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REPRODUCTIVE SUCCESS AND NEST DEPREDATION OF THE FLORIDA SCRUB-JAY

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ABSTRACT.—The Florida Scrub-jay (*Aphelocoma coerulescens*) is listed as a threatened species primarily because of habitat loss throughout much of its range. The Ocala National Forest in Florida contains one of three main subpopulations that must be stable or increasing before the species can be considered for removal from federal listing. However, little information is available on Florida Scrub-jay reproductive success or predation pressure on this forest. I used video cameras during 2002 and 2003 to identify nest predators and timing of predation events. The presence of the video system did not significantly affect the rate of nest abandonment. Thirteen nests were video-monitored of which one was abandoned, five experienced no predation, three were partially depredated, and four had total loss of nest contents. Snakes were responsible for more losses from predation than either mammals or birds. I monitored 195 other scrub-jay nests (no video-monitoring) and measured the mean number of eggs, nestlings, and fledglings produced per breeding pair. No significant difference in reproductive success was detected between years or between year and helper status. Groups with helpers produced significantly more fledglings (0.5 per breeding pair) and had higher daily survival rates of nests in the egg stage, nestling stage, and the entire breeding season than groups lacking helpers. *Received 15 July 2005. Accepted 7 October 2006.*

The Florida Scrub-jay (*Aphelocoma coerulescens*), federally listed as a threatened species, occurs primarily on lands containing fine, well-drained soils along Florida's coastline, and on ancient sand dune ridges in the interior of peninsular Florida. They are monogamous cooperative breeders living in groups on year-round territories. Groups contain a mated pair and as many as six helpers that may be related to one or both members of the breeding pair (Sprunt 1946, Woolfenden 1978). Helpers do not build nests, incubate, feed the incubating female, or brood, but do feed nestlings and fledglings, and also participate in mobbing possible predators (Woolfenden and Fitzpatrick 1984). Pairs will renest if the nest is lost in an effort to produce one brood of fledglings per breeding season (Woolfenden and Fitzpatrick 1984). Preferred habitat consists of dense thickets of scrub oaks (*Quercus* spp.) <3 m tall with bare sand substrate between them and may develop after land has been burned, harvested, or otherwise cleared. The amount of new habitat currently is inadequate and, coupled with conversion of existing habitat for silviculture, agriculture, commercial as well as residential development, has led to an overall reduction in the amount of suitable scrub-jay habitat (Fitzpatrick et al. 1991).

The Ocala National Forest in Florida has a crucial role in the recovery of this species. Three meta populations, Ocala National Forest, Merritt Island/Cape Canaveral, and Lake Wales Ridge (Archbold Biological Station near Lake Placid, Florida), must be stable or increasing before the species can be considered for delisting by the U.S. Fish and Wildlife Service (U.S. Department of Interior [USDI] 1990). The Florida Scrub-jay is limited geographically because of its specific habitat requirements. The population on the Ocala National Forest was estimated to be 2,600–3,400 birds in the 1980s (Cox 1987); current estimates are 851 groups with 2,341 birds (L. S. Lowery, pers. comm.). Information is needed for the Ocala National Forest population on optimal habitat conditions, survival of young and adults, nesting, reproductive success, dispersal, mortality, predation, and territory configuration. A preliminary study in 2001 indicated nest loss was high and mean (± SE) reproductive success was only 2.25 ± 0.31 fledglings/successful nest (n = 8) or 0.60 ± 0.20 fledglings/nesting pair (n = 30; KEF, unpubl. data). Woolfenden and Fitzpatrick (1984) suggested that most nest losses are the result of nest predation. The objectives of my study were to: (1) examine whether pre-

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dation pressure was affecting nesting success; (2) identify whether year or the presence of helpers affected reproduction in the egg stage, nestling stage, or in the number of fledglings produced per breeding pair; and (3) evaluate nest success (daily survival rate of nests) in different stages of the nesting cycle comparing 2002 to 2003 and nests with helpers to those without helpers.

METHODS

Study Area and Banding.—The study was conducted on the Ocala National Forest between Gainesville and Daytona Beach, Florida in Marion, Lake, and Putnam counties. Scrub-jays were trapped using a modified Potter trap and banded with federal aluminum bands and a unique combination of plastic colored leg bands to facilitate field identification. Approximately 69% of video-monitored nests and 30% of observer-monitored nests had pairs in which at least one member was banded. All nestlings in monitored nests were banded if they survived to 10 days of age.

Data Collection.—Nests were selected by randomly driving or walking slowly along sandy, one-lane tracks that are numerous in the area until a group of jays was detected and then observing the birds to locate the nest. Thus, most nests were relatively close to one-track roads, which provided efficient access to territories and nests. There was little human foot traffic to disturb nesting birds or to influence predator movement patterns. Camera equipment was placed under concealing vegetation to minimize the likelihood that equipment would be observed, disturbed, or stolen.

Nests were monitored using two Fieldcam LDTLV video recording systems that consisted of a Sony SVT-LCc300 time lapse videocassette recorder (VCR) in a weatherproof case and a MicroCam 2 black-and-white infrared camera equipped with infrared emitters for night recording (Fuhrman Diversified, Inc., Seabrook, TX, USA) (use of brand names does not convey a recommendation of the product by the U.S. Forest Service). Cameras were mounted on an articulated arm for nests monitored in 2002. A 20-m cable connected the camera to the VCR, which was powered by one or two 12-volt deep-cycle batteries (two batteries if the recording session was going to last longer than 48 hrs). The camera was attached immediately adjacent to the nest shrub and positioned so it was on average 46 cm from the nest. Camera height varied from being level with the nest to as high as 46 cm above it depending on how the branches were arranged close to the nest. The cable connecting the camera to the VCR was placed on top of small shrubs to prevent damage by rodents. I attached the camera directly to a branch above the nest on the shrub in 2003. Placing the camera equipment at a nest required between 5 and 15 min. I replaced video cassettes (T-160) and batteries every 48–72 hrs. Battery replacement required about 5 min. There were no obvious displays of distress by the birds during that time. The lack of agitation was attributed to the VCR being 15–20 m from the nests so the observer did not have to visit the nest itself other than to install the camera on the initial visit. The VCR recorded images at a rate of one every 0.083 and 0.150 sec when operating in 48- and 72-hr modes, respectively.

I monitored 13 Florida Scrub-jay nests (6 in 2002 and 7 in 2003) between 2 May and 7 July 2002, and 9 April and 5 May 2003. One of these nests, monitored during the egg stage from 10 to 11 May 2002, was abandoned the day after the camera was installed. This nest was not included in the predation analysis. Considering the 13 nests, seven had both members of the pair banded, two had one member banded, and four had neither pair member banded. No pairs were monitored in both 2002 and 2003.

The video camera systems were installed either during incubation (n = 11) or after the eggs had hatched (n = 2). Three types of depredation events were characterized in this study: a total depredation event in which all nest contents were taken at the same time; a partial depredation event in which a predator took only part of the nest contents; and a sequential-complete depredation event when one or more predators visited the same nest multiple times until all the nest contents had been removed.

An observer periodically visited the 195 other nests (73 in 2002 and 122 in 2003) that were not video equipped approximately every 3 days, more frequently around the expected date of hatching or fledging. The observer recorded the number of eggs present, number of eggs hatched, number of nestlings, and number of fledglings. These same variables were obtained for video-monitored nests by analyzing content of the video tapes. It is possible that in some cases one or more eggs were removed from the nest before the nest was first observed. Brown-headed Cowbird (*Molothrus ater*) nest parasitism does not appear to be a problem for this species. The number of fledglings was ascertained by frequent visits to the nest around the anticipated time of fledging. Nests that failed to fledge young were distinguished from successful nests by looking for indications the nest had been disturbed or damaged, and by looking for direct evidence of depredation such as loose feathers. Evidence of fledging included feces on the edge of the nest or on the ground beneath it. Occasionally a fledgling was observed in the nest site area immediately after the suspected fledging event, but more often they were seen at a later date and identified because they were banded.

Daily Survival Rates and Exposure Days.—I used the Mayfield method (Mayfield 1961, 1975) to assess nest success. The number of days that each nest is observed and is subject to failing is referred to as exposure days. Dividing the number of nests known to have failed by the sum of the total exposure days results in the daily mortality rate (DMR) or probability the nest will fail on any day. The daily survival rate (DSR), defined as the probability of the nest contents (at least one egg or nestling) surviving from one day to the next, is estimated as 1 − DMR. I calculated the daily survival rate of the nest for the egg stage, nestling stage, and for the entire breeding season for each year and for both years combined for all nests, and then for nests with helpers and those without helpers following Mayfield (1961, 1975). The Mayfield method was calculated on a per nesting attempt basis and not on a per breeding pair basis. I defined egg stage to include laying and incubation. I deleted those nests for which the helper status was unclear or unknown for the Mayfield calculations.

Statistical Analysis.—Data from nests were segregated by year (2002, 2003), type of monitoring (video, observer), and group helper status (no helper, one or more helpers, or helper status unknown). Groups in which helper status could not be verified were excluded from all results except in assessment of nest abandonment. I used the log-likelihood ratio (*G*-test; Sokal and Rohlf 1995) to compare rate of nest abandonment for nests with video cameras to those that were observer-monitored. Means ± SE are reported.

It may be improper to pool data for analysis of reproductive success if a nest found in the egg stage has a different likelihood of producing fledglings than one found in the nestling stage. I segregated data for observer-monitored nests by whether the nest was found in the egg or the nestling stage, and further by year and group helper status (groups with no helpers vs. groups with at least one helper). I used *G*-tests to compare the reproductive success of pairs, whose nests were found in the egg stage, belonging to groups with and without helpers for each year. I performed the same test for the nestling stage. I combined the data for groups with and without helpers and evaluated it using a *G*-test to assess whether time of the nesting cycle (egg vs. nestling) in which the nest was found influenced reproductive success.

I used two-way analysis of variance (ANOVA; Sokal and Rohlf 1995) using PROC GLM (SAS Institute 1989) to examine the possible effect of year and helper status on the number of eggs, nestlings, and fledglings produced per breeding pair. Only observer-monitored nests were included in this part of the analysis. ANOVA was used to detect possible interactions between year and helper status on reproductive success. Least-squares means were used to examine the mean number of eggs, nestlings, and fledglings produced per breeding pair for data segregated by year and helper status (SAS Institute 1989).

I combined data for 2002 and 2003 and examined data separately for pairs with helpers and those that lacked helpers to examine losses from the egg to nestling and from the nestling to fledgling stages. Only nests found during the egg laying or incubation stage and for which helper status was confirmed were included in this part of the analysis. The total numbers of eggs, nestlings, or fledglings for groups with helpers were compared to groups without helpers with a *G*-test. All *G*-tests and ANOVA tests were performed at the 0.10 significance level to reduce the type II error.

TABLE 1. Abandonment per nesting attempt of video- versus observer-monitored Florida Scrub-jay nests on the Ocala National Forest, 2002–2003[a].

	Video (*n*)	Observer (*n*)	Totals
Not abandoned	11	184	195
Abandoned	2[b]	11	13
Totals	13	195	208

[a] Includes nests for which helper status was undetermined.
[b] Includes one nest abandoned after 28 days of incubation (video-monitored for 25 days).

I calculated standard errors for daily nest survival rates following Nur et al. (1999). Daily survival rates of nests were compared for: (1) the egg versus the nestling stage for each year and then for both years combined, (2) the egg and nestling stages for 2002 versus 2003, and (3) pairs with and without helpers using the Chi-square test in program CONTRAST (Hines and Sauer 1989).

RESULTS

Incidence of Nest Abandonment.—There were 208 nesting attempts (defined as a pair laying at least one egg) in 2002 and 2003 of which 13 were monitored by video cameras, including one nest that was abandoned shortly after the video camera was installed (Table 1). One-hundred ninety-five nests were observer-monitored of which 11 (6%) were abandoned compared to two (15%) of 13 nests that were video-monitored. One of these two nests contained infertile eggs that were eventually abandoned after 28 days of incubation (including 25 days of video monitoring). The overall rate of nest abandonment did not differ between observer- and video-monitored nests ($G = 1.52$, df = 1, $P = 0.234$).

Nest Predation.—All nests video-monitored were in either myrtle oak (*Quercus myrtifolia*) or sand live oak (*Q. geminata*) and 10 of 12 were at least 100 cm from the ground. These results exclude the one nest that was abandoned immediately after the camera was installed. The number of exposure days for nests varied from 6 to 37. Eight fledglings were produced in 2002; two of the five nests experienced no predation and produced seven fledglings. One nest experienced partial predation by an eastern coachwhip snake (*Masticophis flagellum*); the snake ate one of two nestlings (one disappeared before the camera was installed), and the remaining nestling eventually fledged. All contents of two other nests, consisting of two nestlings each, were lost to predation from a spotted skunk (*Spilogale putorius*) and a gray fox (*Urocyon cinereoargenteus*). Two of six nests in 2003 experienced no predation, producing six fledglings. One nest was partially depredated (one nestling taken, one fledgling produced) by an eastern coachwhip snake and another nest with one egg and two nestlings was depredated by a presumed corn snake (*Elaphe guttata*). One nest was visited on four occasions by a snake, most probably a corn snake, and one nestling was removed on each visit. An American Crow (*Corvus brachyrhynchos*) was the only avian predator and consumed all three eggs in one nest. All partial nest predation was the result of snakes, whereas predation by birds or mammals resulted in loss of the entire contents of the nest. One nest in 2003, consisting of two infertile eggs, was abandoned after being incubated for 28 days.

Twelve nests were video-monitored and 4 eggs and 13 nestlings were taken by predators while 15 fledglings were produced. Thirteen of these 15 fledglings were from five nests that experienced no predation. An additional four nests lost one egg and nine nestlings to snakes and produced two fledglings. Three eggs and four nestlings in three nests were lost to mammalian or avian predators. Four of five nests with helpers were depredated versus two of seven nests without helpers. Seven of the 10 instances of predation were nocturnal events.

Reproductive Success for Nests in the Egg Versus the Nestling Stage.—Approximately 14% (15 of 108 nests) of nests without and 25% (12 of 48 nests) of the nests with helpers were located in the nestling, rather than the egg stage. I detected no difference in 2002 in the proportion of nests that produced fledglings in groups without versus those with helpers for nests first found during the egg ($G = 0.54$, df = 1, $P = 0.476$, $n = 39$) or nestling stage ($G = 0.77$, df = 1, $P = 0.409$, $n = 17$). I combined the 2002 data for groups with and without helpers and detected no difference in the proportion of nests producing fledglings between nests found in the egg versus those in the nestling stage ($G = 0.02$, df = 1, $P = 0.893$, $n = 56$).

I detected no difference in the proportion of nests in 2003 first found in the egg stage producing fledglings for groups with compared to those without helpers ($G = 0.99$, df = 1, $P = 0.345$, $n = 37$). There were no differences detected for nests first found in the nestling stage for groups with and without helpers ($G = 0.75$, df = 1, $P = 0.415$, $n = 11$). I combined the data in 2003 for nests with and without helpers and the proportion of nests producing fledglings was similar regardless of whether the nest was first located in the egg or nestling stage ($G = 1.28$, df = 1, $P = 0.262$, $n = 48$). Thus, there was no sampling bias for fledging success between nests first encountered during the egg stage versus those first found in the nestling stage.

Reproductive Success per Breeding Pair in Observer-monitored Nests.—The least-squares means for reproductive success per breeding pair for observer-monitored nests were similar in 2002 and 2003 for eggs (3.29 ± 0.28 vs. 3.29 ± 0.20), nestlings (2.50 ± 0.24 vs. 2.37 ± 0.19), and fledglings (2.16 ± 0.25 vs. 1.79 ± 0.19; all P-values ≥0.248). I detected no difference in least-squares means in the number of eggs (3.17 ± 0.29) in nests of groups with helpers compared to nests lacking helpers (3.41 ± 0.17; $F_{1,99} = 0.50$, $P = 0.480$). I did not detect a difference in the number of nestlings produced in nests with (2.56 ± 0.26) versus those without helpers (2.30 ± 0.16; $F_{1,109} = 0.75$, $P = 0.390$). However, the number of fledglings produced per breeding pair was higher for groups with (2.24 ± 0.27) versus groups without helpers (1.71 ± 0.17) ($F_{1,109} = 2.90$, $P = 0.091$). I detected no significant interaction effects between year and helper status in observer-monitored nests in the number of eggs, nestlings, or fledglings produced per pair (all P-values ≥0.390).

Fifty-nine percent of the 263 eggs in nests without helpers survived to become 155 nestlings and 79% of nestlings eventually became 123 fledglings. In groups with helpers, 86 of 111 eggs (77%) survived to the nestling stage, of which 70 (81%) fledged. Combining the data for non-helper and helper groups, 241 (64.4%) of 374 eggs succeeded in becoming nestlings, of which 193 (80%) became fledglings.

Daily Survival Rates and Exposure Days.—There were 203 exposure days (12 video-monitored nests) of which 95 were egg days and 108 were nestling days. There were 2,906 exposure days for the 177 observer-monitored nesting attempts in 2002 and 2003, including 1,497 days in the egg stage and 1,409 in the nestling stage.

Nests with helpers during the egg stage in both 2002 and 2003 had a similar daily survival rate to nests without helpers ($P = 0.181$ and $P = 0.139$, respectively; Table 2). For observer-monitored nests, in both 2002 and 2003, I detected no difference between daily survival rates in the egg stage versus the nestling stage for all nesting attempts, for nests of groups with helpers, or for nests of groups without helpers (all P-values >0.370; Table 2).

The daily survival rate for nests in 2002 with helpers in the nestling stage (DSR = 0.980 ± 0.012) was higher than for nests without helpers (DSR = 0.954 ± 0.009; $\chi^2 = 3.00$, df = 1, $P = 0.083$; Table 2). I detected a higher daily nest survival rate for nests in 2003 in the nestling stage of groups with helpers than those without helpers (DSR = 0.956 ± 0.012 and 0.924 ± 0.012, respectively; $\chi^2 = 3.56$, df = 1, $P = 0.059$; Table 2).

The daily nest survival rates for 2002 combined with 2003 were higher (but not significantly different) in the egg stage than nestling stage for all nesting attempts and for nests without helpers. I found a statistically higher daily survival rate for nests in groups with helpers than in groups lacking helpers for the entire breeding season ($\chi^2 = 3.78$, df = 1, $P = 0.051$), egg stage ($\chi^2 = 2.78$, df = 1, $P = 0.096$), and nestling stage ($\chi^2 = 3.97$, df = 1, $P = 0.046$; Table 2).

I detected a significantly higher daily survival rate for nests with nestlings in 2002 versus 2003 for all nesting attempts ($\chi^2 = 3.34$, df = 1, $P = 0.068$; Table 2) and in 2002 for nests in the nestling stage of groups without helpers ($\chi^2 = 4.00$, df = 1, $P = 0.046$; Table 2).

DISCUSSION

The rate of abandonment of nests was low and for nests with video cameras was not different from nests monitored only by an observer (8 vs. 2%, respectively). The low level of abandonment indicates the cameras were

TABLE 2. Daily survival rate of nests (DSR) ± SE (* = significant *P*-value) (Mayfield analysis) for observer-monitored nests of Florida Scrub-jays on the Ocala National Forest, Florida, 2002–2003.

		Nest Daily Survival Rate (DSR) + SE (Exposure days)			χ^2, *P*
Year	Stage	All nesting attempts	Nests with helpers	Nests without helpers	Nests with helpers vs. non-helpers
2002	Entire season	0.979 ± 0.004 (1281)	0.989 ± 0.006 (267)	0.976 ± 0.005 (1014)	2.77, 0.096*
	Egg	0.956 ± 0.008 (617)	0.975 ± 0.014 (120)	0.952 ± 0.010 (497)	1.79, 0.181
	Nestling	0.959 ± 0.008 (664)	0.980 ± 0.012 (147)	0.954 ± 0.009 (517)	3.00, 0.083*
χ^2, *P*	Egg vs. nestling	0.07, 0.791	0.07, 0.786	0.02, 0.882	
2003	Entire season	0.971 ± 0.004 (1625)	0.979 ± 0.006 (623)	0.966 ± 0.006 (1002)	2.35, 0.126
	Egg	0.947 ± 0.008 (880)	0.960 ± 0.011 (328)	0.938 ± 0.010 (552)	2.19, 0.139
	Nestling	0.937 ± 0.009 (745)	0.956 ± 0.012 (295)	0.924 ± 0.012 (450)	3.56, 0.059*
χ^2, *P*	Egg vs. nestling	0.69, 0.406	0.06, 0.806	0.80, 0.370	
2000 and 2003	Entire season	0.975 ± 0.003 (2906)	0.982 ± 0.004 (890)	0.971 ± 0.004 (2016)	3.78, 0.051*
	Egg	0.951 ± 0.006 (1497)	0.964 ± 0.009 (448)	0.945 ± 0.007 (1049)	2.78, 0.096*
	Nestling	0.947 ± 0.006 (1409)	0.964 ± 0.009 (442)	0.940 ± 0.008 (967)	3.97, 0.046*
χ^2, *P*	Egg vs. nestling	0.222, 0.637	0.0, 1.00	0.221, 0.638	
χ^2, *P*	2002 vs. 2003-entire season	2.00, 0.157	1.39, 0.239	1.64, 0.200	
χ^2, *P*	2002 vs. 2003-egg	0.63, 0.426	0.71, 0.399	0.98, 0.322	
χ^2, *P*	2002 vs. 2003-nestling	3.34, 0.068*	2.00, 0.157	4.00, 0.046*	

readily accepted and did not affect the birds' nesting behavior.

Eastern coachwhip snakes are a known predator on Florida Scrub-jay nestlings (Westcott 1970, Schoech 1999). There is also evidence of nest predation by Red-tailed Hawk (*Buteo jamaicensis*), Eastern Screech-owl (*Otus asio*), Great Horned Owl (*Bubo virginianus*), Northern Harrier (*Circus cyaneus*), and bobcat (*Lynx rufus*); non-verified, but likely predators include the Swallow-tailed Kite (*Elanoides forficatus*), Fish Crow (*Corvus ossifragus*), Blue Jay (*Cyanocitta cristata*), and common raccoon (*Procyon lotor*) (Schaub et al. 1992). Swallow-tailed Kites have been observed trying to pluck nestlings from Florida Scrub-jay nests at the Archbold Station (S. J. Reynolds, pers. comm.). Hence, it is likely that scrub-jay nests are subjected to predation by other species in addition to those that I documented.

In my study, the observer visited within 15–20 m of the video-monitored nests to change the tape and battery every 2–3 days and did not visit the actual nest other than when the camera was deployed. It is possible that visits every 2–3 days may have provided additional clues for certain predators. Hence, the suite of predators might differ based on the different surveillance methods used.

The video camera results of my study (small sample sizes) indicated that predators took more nestlings than eggs. It may be that frequent visits by adults to feed the nestlings and the noise and/or movement produced by the young allow predators to more easily detect them than eggs. Woolfenden and Fitzpatrick (1984) found that nest predation affected the average number of fledglings produced per pair, overall nest success, and number of fledglings produced per breeding pair from successful nests.

The results of my study are similar to those of the wildland population studied by Bowman and Woolfenden (2001) as I found no difference in reproductive success between nests found in the egg stage compared to those found in the nestling stage. Further, the nest daily survival rates that I found indicated a nest had the same chance of surviving if it was in the egg stage as it did in the nestling stage when data for all nests, regardless of helper status, were pooled. The positive effect of helpers became even more obvious when data were pooled for 2002 and 2003. For example, no significant helper effect was evident in the egg stage for either 2002 or 2003, but was found when data for these years were pooled, likely the result of the larger sample size increasing the power of the statistical test (S. J. Zarnoch, pers. comm.). There was a significantly higher daily survival rate for nests with helpers in 2002 and 2003 during the nestling stage when data for both years were pooled. Daily survival rates were higher for nests of groups with helpers than for groups lacking helpers.

The daily nest survival rate data suggest that fledging rates likely would be higher in nests of groups with helpers. There was no difference in the number of eggs or the number of nestlings produced per breeding pair between nests with and without helpers. However, the number of fledglings per breeding pair was significantly higher (on average one-half fledgling) for pairs with helpers than in unassisted groups. Helpers had a positive effect on whether a nest would survive from one day to the next regardless of the stage of the nesting cycle. The daily nest survival rate data and the reproductive data support the conclusion that presence of helpers significantly increased the likelihood that a nest would survive and produce fledglings.

Predation pressure greatly affected reproductive success as 64% of the video-monitored nests had partial or complete predation. Given an equivalent level of loss in the observer-monitored nests, predation pressure would account for the relatively low reproductive success of only 1.71 fledglings per breeding pair in groups with no helpers and 2.24 fledglings per breeding pair in groups with helpers. Population management of this threatened species on the Ocala National Forest will likely require habitat management to increase the number of breeding territories and reduce the effectiveness of predator communities.

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LITERATURE CITED

BOWMAN, R. AND G. E. WOOLFENDEN. 2001. Nest success and the timing of nest failure in Florida Scrub-jays in suburban and wildland habitats. Pages 383–402 *in* Avian ecology and conservation management in an urbanizing world (J. M. Marzuff, R. Bowman, and R. E. Donnelly, Editors). Kluwer Academic Publishers, New York, USA.

COX, J. A. 1987. Status and distribution of the Florida Scrub-jay. Special Publication 3. Florida Ornithological Society, Gainesville, USA.

FITZPATRICK, J. W., G. E. WOOLFENDEN, AND M. T. KOPENY. 1991. Ecology and development-related habitat requirements of the Florida Scrub-jay (*Aphelocoma coerulescens coerulescens*). Office of Environmental Services, Florida Game and Fresh Water Fish Commission, Tallahassee, USA.

HINES, J. E. AND J. R. SAUER. 1989. CONTRAST—a general program for the analysis of several survival or recovery rate estimates. Available at www.mbr-pwrc.usgs.gov/software/doc/contrast.html.

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

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

NUR, N., S. L. JONES, AND G. R. GEUPEL. 1999. Statistical guide to data analysis of avian monitoring programs. Biological Technical Publication BTP-R6001-1999. USDI, Fish and Wildlife Service, Washington, D.C., USA.

SAS INSTITUTE, INC. 1989. SAS/STAT user's guide. Version 6. Fourth Edition. Volume 2. SAS Institute, Inc., Cary, North Carolina, USA.

SCHAUB, R., R. L. MUMME, AND G. E. WOOLFENDEN. 1992. Predation on the eggs and nestlings of Florida Scrub-jays. Auk 109:585–593.

SCHOECH, S. J. 1999. Florida Scrub-jay nestlings preyed upon by eastern coachwhip. Florida Field Naturalist 27:57–58.

SOKAL, R. R. AND F. J. ROHLF. 1995. Biometry. W. H. Freeman, San Francisco, California, USA.

SPRUNT, JR., A. 1946. Florida Scrub-jay. Pages 77–78 *in* Life histories of North American jays, crows, and titmice, part 1 (A. C. Bent, Editor). Smithsonian Institution, U.S. National Museum Bulletin 171.

U.S. DEPARTMENT OF INTERIOR (USDI). 1990. Florida Scrub-jay recovery plan. USDI, Fish and Wildlife Service, Southeast Region, Atlanta, Georgia, USA.

WESCOTT, P. W. 1970. Ecology and behavior of the Florida Scrub Jay. Dissertation. University of Florida, Gainesville, USA.

WOOLFENDEN, G. E. 1978. The inheritance of territory in group-breeding birds. BioScience 28:104–108.

WOOLFENDEN, G. E. AND J. W. FITZPATRICK. 1984. The Florida Scrub-jay: demography of a cooperative-breeding bird. Monographs in Population Biology Number 20. Princeton University Press, Princeton, New Jersey, USA.