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Nest habitat use of the Puerto Rican Nightjar *Caprimulgus noctitherus* in Guánica Biosphere Reserve

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Summary

The Puerto Rican Nightjar *Caprimulgus noctitherus* is a 'Critically Endangered' caprimulgid endemic to coastal dry and lower montane forests of southwest Puerto Rico. I studied nest habitat use of this nightjar at the Guánica Biosphere Reserve in southwestern Puerto Rico. Nightjar nests ($n = 23$) were located in evergreen and deciduous forest and were more common at elevations above 100 m. Nests were located from 2 m to 125 m into the forest from the nearest road or trail and were characterised by a deep layer of leaf litter, and an open midstorey beneath a closed canopy. Six of the 10 nests found in evergreen forest were located within abandoned mahogany (*Sweetenia mahogany*) plantations. Habitat structure and vegetation composition were quantified at each nightjar nest and an equivalent number of randomly selected sites. Four of 13 habitat variables differed significantly ($P < 0.05$) between nest and random sites and included: elevation, leaf litter biomass, midstorey stem density, and canopy closure. Stepwise logistic regression generated a best model describing nightjar nest habitat. Leaf litter biomass, midstorey stem density, and canopy closure correctly classified 77.3% of nightjar nests. Management of forest stands at higher elevations to promote nightjar nest habitat structure, protection of private lands in the periphery of the Guánica Biosphere Reserve, and acquisition of privately owned forest tracts in other portions of the nightjar's range will ensure the long-term persistence of the species.

Resumen

El Guabairo de Puerto Rico *Caprimulgus noctitherus* en un caprimúlgido endémico a los bosques secos costeros y montanos del suroeste de Puerto Rico. Localicé 23 nidos del Guabairo en la Reserva de la Biósfera de Guánica en bosque siempre verde y bosque caducifolio a elevaciones mayores a los 100 m sobre el nivel del mar. Los nidos de Guabairo se encontraron entre 2 m y 125 m de la vereda o camino más cercano en lugares caracterizados por abundante hojarasca, vegetación abierta en el estrato medio del bosque, y un dosel cerrado. Seis de los 10 nidos encontrados en bosque siempreverde estaban en plantaciones abandonadas de caoba dominicana (*Sweetenia mahogany*). Cuantifique la estructura y composición de la vegetación en cada nido de Guabairo y un número equivalente de localidades escogidas aleatoriamente. Cuatro de 13 variables difirieron ($P < 0.05$) entre nidos y puntos aleatorios e incluyeron; elevación, biomasa de la hojarasca, densidad de tallos en el estrato medio del bosque, y cobertura del dosel. Utilicé regresión logística para generar el mejor modelo que describiese el hábitat de anidaje del Guabairo. Biomasa de la hojarasca, la densidad de tallos del estrato intermedio, y la cobertura del dosel clasificaron correctamente el 77.3% de los nidos del Guabairo. El manejo del bosque de altura para promover hábitat de anidaje de Guabairo, la protección de los terrenos privados en la periferia del la Reserva de la Biósfera de Guánica, y la adquisición de áreas boscosas en otras

partes de la distribución del Guabairo es necesario para asegurar la existencia de la especie a largo plazo.

Introduction

Many of the world's nocturnal birds are in the family Caprimulgidae (Sibley and Monroe 1990). Species of the genus *Caprimulgus* are generally ground nesters associated with forested habitats. However, several African species in this genus (e.g., *Caprimulgus aegyptius, C. eximius*) are known to nest in open and forest-savanna habitats (Fry *et al.* 1988). Caprimulgids lay their eggs directly onto a particular substrate (i.e., sand, rock, tree branch) without building a nest. Chicks of caprimulgids are semi-precocial and move repeatedly from the nest site shortly after hatching (Holyoak 2001, Aragonés 2003). The nocturnal habits and cryptic plumages of caprimulgids make them difficult to study. Most reports on the nesting habits of Neotropical caprimulgids have consisted of descriptive accounts of nests and breeding behaviour, some of which were accidentally discovered (Tate 1994, Forcey 2002, Delannoy 2005). Conversely, a number of studies on nesting behaviour, habitat use and management of Nearctic caprimulgids have been published (Mills 1986, Grand and Cushman 2003).

The Puerto Rican Nightjar *Caprimulgus noctitherus*, hereafter termed nightjar, is endemic to coastal dry and lower montane forests of southwest Puerto Rico. This single-island endemic is presently listed by the Puerto Rico Department of Natural and Environmental Resources (DNER), the U.S. Fish and Wildlife Service (FWS), and the International Union for the Conservation of Nature (IUCN) as 'Critically Endangered' throughout its range (Diaz 1983, BirdLife International 2004). The available information on the nesting biology of the nightjar is limited (Kepler and Kepler 1973, Vilella 1995, Delannoy 2005). Moreover, published information on nest habitat use patterns of the nightjar is not available. Here I report on nest habitat use of the nightjar at Guánica Biosphere Reserve, Puerto Rico, and discuss implications for habitat management and conservation for this critically endangered species.

Study Site

Data on the reproductive ecology of the nightjar were collected on the section of Guánica Forest east of Guánica Bay (17°57′56′′ N, 66°52′44′′ W). This forest reserve was first established in 1917; however, timber extraction, charcoal production, grazing, and subsistence farming persisted in some areas of the current reserve through the 1940s (Molina-Colón and Lugo 2006). In 1982, protection and management efforts were increased when Guánica Forest became a part of the UNESCO Man and the Biosphere programme (Canals 1990).

The forest is underlain by limestone that surfaces in some areas, and is virtually the only substrate for plant growth at elevations below 80 m (Roberts 1942). The dominant soil type is of calcareous origin with drainage areas dominated by clay soils. Soils are rocky and have low moisture retention. The climate of Guánica Forest is dry, with short periods of water recharge. Rainfall is seasonally variable (Murphy and Lugo 1986). More than half of the precipitation falls between August and November, with a small secondary peak occurring in May. The dry season extends from January to May; precipitation does not exceed 30 mm during this period.

The Guánica Forest is classified in the Subtropical Dry Forest Life Zone (Ewel and Whitmore 1973). The vegetation of this region has been described by a number of authors (Gleason and Cooke 1927, Wadsworth 1950, Little and Wadsworth 1964, Kepler and Kepler 1973, Little *et al.* 1974, Gonzalez-Liboy *et al.* 1976, Lugo *et al.* 1996). For this study, habitat descriptions followed Lugo *et al.* (1978) and plant taxonomy followed Liogier and Martorell (1982). Approximately 246 tree species have been recorded at Guánica Forest; 35% of which are deciduous during the dry season. The dominant plant families are Fabaceae, Euphorbiaceae and Myrtaceae (Silander *et al.* 1986).

The boundary of the deciduous forest was characterized by shallower slopes where the tree species *Bursera simaruba* and *Bucida buceras* constituted the emergent overstorey (Figure 1).

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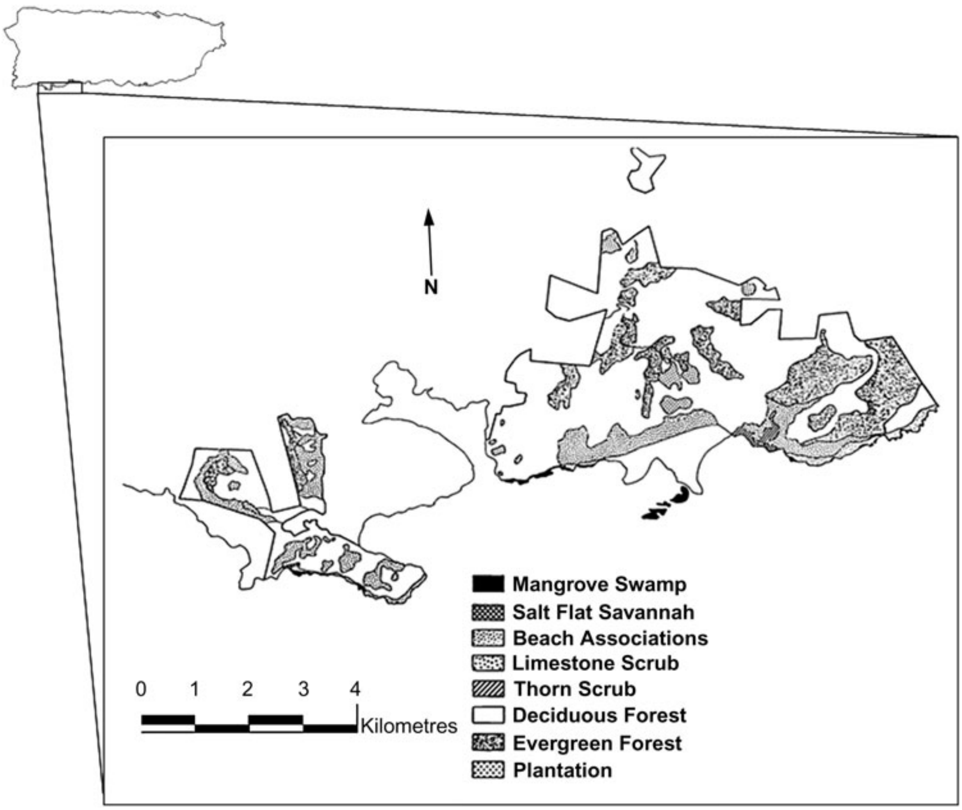

Figure 1. Map of the Guánica Biosphere Reserve indicating major habitat types. Vegetation classification follows Lugo *et al.* (1978).

This association was also characterized by the layering of the forest, with a shorter layer of shrubs and trees found under the emerging canopy. The most common plant species of the midstorey included *Coccoloba microstachya, C. krugii, Colubrina elliptica, Plumeria alba, Capparis* spp., and *Pisonia albida* (González-Liboy *et al.* 1976).

The evergreen forest association occurred in areas with higher soil moisture. This habitat type was dominated by some of the same species found in the deciduous forest plus evergreen species such as *Krugiodendron ferreum, Amyris elemifera, Guaiacum officinale, G. sanctum, Coccoloba diversifolia,* and several species of *Eugenia*. In some areas presence of the grasses *Panicum maximum, Uniola virgata,* and *Aristida adcensionis,* the shrubs *Lantana involucrata, Croton spp.,* and the trees *Leucaena leucocephala* and *Prosopis juliflora* are indicative of fire and grazing disturbance (Canals 1990). During the 1930s, higher elevation areas of evergreen forest (Figure 1) were planted with Dominican Mahogany (*Sweetenia mahogany*) and Logwood (*Haematoxyumn campechianum*). Over time these have developed into areas of mature evergreen forest dominated by a mahogany and logwood overstorey.

Methods

I collected data during 1985–1987 on nightjar nest habitat within Guánica Forest along all existing footpaths, hiking trails and vehicle trails. See Vilella (1995) for a detailed description of nightjar nest searching procedures. Vegetation data were collected at each nest site and an equivalent number of randomly selected sites in order to characterise nightjar nesting habitat. Random sites were selected using a stratified random sampling scheme (Scheiner and Gurevitch 2001). Plots were chosen from the two dominant upland habitat types where nightjars nest (deciduous forest and evergreen forest) by overlaying a vegetation map with a numbered grid, and selecting sites using a random numbers table. Nest sites were selected by designating the location of the nest as the centre of the plot.

Due to the paucity of information on nightjar nest sites I decided to record as much information as possible. Elevation at each vegetation plot was recorded using a Thommen® altimeter to the nearest metre. Vegetation data were collected for overstorey, midstorey and understorey using a modified nested circular plot (Litvaitis *et al.* 1994). The overstorey was recorded as all vegetation over 2 m tall with a 20 cm or greater diameter at breast height (dbh) and was sampled on a 25 m diameter plot (0.05 ha); taxonomic composition, stem density, dbh (cm) classes (20–39.9, 40–59.9, 60–100, > 100) and height of the tallest tree were recorded. Canopy closure was visually estimated from plot centre.

Midstorey vegetation (vegetation 1–2 m tall) was sampled on a 2.5 m diameter plot (0.005 ha). Taxonomic composition and stem density were recorded for the midstorey. Understorey vegetation (plants < 1 m tall) was sampled on a 0.25 m diameter plot (0.0005 ha). Taxonomic composition, cover, distance to nearest tree (metres), and soil condition were recorded in the understorey. Several measurements were taken to quantify microhabitat: cover found within the first 50 cm above plot center, the amount of limestone cover, and leaf litter from a 30 cm diameter circle at the plot centre. Dry weight and composition were obtained for each leaf litter sample.

I tested habitat variables for normality using a Shapiro-Wilk's test. I then used a two-step approach to model nightjar nest habitat. To reduce the variable set I used a one-way ANOVA or Kruskal-Wallis test (as appropriate) to univariately compare nightjar nest site variables with corresponding variables for random sites. For these analyses, each habitat variable was the dependent variable and variable type (random versus nest) was the main effect. Variables that did not differ significantly were not further considered. To avoid excluding biologically important variables, I set a significance level for univariate comparisons at 0.10 (Pielou 1977).

The second step was to develop a nightjar nest habitat model using logistic regression by comparing nest sites to random sites (Brennan *et al.* 1986, Morrison *et al.* 2006). My intention was to assess which variables best described a nest (albeit the small sample) within the context of the surrounding habitat. The reduced variable set was used for the logistic regression as multivariate analyses are sensitive to ratios of variable to sample size, which can lead to unstable classification rates (Brennan *et al.* 1986, Williams *et al.* 1990, Anderson *et al.* 2001). I used logistic regression because I was interested in a binary response variable (used vs. random), and because logistic regression is not constrained by the assumptions of multivariate normality of independent variables nor equality of the covariance matrices among each grouping variable (Agresti 1996, Hosmer and Lemeshow 2000). I paired each nest site observation with a random observation so that prior probability of group membership was 0.5 (Hosmer and Lemeshow 2000). I used a stepwise variable selection procedure to reduce model overspecification and multicolinearity (Myers 1990). Probability to enter to model was 0.25 and probability to stay was 0.05. Means are reported as ± standard deviation. All data were analysed using the SAS system (SAS Institute 2004).

Results

A total of 23 nightjar nests were located during the study (Vilella 1995). Vegetation was quantified at only 22 nest plots as nightjars nested in the same exact location in two successive years. However, I could not determine whether these were the same individual nightjars as birds were not marked. Nightjars nested at elevations ranging from 55 m at the edge of the evergreen and limestone scrub associations to 220 m in deciduous forest near the highest elevations of Guánica Forest. Nightjar nests were located from 2–125 m ($\bar{x} = 32.6 \pm 28$ m) into the forest from the

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nearest road or trail. Overall habitat characteristics of nightjar nests and random sites are presented in Table 1. Ten nests were located in evergreen forest, six of these were found in relict mahogany plantations. The remaining 13 nests were found in deciduous forest (Table 2).

All nightjar nests were located within a metre of the base of a small tree. Nearest tree species in evergreen forest included *Sweetenia mahogany*, *Albizia lebbeck*, *Bursera simaruba*, *Eugenia*

Table 1. Nest habitat characteristics (mean ± SD, range) measured within nightjar nests and random sites in Guánica Forest, Puerto Rico.

Habitat characteristics	*Nest sites (22)*		Random sites (22)	
	Mean ± SD	*Range*	Mean ± SD	Range
Elevation (m)[b]	145 ± 39.5	(55–220)	113 ± 43.5	(35–175)
Leaf litter (grams dry weight)[a]	40.2 ± 14.9	(19.7–72.6)	18.5 ± 12.2	(0.0–40.7)
Height nearest tree (m)	2.88 ± 1.1	(1.2–5.1)	2.6 ± 1.6	(0.47–6.5)
Distance nearest tree (m)	0.4 ± 0.2	(0.06–0.86)	0.5 ± 0.3	(0.1–1.3)
Midstory number of stems[a]	50.1 ± 16.5	(5.0–79.0)	60.4 ± 34.0	(11.0–157.0)
Midstory species richness	13.7 ± 3.7	(8.0–20.0)	11.8 ± 3.4	(7.0–19.0)
Overstory number of stems	14.2 ± 14.7	(4.0–67.0)	8.6 ± 6.0	(0.0–19.0)
Overstory species richness	2.1 ± 0.9	(1.0–4.0)	2.2 ± 1.3	(0.0–5.0)
Overstory stems DBH ≤ 59.9 cm	3.3 ± 2.9	(0–9)	7.1 ± 5.5	(0.0–18)
Overstory stems DBH 60–99.9 cm	5.6 ± 3.2	(2–11)	1.2 ± 1.5	(0.0–5)
Overstory stems DBH ≥ 100 cm	1.3 ± 1.4	(0–5)	0.3 ± 0.8	(0.0–3)
Canopy height (m)	8.0 ± 1.6	(6.0–12.0)	7.1 ± 2.9	(0.0–12.0)
Canopy closure (%)[b]	59.8 ± 16.9	(25.0–90.0)	36.1 ± 28.5	(0.0–80.0)

[a]Significant One-way ANOVA ($P < 0.05$)
[b]Significant Kruskal-Wallis ANOVA ($P < 0.05$)

Table 2. Habitat characteristics of nightjar nests in the evergreen forest association at Guánica Biosphere Reserve, Puerto Rico.

Nest	Altitude (m)	Understory (0.0005 ha)			Midstory (0.005 ha)		Overstory (0.05 ha)		
		Cover (%)	Near tree	Leaf litter (g)	Spp. Richness	No. Stems	Spp. Richness	No. Stems	Canopy Height (m)
1	150	70	*Sweetenia mahogany*	38	15	71	3	11	8
2	110	20	*Sweetenia mahogany*	72.6	13	54	2	66	12
3	140	80	*Albizia lebbeck*	64	10	69	1	14	7
4	150	80	*Bursera simaruba*	48	18	51	2	5	7
5	150	80	*Eugenia spp.*	41	13	96	1	9	9
6	135	75	*Antirhea acutata*	55.5	10	62	2	13	10
7	200	80	*Amyris elemifera*	32.7	16	65	3	7	8
8	110	85	*Sweetenia mahogany*	46	9	33	1	42	12
9	140	75	*Haematoxylon campechianum*	54.3	10	57	1	25	6
10	55	0	*Euphorbia petiolaris*	29.2	9	54	3	12	8

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rhombea, *Haematoxylum campechianum*, and *Euphorbia petiolaris*. Leaf litter biomass of nightjar nests in evergreen forest ranged from 29.2 g to 72.6 g ($\bar{x}$ = 50.7 ± 13.8 g) and was higher than nests in deciduous forest (Table 2). The canopy of nest sites located in evergreen forest where mahogany was not present was dominated by *Guaiacum officinale* and *Bourreria suculenta*. Overstorey trees ranged from 20 cm to 120 cm dbh ($\bar{x}$ = 44.2 ± 21.7 cm). Canopy height ranged from 6–12 m ($\bar{x}$ = 8.1 ± 1.8 m) and canopy closure ranged from 40% to 90% ($\bar{x}$ = 68.5%).

Nearest trees in deciduous forest included *Exostema caribaeum*, *Thouinia portoricensis*, *Capparis cynophallophora*, *Leptocereus quadricostatus*, *Leucaena glabra*, *Reynosa uncinata*, *Eugenia rhombea*, and *Pisonia albida* (Table 3). Leaf litter biomass of nests in deciduous forest ranged from 19.7 g to 51 g ($\bar{x}$ = 31.4 ± 9.2 g/sample). The overstorey of nightjar nests in deciduous forest was dominated by the trees *Bucida buceras* and *Bursera simaruba* (Table 3). However, the canopy of deciduous forest at Guánica was not always well defined and consisted in some places of a few emergent trees protruding over the midstorey. Emergent trees ranged in height from 6–11 m ($\bar{x}$ = 7.9 ± 1.4 m).

Of the 13 structural habitat variables examined at nightjar nests and random sites; leaf litter biomass, height of the nearest tree, and midstorey species richness were normally distributed ($P > 0.20$); the remaining variables failed the normality test. Univariate analysis of variance indicated four of 13 habitat variables differed between nests and random sites (Table 1). These included elevation ($H_1 = 4.09$; $P = 0.043$), leaf litter biomass ($F_{1,42} = 27.9$; $P < 0.00001$), midstorey number of stems ($F_{1,42} = 3.17$; $P = 0.042$), and canopy closure ($H_1 = 7.02$; $P = 0.008$). Thus, a 4-variable logistic regression model was utilised to assess which habitat variables best described a nightjar nest. Logistic regression produced a best nest site model containing

Table 3. Habitat characteristics of nightjar nests in the deciduous forest association at Guánica Biosphere Reserve, Puerto Rico.

Nest	Elevation (m)	Understory (0.0005 ha)			Midstory (0.005 ha)		Overstory (0.05 ha)		
		Cover (%)	Nearest tree	Leaf litter (g)	Spp. Richness	No. Stems	Spp. Richness	No. Stems	Canopy Height (m)
1	200	70	*Exostema caribaeum*	31.5	11	68	3	10	6
2	150	70	*Thouinia portoricensis*	20.7	14	49	1	5	7
3	160	80	*Thouinia portoricensis*	51	15	43	1	4	8
4	160	60	Unkown	19.7	17	50	4	9	8
5	140	50	*Capparis cynophallophora*	43.9	17	79	2	6	9
6	80	60	*Leptocereus quadricostatus*	28	13	40	4	2	10
7[a]	145	50	*Exostema caribaeum*	33.1	20	60	2	6	7
8	115	60	*Leucaena leucocephala*	30.5	13	45	3	4	8
9	125	25	*Reynosa uncinata*	25.6	18	42	3	13	11
10	135	60	*Eugenia spp.*	22.9	8	28	4	17	8
11	220	70	*Pisonia albida*	35.2	11	42	1	5	7

[a]Same nest site location used by nesting nightjars in successive years.

3 variables; leaf litter biomass (parameter = 0.364, SE = 0.143, P = 0.011), midstorey stem density (parameter = −0.104, SE = 0.0592, P = 0.05), and canopy closure (parameter = 0.084, SE = 0.048, P = 0.042). Overall classification rate was 79.5%; the model variable combination correctly classified 77.3% of nightjar nests and 81.8% of random sites.

Discussion

No nightjar nests have ever been reported from the lower elevation coastal scrub forest of Guánica Biosphere Reserve (Kepler and Kepler 1973, Vilella 1995). At lower elevations (< 50 m) the substrate was exposed limestone with occasional solution holes and shallow soil pockets. As a result, these areas had few widely spaced, large deciduous trees (e.g., *Bursera simaruba*) interspersed among which were many shrubs, grasses, cacti, and areas of exposed limestone, providing virtually no usable nesting habitat for nightjars. Above 75 m elevation as the soil became deeper, deciduous tree species and evergreen species were located in deeper red soils (Murphy and Lugo 1986).

Leaf litter biomass, midstorey stem density, and canopy closure best predicted the occurrence of nightjar nests. This suggests sites in Guánica Forest characterised by deep leaf litter, an open midstorey, and a closed canopy constitute optimal nightjar nesting habitat (Table 1). Moreover, breeding nightjars selected structural habitat features associated with the first 2 m above the forest floor. Habitat attributes such as structure of the overstorey contributed less to the variation between nest and random sites. At Guánica Forest the availability of leaf litter and structural complexity of the vegetation increased with elevation and soil development. Lugo *et al.* (1978) reported the highest amounts of total litter at Guánica Forest were found in mahogany plantations (1.48 g m^{-2}/day) followed by deciduous forest (0.79 g m^{-2}/day). Nightjars frequently nest in the relict mahogany plantations of Guánica Biosphere Reserve. The openness of the lower layers of the forest constitutes a major requirement of suitable nightjar nesting habitat and adult nightjars foraged primarily in these layers. Areas of open vegetation near the ground also offered suitable foraging habitat to fledged young, who remain within the parent's territory for up to a month after fledging (Vilella 1995). A number of locations searched at Guánica Forest provided no evidence of nightjar nesting activity. Many of these areas were characterised by a dense, tangled understorey and midstorey dominated by *Lantana involucrata* and *Croton rigidus*, typical of disturbed areas. At Guánica Forest, the structure of the lower layers of the forest is believed to be directly related to the intensity of past disturbance and the amount of time a given area has been protected (Canals 1990, Molina-Colón and Lugo 2006).

Resident nightjar congeners of the Caribbean include Cuban Nightjar *Caprimulgus cubanensis*, endemic to Cuba, Hispaniolan Nightjar *Caprimulgus ekmani* endemic to Hispaniola, *Caprimulgus rufus otiosus* limited to the island of St. Lucia, and White-tailed Nightjar *Caprimulgus cayennensis* restricted to the island of Martinique. With the exception of the White-tailed Nightjar, which nests in open grassy fields in Martinique, all other Caribbean caprimulgids are associated with forest habitats, particularly semi-arid forests (Garrido 1983, Raffaele *et al.* 1998). In St. Lucia, *C. rufus otiosus* is most abundant in the coastal dry forests around Grand Anse. The vegetation in this region is very similar in structure and composition to Guánica Forest (Vilella 1993). Unfortunately, quantitative information on nest habitat use of other Caribbean forest caprimulgids is lacking.

At the time of its discovery, the island of Puerto Rico was practically totally forested (Wadsworth 1950). However, by the early decades of the 20th century deforestation had peaked and less than 10% of the island remained forested. Guánica Forest was heavily cut during this period and available nightjar nesting habitat must have been greatly reduced (Figure 2). It is possible that the relatively small spatial requirements (Vilella 1995) of nightjar breeding pairs may have helped the species survive periods of severe habitat destruction. Moreover, tree plantations established during the 1930s may have provided patches of closed canopy forest

Figure 2. Past and present at the Guánica Biosphere Reserve. A 1931 photograph (top) shows a mahogany plantation amid extensive deforestation near the present reserve headquarters (Photo courtesy Puerto Rico Department of Agriculture). Bottom photograph of the same area under present conditions showing the abandoned mahogany plantation (centre left) now embedded within mature evergreen forest (Photo by Francisco J. Vilella).

allowing nightjar breeding populations to persist (Figure 2). These plantation forest stands included the most important requirements for adequate nightjar breeding habitat; abundant leaf litter, little or no vegetation near the ground, and a closed canopy. At present, suitable nesting habitat exists at higher elevations in naturally regenerated areas of evergreen and deciduous forest without relict plantations (Molina-Colón and Lugo 2006).

If the objectives of the recovery plan approved for the nightjar (Diaz 1983) are to be met, several habitat management alternatives should be pursued. Habitat management options available for the nightjar will depend primarily on whether the birds are found in private or public lands. This is due to access limitations and control over land use practices that are encountered within privately owned lands. Presently, the most urgent conservation need for nightjars within privately owned land is habitat acquisition. At the moment, the amount of terrestrial protected areas in Puerto Rico represents about 7.6% of the total land area (Puerto Rico and satellite islands) which is below the regional average of 8.6% for the Caribbean and Central America (World Resources Institute 2003).

Nightjars occur at moderate to high densities on a number of privately owned areas of dry limestone and lower cordillera forests in southwestern Puerto Rico (Vilella and Zwank 1993). Therefore, measures should be taken to mitigate the impacts of changes on areas that presently possess nightjars and will likely remain under private ownership. Information on the status of the nightjar and the desirability of conserving the region's coastal dry forests should be made available to the relevant landowners. Additionally, reforestation using a mixture of mahogany and native tree species (e.g., *Bucida buceras*, *Bursera simaruba*, *Pisonia albida*, *Exostema caribaeum*) should be strongly encouraged. Landowners surrounding Guánica Forest should be encouraged to pursue silvicultural practices that promote nightjar nesting habitat and informed of conservation programs available for private lands (CEDES 2007). Land uses such as industrial and residential development that promote forest clearing should not be allowed in the periphery of Guánica Forest as Biosphere Reserves are mandated to strongly protect their peripheral buffer zones and promote the establishment of corridors along these buffers (Dyer and Holland 1991).

Nevertheless, the most immediate and effective measures to ensure the continuing existence of the nightjar can be applied on presently occupied habitat under public ownership. Studies of the European Nightjar (*Caprimulgus europaeus*) on heathlands of the United Kingdom provide evidence of disturbance from walkers and pets moving in the vicinity of nests (Langston *et al.* 2007). In Guánica, the unlimited access by birders and amateur nature photographers to forest stands during the peak months of nightjar nesting activity (April–June) should be evaluated. Moreover, my results indicate the main limiting factors associated with use of habitat for nesting by nightjars were the presence of dense, tangled vegetation near the ground. These results illustrate nightjar-habitat ecological relationships that should serve as the basis for future experimental work. Further research should concentrate on experimentally testing the hypotheses raised by my results. For example, the effect on nightjar habitat use of experimentally manipulating the vegetation in the understorey and midstorey layers of the forest should be investigated and habitat management alternatives explored. Management of nest habitat in protected areas and private lands will ensure the long-term persistence of nightjar populations across southwestern Puerto Rico.

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