

## GEOGRAPHIC DISTRIBUTION AND ABUNDANCE OF THE PUERTO RICAN NIGHTJAR

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**Abstract.**—Six areas of Puerto Rico with high potential for occurrence of the Puerto Rican Nightjar (*Caprimulgus noctitherus*) were surveyed to determine present geographic distribution and abundance. Nightjar abundance and distribution were studied in Puerto Rico in 1985–1987, 1989–1990, and 1992. No relict nightjar populations were found in three areas in the northern moist limestone forest region of the island. Nightjars were found in three main areas located in the coastal dry limestone forest and lower cordillera forest of southwestern Puerto Rico. Singing rates of male nightjars were higher during winter (January–March) than during summer (June–August) surveys. A total of 712 singing male nightjars were recorded in 9839 ha. These were distributed among three separate areas: Susúa-Maricao (177), Guánica (347), and Guayanilla (188). Densities were 0.00–0.33 nightjar/ha on Susúa-Maricao, 0.00–0.19 nightjars/ha on Guánica, and 0.04–0.13 nightjars/ha on Guayanilla. First site records of nightjars for the Parguera Hills and Sierra Bermeja, a region of coastal dry forest located in the southwestern end of Puerto Rico, were obtained in 1990 and 1991, respectively. Included in this total were 315 nightjars on 4583 ha of private forest land that is rapidly being cleared for urban, resort and industrial development.

### DISTRIBUCIÓN GEOGRÁFICA Y ABUNDANCIA DEL GUABAIRO PEQUEÑO DE PUERTO RICO (*CAPRIMULGUS NOCTITHERUS*)

**Síopsis.**—Se escogieron seis áreas con alto potencial para la presencia del Guabairo Pequeño de Puerto Rico (*Caprimulgus noctitherus*), para determinar la distribución geográfica y abundancia actual de la especie. El estudio se llevó a cabo durante los años 1985–1987, 1989–1990 y 1992. No se encontraron poblaciones reliquias en tres áreas de la región caliza húmeda del norte de Puerto Rico. Al presente, la especie se encuentra particularmente limitada a tres áreas de bosque calizo seco y bosque de cordillera del suroeste de la Isla. Los guabairos machos, cantan más frecuentemente durante los períodos de invierno (enero-marzo) que durante el verano (junio-agosto). Se detectaron un total de 712 guabairos a lo largo de 9839 hectáreas incluidas en los censos. Este total se distribuyó entre las áreas de Susúa-Maricao (177), Guánica (347) y Guayanilla (188). La densidad (guabairo/hectárea) fue de: 0.00–0.33 en Susúa-Maricao, 0.00–0.19 en Guánica y 0.04–0.13 en Guayanilla. Se detectó por primera vez la presencia de la especie en las colinas de La Parguera (Lajas) y en Sierra Bermeja (Cabo Rojo), regiones de bosque seco localizadas en el extremo suroeste de Puerto Rico. Se incluyeron en este total 315 guabairos que ocurren en 4583 hectáreas de bosque en propiedad privada, el cual está siendo destruido aceleradamente por el desarrollo urbano, turístico e industrial.

The Puerto Rican Nightjar (*Caprimulgus noctitherus*), hereafter termed nightjar, was first described in 1916 from a collection of fossil bones from

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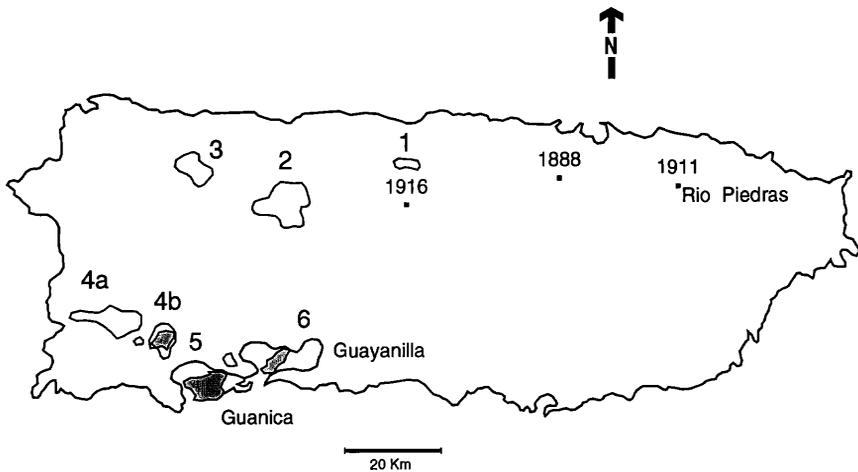


FIGURE 1. Map of Puerto Rico with date and locations of historical Puerto Rican Nightjar records, known distribution of the Puerto Rican Nightjars by 1985 (cross hatched), and regions in which Puerto Rican Nightjars were surveyed in this study (1 = Ciales, 2 = Rio Abajo, 3 = Guajataca, 4a = Maricao, 4b = Susúa, 5 = Guánica, 6 = Guayanilla-Peñuelas).

caves in the moist limestone region of Morovis in north central Puerto Rico and a previously misidentified skin collected at Bayamón near San Juan in 1888 (Wetmore 1919, 1922). Wetmore (1916) also published a record of a bird seen in a small tract of forest near Rio Piedras in 1911 (Fig. 1). Subsequently, the species went unrecorded and was presumed extinct (Danforth 1936). In 1961 a male nightjar was collected in the Guánica Forest, a dry coastal limestone forest reserve 62 km to the southwest of the last recorded sighting 50 yr earlier (Reynard 1962).

Following the rediscovery, opinions on the species' taxonomic status were varied. Some authors familiar with the West Indian avifauna continued to consider it an insular race of the Whip-poor-will (*Caprimulgus vociferus*) (Biaggi 1974, Bond 1961). After sonograms of the Puerto Rican and mainland forms of Whip-poor-will were compared, however, the Puerto Rican form was recognized as a distinct species (American Ornithologists' Union 1983, Wetmore *in* Reynard 1962).

Bond (1962) estimated nightjar numbers to be 25 to 100 breeding pairs confined to the Guánica Forest. The long period of presumed extinction coupled with small estimated population size on an island whose avifauna was considered thoroughly surveyed led to the species being listed as endangered in 1968 by the U.S. Fish and Wildlife Service and by the International Union for the Conservation of Nature and Natural Resources (Vincent 1968).

The first detailed study on the species was conducted from 1969 to 1971 by Kepler and Kepler (1973). They recorded call counts along fixed-width transects in Guánica Forest. In addition, they searched for the bird

throughout southwestern Puerto Rico and other parts of the island. They found nightjars in the Susúa Forest and in the coastal dry limestone forest of the Guayanilla Hills (Kepler and Kepler 1973) (Fig. 1). On the basis of their survey data, a total of 450–500 breeding pairs were thought to be distributed over 3200 ha in three separate areas. Kepler and Kepler (1973) believed that although this species was historically widely distributed in the moist and dry limestone and coastal forests of Puerto Rico, distribution was now limited to these three localities.

Following the Kepler's surveys, yearly nightjar counts along a few selected routes were conducted in the Guánica Forest during 1976–1984 (Wiley 1985) and during June and July 1984 and January 1985 in Guánica and Susúa Forests (Noble 1984, Noble et al. 1986). Nightjar densities varied little from those obtained earlier by the Keplers' along the same routes. The objectives of our study were to determine current distribution and abundance of this species.

#### STUDY AREAS

To identify areas in Puerto Rico where nightjars may exist, we first delineated the island's forested areas from aerial photographs and recent U.S. Geological Survey (USGS) topographic maps. Secondly, we conducted ground and aerial surveys in those forested areas. Six areas were selected (Fig. 1). The three (1, 2, 3) in the northern moist limestone region of the island were chosen because of their proximity to historical records of nightjars (Wetmore 1922) and present existence of large, continuous tracts of mature moist limestone forest.

The other three areas in southwestern Puerto Rico were chosen based on known concentrations of nightjars and presence of seemingly suitable habitat (Kepler and Kepler 1973, Noble 1984, Noble et al. 1986). Climate, topography and vegetation characteristics of the study areas are described in Cardona et al. (1986), Cintrón and Beck (1977) and Silander (1986).

#### METHODS

Each selected area was visited to determine current vegetative status and access. The number of routes in each area was dictated by trespass permission and availability of footpaths and cattle trails. Nightjars were surveyed along routes established on existing trails. On at least three occasions during crepuscular hours we played recordings of singing nightjars along all survey routes to determine presence or absence of nightjars (Marion et al. 1981). Playback recordings can be used to determine presence of forest caprimulgids because this group shows strong site tenacity and inclination of males to sing repeatedly during dusk and early night hours (Baker and Peake 1966, Lack 1957). Every 200 m we played a recording for 2 min and then listened for a response for 3 min. A considerable number of routes we selected in southwestern Puerto Rico where nightjars occurred had never been surveyed by previous workers. This was included in our analyses to provide information on the presence

of this endangered species in areas currently under public and/or private ownership.

Whenever a response was obtained on a preliminary search, the birds were surveyed along the route to estimate abundance. From two to 14 observers in parties of two took part in the surveys which were conducted at dawn (0545–0635 January–March; 0530–0610 June–August) and dusk (1825–1910 January–March; 1910–2000 June–August). We surveyed by walking slowly along a transect and counting all singing nightjars following procedures established by Noble et al. (1986) in which all singing nightjars are assumed to be heard as far as 300 m on either side of the survey route. Survey routes greater than 1.5 km were surveyed by parties starting at each end. As survey routes were often less than 600 m apart, we attempted to avoid duplicate counts whenever possible by not surveying simultaneously from adjacent routes. We also counted nightjars heard singing at the route ends when possible. For every route end, area was increased by 14.1 ha (Noble 1984). To obtain a minimum estimate of abundance (nightjar/ha), we used the highest number of nightjars heard on each route as the minimum number of birds present. Route distances were paced in the field and later corroborated on USGS topographic maps with an electronic digitizer and planimeter. Surveys were conducted during full moon on clear to partly cloudy nights when wind velocity did not exceed 16 km/h to reduce the variability that these factors appear to have on calling rates (Cooper 1981, Kepler and Kepler 1973, Mills 1986).

Surveys were conducted on all routes in winter and summer. Winter and summer counts were compared by analysis of variance (Steel and Torrie 1980). Statistical analysis ( $\alpha = 0.05$ ) was conducted with the Statistical Analysis System (Joyner 1985).

We observed 82 birds that responded to a taped song. We catalogued all as males by plumage characteristics. Males of the genus *Caprimulgus* are identified by having varying amounts of white on the tail feathers. On the basis of these observations we assume only male Puerto Rican Nightjars sing. A record exists of a female Whip-poor-will singing, but the individual was not collected and sex was determined only by plumage (Bent 1940).

## RESULTS

We found no nightjars in approximately 985 ha of moist limestone forest in northern Puerto Rico. We heard nightjars in several areas of dry limestone and lower cordillera forests in the southwestern part of the island (Table 1). We estimated abundance and determined distribution of nightjars in these areas from 369 surveys conducted along 71 routes from 15 Aug. 1985 to 15 Aug. 1987, June 1989, March 1990, and February 1992.

The number of nightjars heard along these routes was higher during winter (January–March) than during summer (June–August) ( $F = 8.32$ ;  $df = 1,298$ ;  $P < 0.01$ ). We heard consistently higher numbers during

TABLE 1. Results of Puerto Rican Nightjar surveys in six regions of Puerto Rico.

Location	Area surveyed (ha)	Habitat type	Nightjars present
Ciales	326	Moist Limestone Forest	No
Río Abajo	348	Moist Limestone Forest	No
Guajataca	310	Moist Limestone Forest	No
Susúa-Maricao	2745	Lower Cordillera Forest	Yes
Guánica	4394	Dry Limestone Forest	Yes
Guayanilla	2701	Dry Limestone Forest	Yes

summer surveys than winter surveys along some individual routes in both limestone and lower cordillera forest. Nevertheless, we chose to estimate abundance based upon the number of nightjars heard per route during the season of the year when calling rates are higher (i.e., winter).

*Surveys in the Susúa-Maricao region.*—A total of 177 nightjars were detected on 2744.4 ha of lower cordillera forest in the Susúa-Maricao region (Fig. 2). In this region, nightjars were most abundant in and around the Susúa Forest (routes 1–14;  $\bar{x} = 0.11 \pm 0.09$  nightjar/ha) (mean  $\pm$  SE). Abundance was greatest on 535 ha in the southern section of the forest and adjacent lands (routes 2–6;  $\bar{x} = 0.19 \pm 0.09$  nightjar/ha). These routes were at the lowest elevations surveyed in this region.

The density of nightjars on the northern part of the Susúa Forest and adjacent lands (routes 1, 7–14;  $\bar{x} = 0.05 \pm 0.01$  nightjar/ha) was lower than on the southern sections. This area is steeper and at a higher elevation and receives most of the precipitation on the Susúa Forest (Table 2).

Eleven nightjars were heard on 832 ha of lower cordillera forest surveyed in the Maricao Forest and adjacent lands (routes 15–19). Mean density was  $0.03 \pm 0.03$  nightjars/ha. Of 11 heard, nine were on forested private land 2 km southeast of Maricao Forest (routes 15–16). Within the Maricao Forest, only two nightjars were heard, on the northern end of route 17 in a eucalyptus (*Eucalyptus robusta*) plantation.

*Surveys in the Guánica region.*—We recorded 347 nightjars on 4394 ha of coastal dry limestone forest in the Guánica region (Table 3). Survey routes ( $n = 31$ ) were in and around the Guánica Forest (routes 1–27), the Barina Hills (routes 28–30), and at Punta Verraco (route 31) (Fig. 3). Densities of nightjars on 10 of 31 routes were as high as 1 nightjar/10 ha. These routes were on forested uplands of the Guánica Forest east of Guánica Bay (routes 2–4, 6, 8–11, 26) and adjacent private lands (route 27). Densities of the remaining ranged from 0.06 to 0.10 nightjar/ha. Six of these routes (routes 1, 5, 7, 12–14) were in the eastern section of Guánica Forest. The other four routes (routes 28–31) were on the privately owned Barina Hills and on Punta Verraco. Nightjar density at the remaining 11 routes (routes 15–25) was low ( $<0.05$  nightjar/ha). Three of these (routes 15–17) were on the southern slopes of the eastern section of Guánica Forest. Numbers were lower at lower elevations, but density

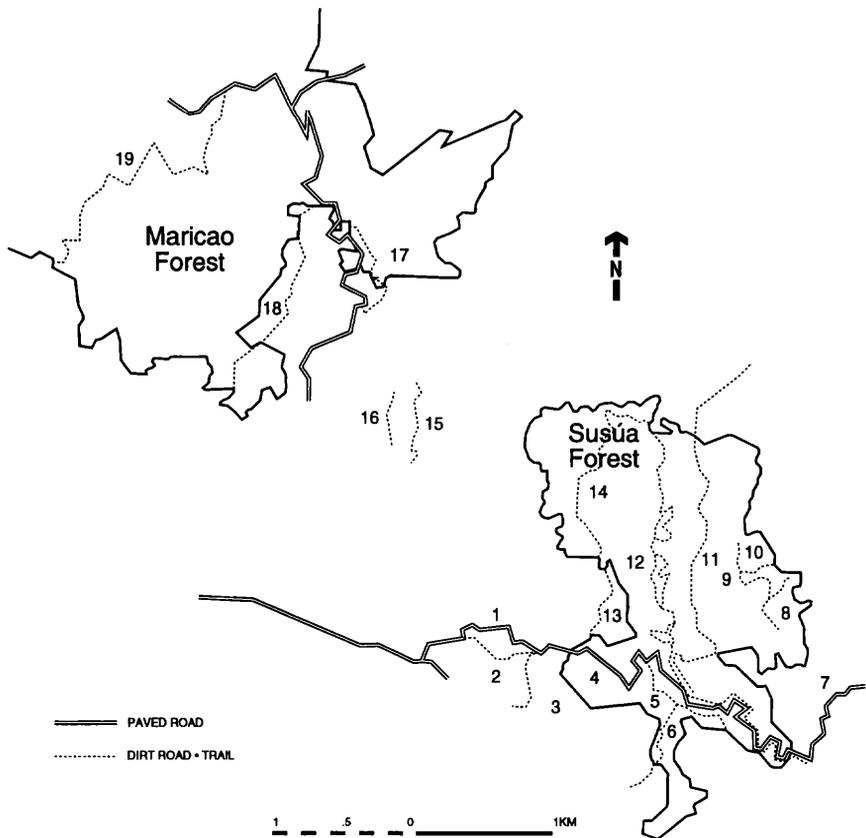


FIGURE 2. Map of the Susúa-Maricao area where Puerto Rican Nightjars were surveyed. Numbers indicate census routes and correspond to routes listed in Table 3. Boundaries of Susúa (right) and part of Maricao (left forests) are outlined.

was greater than previously reported (Kepler and Kepler 1973, Noble 1984). In addition, nightjars were singing along these routes throughout the year.

We discovered a small population of nightjars on the section of Guánica Forest west of Guánica Bay (routes 18–25). Nightjar density in this area was low ( $\bar{x} = 0.02 \pm 0.01$  nightjar/ha). Most of the birds occurred on the northern portion of this area (routes 18–21). Nightjars were singing on both private and public land in and around the hills of Cerro Montalva (northern junction of routes 20–21) where elevations exceed 100 m. Three nightjars were heard in the hills on the southern section of this area (routes 22–23). These birds were in limestone forest at the top of the hills at about 60 m elevation.

Additionally, in March 1990, a single nightjar was detected in the Parguera Hills, the first record for this area 10 km west of the western

TABLE 2. Results of surveys of Puerto Rican Nightjars in the Susúa-Maricao region, 1985–1987, 1989–1990 and 1992.

Survey route	Route length (km)	Area surveyed (ha)	# surveys	Min-Max males	Mean abundance (nightjar/ha)
1 <sup>1</sup>	1.90	128.2	4	3–5	0.039
2 <sup>1</sup>	1.04	76.6	4	5–7	0.091
3 <sup>1</sup>	1.13	82.0	4	8–10	0.122
4 <sup>1</sup>	2.39	157.6	6	12–21	0.133
5	1.60	110.2	4	14–27	0.245
6	1.57	108.4	4	6–36	0.332
7 <sup>1</sup>	2.01	134.8	4	4–7	0.052
8 <sup>1</sup>	1.26	89.8	4	0–4	0.045
9 <sup>1</sup>	0.86	65.8	4	1–3	0.046
10 <sup>1</sup>	0.96	71.8	4	0–3	0.042
11	5.26	329.8	6	12–22	0.067
12	4.00	254.2	4	4–7	0.028
13 <sup>1</sup>	1.32	93.4	4	1–3	0.032
14	3.26	209.8	4	8–11	0.052
15 <sup>1</sup>	1.40	98.2	3	2–5	0.051
16 <sup>1</sup>	0.82	63.4	3	1–4	0.063
17 <sup>1</sup>	1.90	128.2	4	0–2	0.016
18 <sup>1</sup>	3.12	201.2	4	0	0.00
19 <sup>1</sup>	5.45	341.2	5	0	0.00
Total	41.25	2744.6	91	81–177	

<sup>1</sup> New routes on which Puerto Rican Nightjars were not surveyed before 1985.

section of Guánica Forest. Furthermore, in February 1992 nightjars were first recorded in Sierra Bermeja, an area of dry coastal forest approximately 20 km from the western end of Guánica Forest. In Sierra Bermeja, seven nightjars were heard in two separate locations.

*Surveys in the Guayanilla-Peñuelas region.*—We heard 188 nightjars along 20 survey routes in approximately 2700 ha of private land in the Guayanilla Hills (Fig. 4). Nightjar density was highest ( $\bar{x} = 0.12 \pm 0.01$  nightjar/ha) on routes 4, 6, 8 and 11–13, which surveyed 637 ha. Density estimates along routes 2, 9, 14, 16–17 and 20 that included 842 ha were moderately high ( $\bar{x} = 0.07 \pm 0.01$  nightjar/ha) (Table 4). Remaining routes 1, 3, 5, 7, 10, 15, 18 and 19), totaling 1266 ha had low nightjar densities ( $\bar{x} = 0.05 \pm 0.01$  nightjar/ha).

#### DISCUSSION

No nightjars were heard during surveys of the Ciales, Rio Abajo, and Guajataca regions from 1985 to 1987. Rio Abajo and Guajataca forests have a combined area of over 3200 ha, are heavily forested, and have very low human densities. Nevertheless, it should be mentioned that these regions of moist limestone forest are mature secondary forest (approx. 70 yr old), which have regenerated following periods of intensive deforestation during the late 1800s and early 1900s. As such, they probably

TABLE 3. Results of surveys of Puerto Rican Nightjars in the Guánica Forest region, 1985-1987, 1989-1990 and 1992.

Survey route	Route length (km)	Area surveyed (ha)	# surveys	Min-Max males	Mean abundance (nightjar/ha)
1	2.04	165.0	14	23-30	0.182
2	1.68	129.2	6	15-26	0.201
3	2.73	206.4	6	14-21	0.102
4 <sup>1</sup>	1.91	128.8	6	16-24	0.186
5	5.95	349.6	9	12-21	0.060
6	1.07	106.8	4	9-15	0.140
7	1.88	141.2	7	8-14	0.099
8	1.13	82.0	12	7-11	0.134
9	0.90	96.6	15	9-14	0.145
10 <sup>1</sup>	1.26	89.8	5	8-11	0.122
11	1.31	92.8	10	6-10	0.108
12	2.17	172.8	3	12-16	0.093
13	2.65	201.6	5	10-14	0.069
14	1.33	122.4	3	3-8	0.065
15	1.21	101.0	4	2-5	0.050
16 <sup>1</sup>	4.13	262.0	3	5-8	0.031
17 <sup>1</sup>	2.98	193.0	3	3-5	0.026
18 <sup>1</sup>	2.36	155.8	4	0-2	0.013
19 <sup>1</sup>	2.00	134.2	4	1-5	0.037
20 <sup>1</sup>	2.25	149.2	4	2-4	0.027
21	1.35	95.2	4	0-3	0.032
22 <sup>1</sup>	1.60	110.2	4	0-1	0.009
23 <sup>1</sup>	1.30	92.2	4	0-2	0.022
24	0.88	67.0	4	0	0.00
25	1.17	84.4	4	0	0.00
26 <sup>1</sup>	0.91	68.8	6	7	0.102
27 <sup>1</sup>	2.80	182.2	6	10-24	0.132
28 <sup>1</sup>	1.47	102.4	4	6-8	0.078
29 <sup>1</sup>	3.26	209.8	4	4-15	0.071
30 <sup>1</sup>	2.12	141.4	4	8-11	0.078
31	2.43	160.0	5	9-12	0.075
Total	61.63	4393.8	176	212-347	

<sup>1</sup> New routes on which Puerto Rican Nightjars were not surveyed before 1985.

provided the best habitat in the moist limestone forest region for relict populations of nightjars.

Our findings agree with those of Kepler and Kepler (1973), who concluded that nightjars had been extirpated from northern Puerto Rico. This extirpation may have occurred as a result of the large scale deforestation, which occurred during the last decades of the 19th century and early decades of the 1900s. By the end of the 1920s, approximately 3% of the original forest cover of Puerto Rico remained, mostly limited to the mountain peaks (Wadsworth 1950, Wiley 1985).

In southwestern Puerto Rico, we discovered nightjars at several new locations (Fig. 5). We believe our success was due to both intensity of

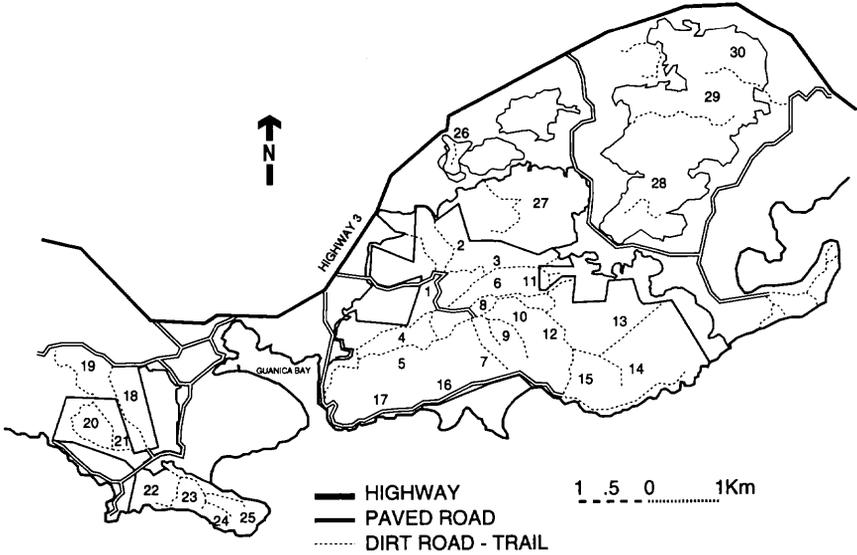


FIGURE 3. Map of the Guánica Forest region where Puerto Rican Nightjars were surveyed. Numbers indicate census routes and correspond to routes listed in Table 4. Topographic outline follows the 25 m contour.

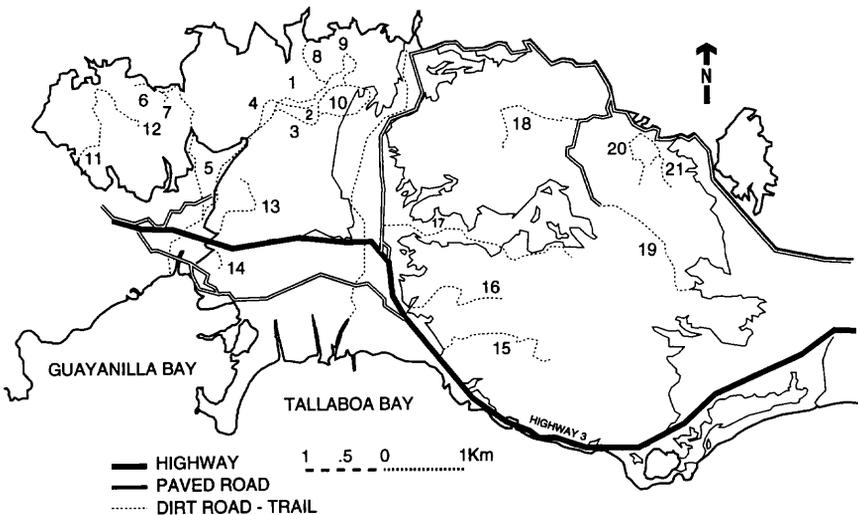


FIGURE 4. Map of the Guayanilla-Peñuelas region where Puerto Rican Nightjars were surveyed. Numbers indicate census routes and correspond to routes listed in Table 5. Topographic outline follows the 25 m contour.

TABLE 4. Results of surveys of Puerto Rican Nightjars in the Guayanilla-Peñuelas region, 1985-1987, 1989 and 1990. None of these routes had been surveyed before 1985.

Survey route	Route length (km)	Area surveyed (ha)	# surveys	Min-Max males	Mean abundance (nightjar/ha)
1	1.60	124.4	6	3-5	0.040
2	0.80	62.2	6	5	0.080
3	2.30	60.0	5	2-3	0.050
4	0.80	24.6	5	3	0.122
5	2.60	91.0	9	2-5	0.055
6	0.70	57.7	9	5-7	0.121
7	1.10	78.4	9	1-4	0.051
8	1.30	92.2	6	8-11	0.119
9	1.52	105.4	6	4-6	0.057
10	2.95	177.0	6	5-8	0.045
11	2.12	155.6	4	11-18	0.116
12	1.87	140.6	4	9-15	0.107
13	2.30	166.2	4	12-22	0.132
14	1.23	102.2	2	5	0.049
15	3.10	200.2	4	6-10	0.050
16	2.68	175.0	4	11-14	0.080
17	4.35	275.2	4	10-19	0.069
18	2.68	175.0	4	5-7	0.040
19	3.28	196.8	3	6-9	0.046
20	1.79	121.6	2	7	0.058
Total	42.82	2700.5	104	120-188	

searches and use of playback recordings to detect nightjar presence at new sites. In many avian species the frequency and duration of singing activity is directly related to density (Krebs 1971, Kroodsma 1976). In all regions surveyed where nightjar abundance was low, birds did not sing for prolonged periods and sometimes were only detected following a playback of the recorded song. Furthermore, Reynard (1962) found that nightjars exhibit chorusing behavior; when a period of silence is broken by one bird, others nearby readily join in. The nightjars we surveyed responded similarly to taped songs, which allowed us to locate additional birds that would have otherwise gone undetected.

In previous surveys of nightjars, it was assumed each singing nightjar represented a breeding pair (Kepler and Kepler 1973, Noble et al. 1986, Reynard 1962, Wiley 1985). As all singing birds may not be mated, interpretation of a singing bird as a breeding pair may overestimate reproductive potential for a particular species. Additionally, unmated male nightjars (*Caprimulgus* spp.) may actually sing more vigorously, as they are attempting to attract mates (Jackson 1984; H. D. Jackson, pers. comm.). For these reasons, we chose to report only the number of singing male nightjars heard per route.

We heard more nightjars singing along survey routes during winter surveys (January-March) than summer surveys (June-August). Our

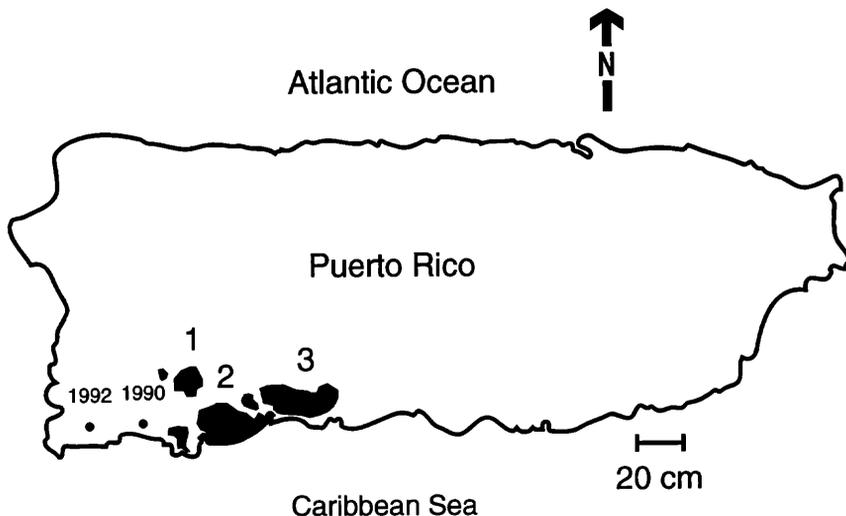


FIGURE 5. Known geographical distribution of the Puerto Rican Nightjar by 1992. Numbered areas refer to areas of greater abundance (1 = Susúa-Maricao, 2 = Guánica, 3 = Guayanilla). Dated sites refer to recent nightjar records for the Parguera Hills (1990) and Sierra Bermeja (1991).

results support those of Kepler and Kepler (1973), who reported the peak calling period for nightjars extends from February to May. Noble (1984), however, heard more during the summer. These differences may be related to the fact that the surveys conducted by Noble (1984) were limited to one summer and one winter period during 1984–1985. Both the surveys conducted by Kepler and Kepler as well as our own, however, were conducted over a longer period of time, 3 yr and 6 yr, respectively.

We found 2744 ha to support nightjars currently in the lower cordillera forest region of Susúa and Maricao. This area is approximately twice that estimated by Noble et al. (1986) and more than four times that estimated by Kepler and Kepler (1973). Highest densities were found in the southern section of Susúa Forest and adjacent lands. There the vegetation represents a transitional zone between dry coastal and dry limestone forests to the south and more humid lower cordillera forests located on the northern region of Susúa and Maricao forests (Silander 1986).

Although most nightjars occur on the southern slopes of Susúa Forest, they can be found in the mature lower cordillera forest at higher elevations. Areas on the southeastern slopes of the Maricao Forest currently do not seem to harbor nightjars. These areas are similar to the higher elevation sites found in and around Susúa Forest and, as such, seem to be marginal habitat. Extremely steep topography and high precipitation could be the factors limiting use of these areas by nightjars.

In the Guánica region, Noble (1984) estimated that 325 nightjars occupied 2659 ha of coastal dry limestone forest. Noble (1984) thought

nightjars were limited to the section of Guánica Forest east of Guánica bay and adjacent private land. We found nightjars west of Guánica Bay, albeit in small numbers. Abundance was greater there on the forested uplands and less in the limestone forests and coastal scrub areas closer to the coast. The presence of nightjars in the Parguera Hills and Sierra Bermeja suggests that the species may there inhabit patches of suitable habitat. This region of coastal dry forest extends from the western section of Guánica Forest to the southwestern end of Puerto Rico at Cabo Rojo.

Nightjars were more abundant east of Guánica Bay, where the birds concentrated in and around the eastern section of Guánica Forest. In this area nightjars were consistently heard singing below 25 m on the southern slopes near the coast and at the forest's edge near homes and agricultural fields on the northern boundary of the forest.

Nightjar density was highest in the deciduous forest, evergreen forest and plantation uplands of Guánica Forest. Nightjar densities were comparable to the highest estimates reported for congeners (Bjorklund and Bjorklund 1983, Cooper 1981, Gribble 1983, Jackson 1984), and thus the spatial needs in this genus may be rather similar. In addition, densities have been similar since the early Keplers' surveys in 1969 (Table 5), suggesting that nightjar abundance on the eastern section of Guánica Forest may be at or near carrying capacity.

Approximately 66% (2700 ha) of the available habitat in the Guayanilla-Peñuelas region was surveyed. Nightjars were found throughout this region, although the birds seemed to be more numerous in the western section where the most pristine tracts of mature dry limestone forest remain. Nightjars were heard singing on grazed lands where the canopy was retained although in lower numbers, suggesting that nightjars can exist on lands with some degree of disturbance (Vilella and Zwank 1987).

*Conservation measures.*—At present, privately owned forests occupied by nightjars are being rapidly converted to other uses. Forests are being cleared outside protected areas for agriculture, housing, road construction, resort development and industry. Plans to build a large resort on a tract of private land that borders the southern boundary of the Guánica Forest's eastern section were abandoned only after fierce public outcry (Canals 1990). Moreover, there is currently no conservation unit established in the region of Guayanilla, where a considerable area of mature coastal dry limestone forest remains. Plans have been proposed to install a toxic waste incinerator in the industrial complex south of the Guayanilla Hills. Additionally, the region of the Parguera Hills and Sierra Bermeja from where the latest nightjar records have recently come, is under intense pressure for urban and resort development. The abundance and distribution, as well as amount of forest land used by nightjars in this part of the species range is presently unknown (Fig. 5).

The most pressing conservation need for the species within privately owned land is habitat protection. Nightjars occur at moderate to high densities on a number of privately owned areas of dry limestone and lower cordillera forest in southwestern Puerto Rico. Of these, the most critical

TABLE 5. Comparison of 1969–1992 surveys of Nightjars in the Guánica Forest, Puerto Rico.

Years	Distance surveyed (km)	Number of Nightjars	Density Nightjar/ha	Source <sup>1</sup>
1969–1971	31.3	275	0.11	Kepler and Kepler (1973)
1976–1984 <sup>2</sup>	8.1	57	0.14	Wiley (1985)
1984	14.3	98	0.15	Noble (1984)
1985–1992	13.4	99	0.14	Present study

<sup>1</sup> Survey data obtained from routes numbered 1, 2, 3 and 5 by Kepler and Kepler (1973).

<sup>2</sup> Figures are mean values obtained between 1976 and 1984.

sites are in the Guayanilla Hills because at present, no protected areas exist. Acquisition of approximately 1500 ha of dry forest would insure the protection of the best nightjar habitat found within this region (Fig. 4). This region also includes unique moist forest life zones found deep in limestone gorges that are presently not represented in any protected area of southwestern Puerto Rico (Cintrón and Beck 1977). Similarly, private lands adjacent to the southern boundaries of Susúa Forest (Fig. 2) should also be considered for acquisition. These privately owned lands are one of the few remaining areas of coastal dry-cordillera ecotonal forest. Approximately 500 ha appear to constitute the most suitable nightjar nesting habitat.

Additionally, small sized (200 ha) tracts of privately owned forestland located on the northeastern boundary of the Guánica Forest were found to possess some of the most pristine examples of mature deciduous dry limestone forest. This area is located on the highest elevations of the reserve at the eastern end of survey route 11 (Fig. 3).

It is unrealistic to assume that all of the existing tracts of privately owned dry forest will be acquired and preserved. Therefore, provisions should be taken to mitigate the impacts on areas that presently harbor nightjars and will likely remain under private ownership. Information on the status of the nightjar and the desirability of conserving the forests of southwestern Puerto Rico should be made available to the pertinent landowners through the commonwealth and federal resource management agencies. Additionally, agroforestry practices that promote the establishment of plantation (e.g., *Swietenia mahogany*) as well as native deciduous tree species (e.g., *Bucida buceras*) for reforestation should be strongly encouraged. Conversely, land uses such as industrial and residential development that promote forest clearing should be minimized.

The most immediate measures to insure the continuing existence of the species can be applied on those lands presently under public ownership, namely the Susúa and Guánica forests. The designation of both reserves as critical habitat by the federal government would provide additional protection and insure the species' continued existence. Major improvements would be obtained if Susúa Forest was designated as critical

TABLE 6. Abundance of Puerto Rican Nightjars on public and private land in the Susúa-Maricao, Guánica and Guayanilla regions of southwestern Puerto Rico, 1992.

Region	Area (ha)		# nightjars		Total # nightjars
	Public	Private	Public	Private	
Maricao-Susúa	1947.8	796.6	127	50	177
Guánica	3308.0	1085.8	270	77	347
Guayanilla	—	2700.5	—	188	188
Total	5256	4583	397	315	712

habitat and lands on the southern boundaries of the forest were acquired or protected. Similarly, designation of Guánica Forest as critical habitat would help to protect the area from existing development threats. The opening and development of the forest road system has been proposed several times. The areas along the forest roads and trails are located within optimal nightjar nesting habitat, however (Vilella and Zwank 1988). It is imperative that the present state of the Guánica Forest system of trails remains undisturbed.

Our total of 712 singing male nightjars included 315 on 4583 ha of private land (Table 6). Noble (1984) estimated the total number of nightjars based on the total amount of available private land. His estimates could be high because of ongoing conversion of private forest to other uses. As a result of this rapid habitat turnover on private lands, we chose to estimate the abundance based solely upon the private land that we surveyed. It must be emphasized that the number of nightjars reported refer only to adult males, as these were the ones detected by our method and utilized as an index of abundance. At present, however, approximately 1400–2000 individuals distributed over 10,000 ha of coastal dry and cordillera forest in southwestern Puerto Rico may exist.

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#### LITERATURE CITED

- AMERICAN ORNITHOLOGISTS' UNION. 1983. Check-list of North American birds. 6th ed. American Ornithologists' Union, Lawrence, Kansas. 877 pp.
- BAKER, W. W., AND R. H. PEAKE. 1966. Whip-poor-will populations in the lower Piedmont of Georgia. *Oriole* 31:15–19.

- BENT, A. C. 1940. Life histories of North American cuckoos, goatsuckers, hummingbirds, and their allies. U.S. Natl. Mus. Bull. 176. 506 pp.
- BIAGGI, V., JR. 1974. Las aves de Puerto Rico. Editorial Universitaria, Universidad de Puerto Rico, San Juan, Puerto Rico. 373 pp.
- BJORKLUND, R. G., AND E. R. BJORKLUND. 1983. Abundance of Whip-poor-wills, *Caprimulgus vociferus*, in the Sand Ridge State Forest. Trans. Illinois Acad. Sci. 76(1-2): 271-276.
- BOND, J. 1961. Birds of the West Indies. Houghton Mifflin Company, Boston, Massachusetts. 256 pp.
- BOND, J. 1962. Seventh supplement to the checklist of birds of the West Indies (1956). Acad. Nat. Sci., Philadelphia, Pennsylvania. 16 pp.
- CANALS, M. E. 1990. El futuro del Bosque de Guánica como una unidad efectiva de conservación. Acta Científica 4(1-3):109-112.
- CARDONA, J. E., M. RIVERA, M. VAZQUEZ OTERO, AND C. R. LABOY. 1986. Availability of food resources for the Puerto Rican Parrot and the Puerto Rican Plain Pigeon in Rio Abajo Forest. Final Report Pittman-Robertson Project W-10 (ES-1). Puerto Rico Department of Natural Resources, San Juan, Puerto Rico. 91 pp.
- CINTRÓN, B. B., AND B. F. BECK. 1977. Isolation of a plant community by karst processes in southwestern Puerto Rico. Nat. Speleol. Soc. Bull. 39:73-79.
- COOPER, R. J. 1981. Relative abundance of Georgia caprimulgids based on call-counts. Wilson Bull. 93:363-371.
- DANFORTH, S. T. 1936. Los pájaros de Puerto Rico. Rand McNally and Co., New York, New York. 124 pp.
- GRIBBLE, F. C. 1983. Nightjars in Britain and Ireland in 1981. Bird Study 30:165-176.
- JACKSON, H. D. 1984. Capture/recapture data on the nightjars of Ranelia Farm, Zimbabwe. Safring News 14(1):43-50.
- JOYNER, S. P. 1985. SAS/STAT guide for personal computers. Version 6 ed. SAS Institute, Inc. Cary, North Carolina. 895 pp.
- KEPLER, C. B., AND A. K. KEPLER. 1973. The distribution and ecology of the Puerto Rican Whip-poor-will. Living Bird 11:51-60.
- KREBS, J. R. 1971. Territory and breeding density in the Great Tit (*Parus major* L.). Ecology 52:2-22.
- KROODSMA, D. E. 1976. The effect of large song repertoires on neighbor "recognition" in male Song Sparrows. Condor 78:97-99.
- LACK, D. 1957. Notes on nesting nightjars. Brit. Birds 50:273-277.
- MARION, W. R., T. E. O'MEARA, AND D. S. MAEHR. 1981. Use of playback recordings in sampling elusive or secretive birds. Stud. Avian Biol. 6:81-85.
- MILLS, A. M. 1986. The influence of moonlight on the behavior of goatsuckers (Caprimulgidae). Auk 103:370-378.
- NOBLE, R. E. 1984. 1984 status of the endangered Puerto Rican Whip-poor-will. Louisiana State University Agric. Cent., Baton Rouge, Louisiana. 64 pp.
- , F. J. VILELLA, AND P. J. ZWANK. 1986. Status of the endangered Puerto Rican Nightjar in 1985. Carib. J. Sci. 22(3-4):137-143.
- REYNARD, G. B. 1962. The rediscovery of the Puerto Rican Whip-poor-will. Living Bird. 1:51-60.
- SILANDER, S. 1986. Compendio enciclopédico de los recursos naturales de Puerto Rico. Volume X. Puerto Rico Department of Natural Resources, San Juan, Puerto Rico. 183 pp.
- STEEL, R. G. D., AND J. H. TORRIE. 1980. Principles and procedures of statistics: A biometrical approach. McGraw-Hill, New York, New York. 481 pp.
- VILELLA, F. J., AND P. J. ZWANK. 1987. Density and distribution of the Puerto Rican Nightjar in the Guayanilla Hills. Carib. J. Sci. 23(2):238-242.
- , AND ———. 1988. Red Data Book: Puerto Rican Nightjar. ICBP World Bird-watch 10:9.
- VINCENT, J. 1968. Puerto Rico Whippoorwill. In Red data book. Volume 2: Aves. I.U.C.N. Survival Service Comm., Morges, Switzerland.

- WADSWORTH, F. H. 1950. Notes on the climax forests of Puerto Rico and their destruction and conservation prior to 1900. *Caribb. Forester* 2(1):38-47.
- WETMORE, A. 1916. Birds of Porto Rico. Bull. 326, U.S. Dept. Agr., 140 pp.
- . 1919. Description of a Whippoorwill from Porto Rico. *Proc. Biol. Soc. Washington* 32:235-237.
- . 1922. Bird remains from the caves of Porto Rico. *Amer. Mus. Nat. Hist. Bull.* 46:297-333.
- WILEY, J. W. 1985. Bird conservation in the United States Caribbean. Pp. 107-159, in S. A. Temple, ed. *Bird conservation 2*. International Council for Bird Preservation. University of Wisconsin Press, Madison, Wisconsin.

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### MEETINGS OF INTEREST

**Eastern Bird Banding Association**, 70th annual meeting, Watson Homestead, Painted Post, New York, 2-4 April 1993.

Address inquiries to: Mr. and Mrs. John Forness, 3086 Haskell Road, Cuba, NY 14727-9402.

**Wilson Ornithological Society**, annual meeting, University of Guelph, Guelph, Ontario, Canada, 29 April-1 May 1993.

Address inquiries to: Alex Middleton, Chair, Local Committee, Zoology Department, University of Guelph, Guelph, ON N1G 2W1, Canada.

**American Ornithologists' Union**, 111th annual meeting, Fairbanks, Alaska, 8-13 June 1993.

Address inquiries to: Edward C. Murphy, Institute of Arctic Biology, University of Alaska, Fairbanks, AK 99775-0180.

**Animal Behavior Society**, 30th annual meeting, University of California, Davis, California, 24-30 July 1993.

Address inquiries to: Benjamin Hart, Department of Physiology, School of Veterinary Medicine, University of California, Davis, CA 95616.

**Society of Caribbean Ornithology**, Cienega de Zapata, Cuba, 1-6 August 1993.

Address inquiries to: James W. Wiley, 2201 Ashland Street, Ruston, LA 71270.