Managers should devise methods to preserve or reestablish these nest sites when conducting fuel reduction, exotic vegetation removal, or post-fire restoration activities.

KEY WORDS fuel reduction, mourning dove, nest survival, New Mexico, riparian, wildfire, *Zenaida macroura*.

Riparian forests are critical to conservation of breeding bird populations in the American Southwest (Knopf and Sampson 1994, Rich et al. 2004). Owing to high levels of structural and species diversity in lowland riparian forests, this vegetation type provides greater numbers of nest sites for generalist and riparian specialists than adjacent upland habitats, resulting in high densities of breeding birds (Carothers et al. 1974, Knopf et al. 1988). These forests have received attention by land managers and researchers because they are subjected to changes in composition and structure brought upon by natural and anthropogenic factors (Stromberg et al. 2010). For centuries, humans have altered disturbance regimes along southwestern rivers by decreasing the magnitude and frequency of floods and introducing novel disturbances such as intensive livestock grazing, wildfire, and manual vegetation removal (Busch 1995, Periman and Kelly 2000). In response, flood-dependent native vegetation has declined in some areas and has been replaced by exotic species, such as Russian olive (*Elaeagnus angustifolia*) and saltcedar (*Tamarix ramosissima*), that are better adapted to altered conditions (Howe and Knopf 1991, Busch and Smith 1995, Shafroth et al. 2002). Previous studies have found that changes to riparian forests have increased nesting densities of some bird species, such as Bewick's wrens (*Thryomanes bewickii*) and other species that occupy dense vegetation, but have decreased densities of others, such as yellow-billed cuckoos (*Coccyzus americana*) and other broadleaf-obligates (Hunter et al. 1987, Taylor 2003, Sogge et al. 2008). Few studies, however, have compared nest site use and nest survival between areas undergoing multiple disturbances. This information is required to understand how changes in structure and composition influence bird populations (Martin 1992).

Mourning dove (*Zenaida macroura*) populations have declined in many areas of the United States including the Central Management Unit (CMU; Baskett 1993, Dolton et al. 2007, Sauer et al. 2008). In the western United States, declines in mourning dove productivity have been linked to changes in natural and anthropogenic habitats that lower nest site availability (Miller et al. 2001). New Mexico is 1 of 2 states within the CMU where dove populations have increased in recent years (Dolton et al. 2007) or remained relatively stable (Sauer et al. 2010). These trends suggest that nest sites have remained abundant and juvenile survival rates

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are high enough to compensate for adult mortality. Riparian forests provide much of the nesting habitat for mourning doves and other land bird species in arid portions of the CMU (Carothers et al. 1974, Drobney et al. 1998, Hayslette et al. 2000). An understanding of factors affecting nest site availability, nest site use, and nest survival of mourning doves in riparian forests is needed to understand population trends in New Mexico.

The riparian forests of the Middle Rio Grande in central New Mexico provide an ideal opportunity to examine the effects of vegetation change on mourning dove reproduction. During the last century, magnitude and spatial extent of flooding has decreased, lowering recruitment of flood-dependant, native plants (Howe and Knopf 1991). At the same time, exotic vegetation and woody debris have accumulated in the forest understory. These changes have contributed to increased frequency of catastrophic wildfire (Stuever et al. 1995, Molles et al. 1998). Managers have begun mechanical clearing of exotic vegetation and woody debris to reduce fuel loads and restore a native-dominated forest along the Middle Rio Grande. Such activities drastically change the structure and composition of the forest and alter the density of various animals (Bateman et al. 2008). Wildfire also alters the structure and composition of riparian forests, creating shrub-like conditions that support high densities of generalist birds including mourning doves (Busch 1995, Smith et al. 2009*a*, Stromberg et al. 2009). To examine nesting biology of mourning doves in response to changes in structure and composition, we monitored nests in undisturbed riparian forest plots, plots cleared for fuel reduction, and post-wildfire sites. Our objectives were to 1) determine if nest site use differs between forest types, 2) compare nest survival among forest types, and 3) identify factors influencing nest survival.

STUDY AREA

We established study sites along the Middle Rio Grande in central New Mexico (Fig. 1), where humans have made extensive changes to hydrology and vegetation to increase agricultural production and support population growth. Historically, multi-aged stands of flood-dependant species, such as Rio Grande cottonwood (*Populus deltoides wislizenii*) and willow (*Salix* spp.), were created when germination sites were left exposed throughout the floodplain by flooding and channel movement. In the early 20th century, levees, channel stabilization devices, and conveyance canals were installed to reduce flood damage and provide irrigation. The completion of Cochiti Dam in 1974 further reduced the frequency and intensity of floods (Howe and Knopf 1991, Scurlock 1998). Because of these changes, cottonwood stands are largely confined between the levees and undergo little to no recruitment (Howe and Knopf 1991, Molles et al. 1998).

As part of a large-scale fuel reduction experiment, we divided the study area into three blocks (Smith et al. 2009*b*). The north block was located in Bernalillo County on land owned and managed by City of Albuquerque Open Space and the Middle Rio Grande Conservancy District (MRGCD). The middle block was in Valencia and Socorro Counties on MRGCD land and the south block was in Socorro County on MRGCD land and Bosque Del Apache National Wildlife Refuge (Fig. 1A). Each experimental block contained 1 control plot and 3 fuel reduction treatment plots. Fuel reductions were applied between 2002 and 2005 (Table 1) and involved manual clearing of exotic vegetation and woody debris from the understory (Smith et al. 2009*b*).

Control and pre-treatment plots typically consisted of a cottonwood canopy with some Goodding's willow (*Salix gooddingii*) also present in the canopy. Some exotic trees including Siberian elm (*Ulmus pumila*) and white mulberry (*Morus alba*) were in the canopies of the north and middle blocks. Saltcedar and Russian olive were the most common exotic plant species and grew as large shrubs or small trees (Fig. 2A). Russian olive is the dominant exotic species in the north reaches of the Middle Rio Grande and saltcedar is dominant in the south (Mortenson and Weisberg 2010).

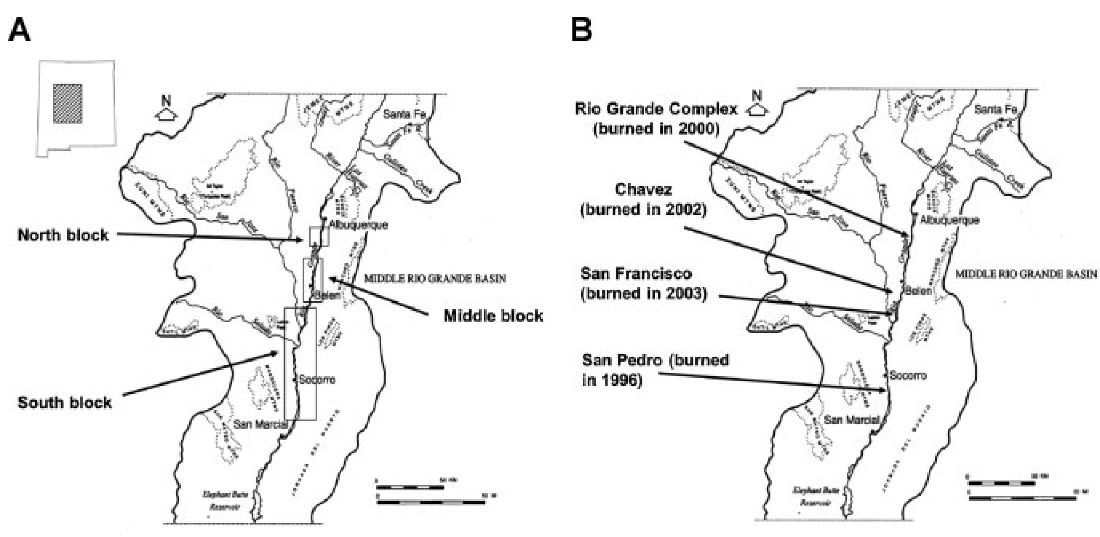

Figure 1. Location of (A) fuel reduction blocks and (B) post-wildfire sites in the Middle Rio Grande study area, New Mexico where we monitored mourning dove nests from 2000 to 2007. Each block contained 1 control plot and 3 fuel reduction plots.

Table 1. Treatment status and number of mourning dove nests found at control and fuel reduction (FR) plots along the Middle Rio Grande, New Mexico from 2000 to 2007.

				Years searched		Number of nests per year	
Plot	Plot type	Size (ha)	Treatment year	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
NO1[a]	Control	16.1		2000–2007		1.1	
NO2	FR	18.3	2002	2000–2002	2003–2007	1.7	1.0
NO3	FR	17.0	2003	2000–2003	2004–2007	1.8	0.8
NO4	FR	23.4	2002	2000–2002	2003–2007	2.0	1.4
MI1	FR	19.4	2003	2000–2003-	2004–2007	0.8	0.3
MI2	FR	29.2	2004	2000–2004	2005–2007	4.6	2.0
MI3	FR	13.2	2003	2000–2003	2004–2007	1.5	4.3
MI4–MI7[b]	Control	35.0		2000–2007		6.8	
SO1	Control	28.9		2000–2007		3.5	
SO2	FR	15.5	2002	2000–2002	2003–2007	1.7	2.2
SO3	FR	26.7	2002	2000–2002	2003–2007	2.3	2.4
SO4	FR	15.5	2002	2000–2002	2003–2007	1.0	3.6

[a] Control plots did not receive fuel reduction treatments.
[b] The MI4 control plot was burned by a wildfire in 2002 and subsequently replaced by MI7.

Native shrubs included coyote willow (*Salix exigua*), screwbean mesquite (*Prosopis pubescens*), and New Mexico desert-olive (*Forestiera pubescens*). Following fuel reduction treatments, cottonwood was the dominant woody species in each plot, though several species of native trees and shrubs remained present in the understory (Fig. 2B; Smith et al. 2009*b*).

In addition to undisturbed and fuel reduction plots, we collected data in post-wildfire sites that had burned in the middle and south study blocks prior to and during our study period (Fig. 1B). The oldest burn occurred in 1996 and the most recent in 2003 (Table 2). The area of post-wildfire study sites varied from 6.1 ha to 31.4 ha (Table 2). Fires in this forest, which were typically ignited accidentally, top-killed most trees and shrubs (Fig. 2C; Stuever 1997, Smith et al. 2009*a*). At the sites we monitored, some large trees and shrubs survived where fire intensity was low, but most cottonwoods were top-killed (D. M. Smith, U.S. Department

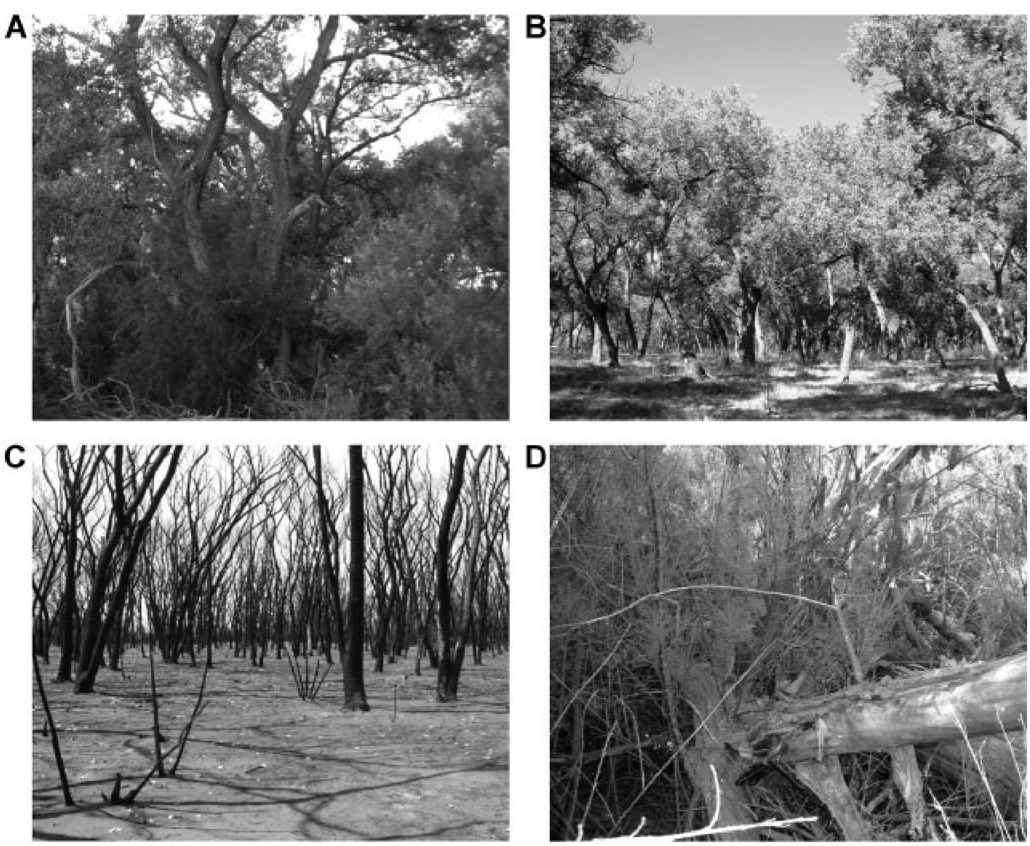

Figure 2. Forest types where we monitored mourning dove nests along the Middle Rio Grande, New Mexico from 2000 to 2007. A: Typical undisturbed plot with cottonwood canopy and dense exotic vegetation in the understory. B: Fuel reduction site 5 years after treatment with little woody vegetation in the understory. C: Recently burned wildfire site with all vegetation top-killed. D: Post-wildfire site 6 years after burn with resprouted exotic vegetation growing around fallen woody debris.

Table 2. Year of fire, study area size, search effort, and number of mourning dove nests found in wildfire plots along the Middle Rio Grande, New Mexico from 2001 to 2007

Plot	Wildfire name	Year of fire	Size (ha)	Years searched	Number of nests per year
MI5	Rio Grande Complex	2000	22.3	2001–2003	3.3
MI6	Rio Grande Complex	2000	31.4	2001–2007	14.7
MI4	Chavez	2002	9.4	2003–2007	8.6
BR1	San Francisco	2003	38.0	2005–2007	18.0
SO5	San Pedro	1996	22.1	2002–2004, 2006–2007	1.8
SO6	San Pedro	1996	6.1	2002–2007	1.5

of Agriculture Forest Service, personal observation). During the first year following fire, cottonwood, saltcedar, and other woody species resprouted, forming shrub-like stands (Smith et al. 2009*a*). Woody debris accumulated in these sites when bark, branches, and trunks of cottonwoods fell to the ground (Fig. 2D).

METHODS

Nest Monitoring

From 2000 to 2007, we searched for and monitored nests of all species encountered in the study area. A crew of technicians visited each study plot at least once per week to search for nests from late April to late August in the morning and early afternoon. Crew members rotated among research sites to avoid detection biases between forest types. We located mourning dove nests by flushing or observing adults on nests. Upon discovery of a nest, we marked a location >5 m from the nest with flagging tape and recorded the position with a Global Positioning System receiver. We wrote the direction to the nest on the flagging tape to allow revisits until the nest attempt was complete. Because of the large size of the study area, we were unable to revisit nests at regular frequencies. Intervals between nest checks varied from 1 to 19 days, with an average length of 4.8 days. To ensure that we determined nest fates accurately, multiple observers visited each nest, including some with many years of experience in the study area. When nests were too high to observe their contents, we used binoculars to look for incubating or brooding adults, which rarely leave nests unattended (Westmoreland et al. 1986). We assumed that empty nests were successful if we had previously observed nestlings $\geq$10 days old (Miller et al. 2001), we observed fledglings near a nest around the time they were expected to fledge, or we observed fecal material inside the nest. We assumed that nests were unsuccessful if they were empty before nestlings reached 10 days in age, the nest appeared greatly disturbed, or we observed remains of eggs or nestlings. To prevent underestimation of survival rate, we did not include nests in our survival analyses if they were abandoned during nest building or failed due to human interference, following guidelines by Miller et al. (2001). Upon completion of each nesting attempt, we identified the nest substrate, recorded nest plant condition (live or dead), and measured nest height, using a clinometer when necessary.

Statistical Analyses

We calculated means and 95% confidence intervals to compare nest height between forest types (control, pre-treatment fuel reduction, post-treatment fuel reduction, and wildfire). We also calculated percent use of substrates by doves across the study area separately for each block. Nest substrate classes were cottonwood, Russian olive, and saltcedar for nests constructed in these species, the 3 most abundant in the study area. We classified nest substrates that were less common plant species and human-produced structures as other, dead trees and shrubs as snags, and fallen logs or bark as fallen debris.

We used the logistic-exposure method developed by Shaffer (2004) in SAS PROC GENMOD (SAS Institute, Inc., Cary, NC) to estimate daily survival rate (DSR) of nests and determine if temporal, plot-scale, or nest-site variables best explained variation in DSR. In the first stage of model selection, we constructed models with various combinations of 3 temporal variables: categorical effects of year, linear effects of date, which was based on mean date across a nest check interval (Shaffer 2004), and quadratic effects of date. We used PROC GENMOD to select which models best fit the data (Shaffer 2004). We calculated Akaike's Information Criteria adjusted for sample size (AIC_c) to select the best-supported model. We ranked all models using ΔAIC_c and Akaike weights (w_i), and we considered models with $\Delta AIC_c \leq 2$ to be well supported by the data (Burnham and Anderson 2002).

In the second stage of model selection, we tested for effects of forest type and nest site on nest survival. We constructed plot-scale models containing categorical effects of forest type to determine if survival was affected by fuel reduction or wildfire. We included an additional plot-scale model containing categorical effects of study block location to account for effects of unmeasured variables that varied between reaches of the study site (north, middle, and south). We also constructed nest site models containing categorical effects of nest substrate and linear effects of nest height. We included the best-supported temporal model as a null model in the second set, along with the global model containing all variables. We tested goodness-of-fit of the global model using the Hosmer and Lemeshow test (2000).

We used the ESTIMATE function in SAS to calculate DSR and 95% confidence intervals from the best-supported nest survival model from the second selection stage, incorporating temporal variables into estimates where these effects were supported (Shaffer and Thompson 2007). We adjusted DSR to period survival, the predicted survival rate for a given period, by raising DSR to the power of 27, the number of days in the mourning dove nesting cycle (Westmoreland et al. 1986, Ehrlich et al. 1988, Miller et al. 2001).

RESULTS

We observed 456 mourning dove nest attempts. Of these nests, 50% were located in post-wildfire sites, 19% were in control plots, 14% were in pre-treatment fuel reduction plots, and 17% were in post-treatment fuel reduction plots. We located the greatest number of nests per year in the San Francisco post-wildfire site (Table 2) and the lowest in a pre-treatment and post-treatment fuel reduction plot (MI1; Table 1). Overall, mean number of nests located per year was greatest for post-wildfire sites (8.0), intermediate in control plots (3.8) and lowest in pre-treatment (1.9) and post-treatment (2.0) fuel reduction plots. Nest height was greatest in post-treatment fuel reduction plots (mean = 4.96 m, 95% CI: 4.06–5.85 m), lowest in post-wildfire sites (mean = 2.11 m, 95% CI: 1.92–2.29 m), and intermediate in control (mean = 2.65 m, 95% CI: 2.29–3.01 m) and pre-treatment fuel reduction (mean = 2.67 m, 95% CI: 2.11–3.22 m) plots. Nest substrate differed between forest types and study blocks (Table 3). In control plots, snags were the substrates most frequently used in the north, Russian olives were most frequently used in the middle, and cottonwoods were most frequently used in the south. Russian olives were the substrates most frequently used in the north and middle fuel reduction plots pre-treatment, and saltcedars were the most frequently used substrates in the south pre-treatment plots. Most nests in post-treatment fuel reduction plots were constructed in cottonwoods, regardless of block. Most nests at post-wildfire sites in the middle block were constructed in fallen debris whereas most were constructed in cottonwoods in the south block post-wildfire sites (Table 3).

We located 325 nests with data sufficient for logistic-exposure analysis. Apparent survival (% successful/total nests) of these nests was 33%. The goodness-of-fit test showed that the global nest survival model adequately fit the data ($\chi^2 = 5.02$, $P = 0.76$). In the first stage of model selection, effects of year and quadratic effects of date received the most support, followed by quadratic effects of date alone (Table 4). In our second stage of model selection, the best-supported temporal model from the first stage also received the most support (Table 5). Using the best-supported temporal model, DSR estimates ranged between 0.869 and 0.949 among years, which corresponds to period survival rates of 2.3% and 24.2%, respectively. In most years, however, confidence intervals were large, indicating low precision of these estimates (Fig. 3) Estimates across the range of nesting season dates showed that nest survival declined toward the middle of the season and increased toward the end (Fig. 4). Confidence intervals were generally smaller for date than for year effects (Fig. 4).

DISCUSSION

We found evidence that changes in composition and structure of riparian vegetation, brought upon by fuel reduction and wildfire, affected nest site use by mourning doves. We did not; however, find meaningful differences in nest survival between forest types or nest sites, a pattern found in several other studies of mourning doves (Miller et al. 2010). These results suggest that changes in riparian forest structure and composition influence productivity by altering nest site availability, but not nest survival rates.

Table 3. Percent use of nest substrates by mourning doves at control plots, fuel reduction plots, and post-wildfire sites along the Middle Rio Grande, New Mexico from 2000 to 2007.

Block	Substrate	Percent use control	Percent use pre-fuel reduction	Percent use post-fuel reduction	Percent use post-wildfire[a]
All (n = 456)	Fallen woody debris	3.4	14.3	6.5	29.5
	Russian olive	31.5	25.4	1.3	13.2
	Cottonwood	23.6	11.1	64.9	15.4
	Saltcedar	13.5	36.5	2.6	20.3
	Snag	19.1	7.9	6.5	15.9
	Other[b]	9.0	4.8	18.2	5.7
North (n = 40)	Fallen woody debris	0	5.9	0	
	Russian olive	11.1	41.2	0	
	Cottonwood	11.1	5.9	71.4	
	Saltcedar	11.1	29.4	0	
	Snag	44.4	11.8	7.1	
	Other	22.2	5.9	21.4	
Middle (n = 261)	Fallen woody debris	3.8	16.1	0	31.6
	Russian olive	42.3	29.0	0	16.1
	Cottonwood	21.2	16.1	73.9	7.1
	Saltcedar	11.5	22.6	0	20.0
	Snag	13.5	9.7	8.7	17.4
	Other	7.7	6.5	17.4	7.7
South (n = 155)	Fallen woody debris	3.6	20.0	12.5	25.0
	Russian olive	17.9	0	2.5	6.9
	Cottonwood	32.1	6.7	57.5	33.3
	Saltcedar	17.9	73.3	5.0	20.8
	Snag	21.4	0	5.0	12.5
	Other	7.1	0	17.5	1.4

[a] There were no post-wildfire sites in the North Block.
[b] The category "other" includes the substrates New Mexico olive, ground, human-made structure, screwbean mesquite, coyote willow, Siberian elm, and vine.

Table 4. Model selection results for temporal effects on mourning dove nest survival along the Middle Rio Grande, New Mexico from 2000 to 2007.

Model[a]	K[b]	ΔAIC_c [c]	w_i [d]
Year date^2	10	0.0	0.58
Date^2	3	1.66	0.25
Year	8	3.91	0.08
Year date	9	5.28	0.04
Date	2	5.91	0.08
Constant	2	7.60	0.07
Year X date	16	13.83	0.001

[a] Model terms are: Date = linear effect of mean interval date; Date^2 = quadratic effect of interval date; Year = year of nesting attempt; Constant = no temporal effects.
[b] K = number of estimated model parameters.
[c] ΔAIC_c = difference in Akaike's Information Criteria from the best model in each set.
[d] w_i = Akaike weight.

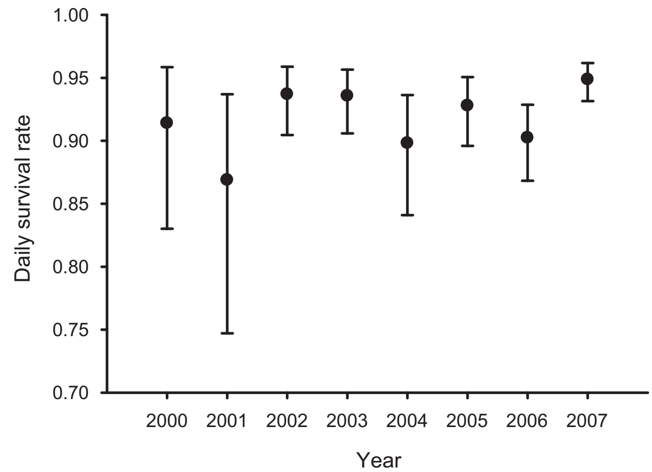

Figure 3. Estimates of daily nest survival rate of mourning doves across years derived from the best-supported logistic-exposure model from 2000 to 2007 along the Middle Rio Grande, New Mexico.

Control and pre-treatment fuel reduction plots provided a diversity of nest sites for mourning doves. Doves nested at a range of heights in large cottonwood trees and in smaller exotic trees such as Russian olive and saltcedar. Doves constructed a high percentage of nests in Russian olive, which was the most abundant exotic species in the north and middle blocks. Similarly, Stoleson and Finch (2001) found disproportionately high use of Russian olive by mourning doves along the Gila River in southwestern New Mexico, suggesting high preference for this nest plant species, along with similar-sized native species. Saltcedar was the most commonly used substrate at the south block pre-treatment fuel reduction plots, where it is more abundant than Russian olive. Frequent use of Russian olive and saltcedar indicates that these plant species are attractive nest sites for mourning doves, even in the presence of native species. Logistic-exposure nest survival results showed no differences for nest survival among substrates, indicating that nest survival was similar between nests constructed in native and exotic plants. These results support recent findings (Jones and Bock 2005, Sogge et al. 2008, Smith et al. 2009*b*) that exotic vegetation can provide suitable nesting habitat for certain species of birds in the American Southwest because it provides nest sites without compromising nest survival.

Removal of exotic vegetation from the understory of fuel reduction plots decreased the number of potential nest sites for mourning doves and other species (Bateman et al. 2008, Smith et al. 2009*b*). Unsurprisingly, mean nest height and use of cottonwood increased following fuel reduction. We found fewer nests in post-treatment than pre-treatment fuel reduction plots in the north and middle blocks, but fewer nests in pre-treatment plots in the south block. This observation suggests that fuel reduction did not have a consistent effect on nest density. However, our study was not designed to evaluate detectability of nests in different forest types, so we cannot make conclusions about the effects of fuel reduction on number of nesting opportunities available to mourning doves. Fuel reduction does result in decreased density of understory-nesting birds in riparian (Bateman et al. 2008), deciduous (Tomcho et al. 2006, Hache and Villard 2010), and coniferous forests (Hurteau et al. 2008). Nest density of mourning doves likely decreased in the understory of our fuel reduction plots following treatment. If fuel reduction plots are not subject to future disturbances,

Table 5. Model selection results for temporal, plot-level, and nest-site effects on mourning dove nest survival along the Middle Rio Grande, New Mexico from 2000 to 2007. The full model set contained 9 models, but only models with ΔAIC_c[a] < 10.0 are shown.

Model[b]	K[c]	ΔAIC_c	w_i [d]
Year Date^2	10	0	0.96
Block	3	8.22	0.02
Height	2	8.90	0.01

[a] ΔAIC_c = difference in Akaike's information criteria from the best model in each set.
[b] Model terms are Block = study block (North, Middle, or South); Height = nest height; Date^2 = quadratic effect of date; Year = year of nesting attempt.
[c] K = number of estimated model parameters.
[d] w_i = Akaike weight.

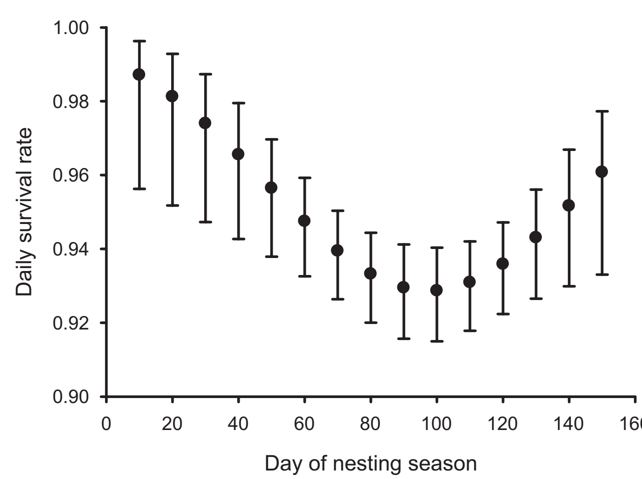

Figure 4. Estimates of daily nest survival rate of mourning doves across the range of interval dates derived from the best-supported logistic-exposure model from 2000 to 2007 along the Middle Rio Grande, New Mexico.

nest density in this layer will increase over time as woody vegetation and debris accumulate in the understory.

Wildfire disturbance differed from fuel reduction in its effects on vegetation structure and nest site availability for mourning doves. Native and exotic woody vegetation was top-killed by fire but quickly resprouted, making nest sites available 1 year post-burn (Smith et al. 2009*a*). As time since fire increased, the number of understory nest sites accumulated when branches and pieces of bark fell from cottonwood snags into resprouted vegetation. The fallen debris provided stability and the resprouts provided cover, factors that are important for mourning dove nest survival (Coon et al. 1981). Previous studies in western riparian and chaparral vegetation have also shown that increases in low woody vegetation following fire increase density and nest site availably of understory-nesting species (Gardali et al. 2003, Mendelsohn et al. 2008). These results suggest that mourning doves and other understory-nesting birds along the Middle Rio Grande benefit from increased nest site availability, brought upon by changes to vegetation structure following wildfire. Lack of support for logistic-exposure models containing effects of forest type indicates that mourning dove nest survival is not reduced in post-wildfire nest sites, as we have found with other species nesting along the Middle Rio Grande (Smith et al. 2007, 2009*b*).

Our nest survival estimates were relatively low compared to those reported in other studies. The overall apparent survival rate of 33% was greater than the rate of 13% estimated by Best and Stauffer (1980) in riparian woodlands in Iowa but lower than 43% estimated by Westmoreland and Best (1985) in Iowa windbreaks and 37–40% estimated in Missouri woodlands by Drobney et al. (1998). Our logistic-exposure period survival estimate for the mean interval date was of 13.6% and was lower than Mayfield nest survival estimates from a subset of nests experimentally disturbed by investigators in Iowa (15%; Westmoreland and Best 1985), lower than Mayfield estimates in California (22–45%; Miller et al. 2001) and Maryland (21–68%; Coon et al. 1981, Nichols et al. 1984) woodlands, and lower than in Kansas grasslands (32–49%; Hughes et al. 2000). These comparisons suggest that nest survival is lower along the Middle Rio Grande than in other areas of the United States, which is unexpected, given increasing population trends in New Mexico (Dolton et al. 2007). We may have biased our estimates by flushing birds off of nests while searching or checking their contents, thereby reducing nest survival (Westmoreland and Best 1985). Alternately, the length of the mourning dove breeding season along the Middle Rio Grande, may allow numerous nesting attempts, which would balance mortality. We have observed active nests in the study area from late March to late August (D. M. Smith, unpublished data) and mourning doves have many adaptations to maximize number of nest attempts in a nesting season (Westmoreland et al. 1986). Information about the number of attempts made by mourning doves along the Middle Rio Grande is needed to fully understand productivity in this region.

Our model selection procedures indicated that temporal variables had the greatest effect on nest survival. Daily survival rate estimates varied among years and across the nesting season. With year held constant, survival decreased towards the middle of the nesting season, then increased towards the end. This pattern could be explained by intra-season variation in climate, nest predator activity, or availability of their alternate prey. Climate has been shown to have a large effect on mourning dove nest survival (Coon et al. 1981, Miller et al. 2001), and likely has a greater effect than forest composition or structure (Miller et al. 2010). Weather patterns varied considerably within years of our study (Smith et al. 2009*a*). Average temperature typically peaks at the beginning of summer in central New Mexico, then decreases with the start of the monsoon (Smith et al. 2009*a*), a pattern opposite to that of nest survival. Cool and wet weather has been shown to limit nest density and nest survival of mourning doves at other sites (Miller et al. 2001, 2010), but high temperatures and drought can limit nest density and cause nest failure as well (Bolger et al. 2005, Chase et al. 2005). Further research comparing weather patterns to nest survival across river systems is needed to determine effects of climate on nest survival of mourning doves in the American Southwest. In addition, causes of nest failure should be identified to determine if weather directly causes mortality of eggs or nestlings or if weather indirectly affects nest survival by altering nest predator activity, as has been indicated by other studies (Martin 2007, Moynahan et al. 2007). Identification of nest predator species, as well as knowledge of their response to variation in climate will provide important insights into causes of nest failure of mourning doves and other species in southwestern riparian forests.

MANAGEMENT IMPLICATIONS

Our results show that wildfire and fuel reduction have very different effects on nest site availability for mourning doves along the Middle Rio Grande. Because fuel reduction reduces the number of potential nest sites in the forest understory, managers interested in preserving current population sizes of mourning doves or other understory-nesting species should ensure that native woody plants, such as Goodding's willow and young cottonwoods, remain in the understory to provide nest sites for doves and other species. When wildfires occur, managers could increase nest site availability for understory-nesting birds by allowing post-wildfire sites to recover without removal of debris and resprouted shrubs. Because nest survival rates along the Middle Rio Grande were relatively low, mourning doves must have opportunities to attempt several nests each year to offset losses to mortality. Future studies along the Middle Rio Grande should therefore focus on the effects of forest structure and composition on number of nests attempted by mourning doves. Information from such studies is needed to develop riparian management practices that prevent decreases in productivity.

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