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SEASONAL MOVEMENTS OF THE BAHAMA PARROT (*AMAZONA LEUCOCEPHALA BAHAMENSIS*) BETWEEN PINE AND HARDWOOD FORESTS: IMPLICATIONS FOR HABITAT CONSERVATION

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Resumen. – Movimientos estacionales de la Cotorra de Bahamas (*Amazona leucocephala bahamensis*) entre los bosques de pino y de madera dura: implicaciones para la conservación del hábitat. – El Parque Nacional Abaco, localizado en la isla de Great Abaco, Las Bahamas, fue establecido para proteger el hábitat de una de las dos poblaciones restantes de la Cotorra de Bahamas (*Amazona leucocephala bahamensis*). Actualmente, el parque protege las áreas de alta densidad de nidificación. Resultados de un estudio de telemetría realizado de Agosto 2003 a Julio 2004 muestran que el parque es primeramente utilizado por las cotorras durante los meses de reproducción, pero es insuficiente para mantener la población de la cotorra durante las estaciones no reproductivas. Durante la estación no reproductiva, las cotorras se dispersan hacia áreas de bosques maderables a lo largo del perímetro de la isla. Basado en polígonos convexos mínimos, el promedio anual de la razón de casa de la población de la cotorra de Abaco fue estimado a 18,593 ha (SE = 1947 ha). El análisis kernel sugiere una preferencia para bosques de madera dura fuera del Parque Nacional Abaco durante la estación no reproductiva. Las recomendaciones para la inclusión de áreas maderables entre los límites del parque protegido son, 1) Conectar hábitat de madera dura adyacentes al parque, 2) Crear parques satélites en áreas actualmente utilizadas por las cotorras durante períodos no reproductivos, y 3) Incorporar prácticas de manejo que promuevan el recrecimiento de áreas de madera dura entre los límites actuales del parque, sin disturbio en las áreas de nidificación.

Abstract. – The Bahama's Abaco National Park on Great Abaco Island was established to protect the habitat for one of two remaining populations of the Bahama Parrot (*Amazona leucocephala bahamensis*). The park currently protects the only high density nesting areas on the island. Results of a telemetry study conducted from August 2003 to July 2004 show that the park is primarily used by parrots during the breeding months, but is insufficient to support the parrot population during the non-breeding season. During the non-breeding season, the parrots disperse to hardwood areas along the perimeter of the island. Based on minimum convex polygons, the mean annual home range of the Abaco parrot population was estimated to be 18,593 ha (SE = 1947 ha). The results of a kernel analysis suggest a preference for hardwood coppice habitat outside of Abaco National Park during the non-breeding season. Recommendations are to include more hardwood areas within the protected park boundaries by 1) annexing hardwood habitat adjacent to the park; 2) creating satellite parks in areas currently used by parrots during non-breeding periods, and 3) incorporating management actions that favor the regrowth of hardwood habitats within the current park boundaries without disturbing ground nesting areas. *Accepted 2 November 2007.*

Key words: *Amazona leucocephala bahamensis*, Bahama Parrot, home range, kernel, minimum convex polygon, Abaco National Park, habitat use, Caribbean pine, hardwood, movement.

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INTRODUCTION

Nature preserves are created to meet numerous objectives including biodiversity protection (Newmark 1995), single-species conservation (Pendergast *et al.* 1999, McCarth ey *et al*. 2005), recreation (Curtin 1993) or preservation of natural features (Shafer 1999). Regardless of the primary objective of the preserve, method-based design approaches are most cost-effective, and optimize management objectives (Margules & Usher 1981, Pressey *et al.* 1993, Prendergrast *et al.* 1999, Rothley 1999, Gurd 2001). Often essential information about targeted habitats and species may not be available when creating a reserve. In such cases, *ad hoc* and/or *post hoc* methods are typically used.

In 1994, the Bahamas National Trust established the 8300-ha Abaco National Park (ANP) on Great Abaco Island. The intent for the ANP was to protect important Bahama Parrot (*Amazona leucocephala bahamensis*) habitat. The park boundaries were established using the best ecological information for the parrot habitat use available at the time (BNT 2006). The majority of the park consists of pine forest, and encompasses the best known breeding grounds for the endangered parrot (Snyder 1982, Gnam & Rockwell 1991a). In addition to using the pine forest as a nesting area, the parrot uses Caribbean pine (*Pinus caribea*) as a primary foraging source during the breeding season (Gnam & Rockwell 1991b).

Surveys were initiated in 2002 to estimate population size and to determine the species' status (Rivera *et al.* 2005). Preliminary surveys were conducted during winter and spring to determine the optimum time for conducting population surveys. Fewer parrots were observed in the pine forest of southern Abaco and Abaco National Park during the non-breeding season than during breeding periods (Rivera *et al.* 2005). This raised questions as to temporal-spatial variability in population distribution outside of the breeding season.

The purpose of this study was to determine the: 1) location of parrots during non-breeding months; 2) extent of the area used by parrots throughout the whole year; 3) essential habitat needs of the parrot population on Great Abaco Island; and 4) adequacy of the current park for parrot conservation.

METHODS

Study area. I conducted this study in the southern portion of Great Abaco Island, The Bahamas. The study area ranged from Marsh Harbour (26°30'N, 77°04'W) south to Hole-in-the-Wall (25°51'N, 77°11'W) and Sandy Point (26°00'N, 77°24'W) and completely encompassed Abaco National Park. The habitat is classified as predominantly Caribbean pine forest with varied understory vegetation and a hardwood (coppice) perimeter along the eastern portion of the island. Most of the study area is flat with some limestone ridges no higher than 37 m above sea level (Sealey 1994)

Telemetry. During August and September 2003, 5 adult parrots and 28 chicks were outfitted with 11g Holohil unique-frequency collar transmitters. Chicks were pulled from the nest two weeks prior to fledging to band and radio-tag. Adults were also captured for banding and radio-tagging while in the nest cavity to feed chicks.

Radio-tagged parrots were subsequently monitored on a weekly basis by visiting a set of permanent platforms and supplementing these sites with on-the-ground tracking. Thirteen permanent platforms were constructed in an array throughout southern Abaco to facilitate coverage. Three additional canopy level towers, already in place, were incorporated into the array. Parrots were tracked from

TABLE 1. Calculated 95% and 50% kernel estimate and breakdown by location and habitat type.

	95% kernel estimate area (ha)	50% kernel estimate area (ha)	Total in 41,148 ha study area
Total kernel area calculated	16,875.13	2,896.10	—
Inside park	4,276.85	646.43	8,300
Coppice habita	3,236.21	1,296.00	6,040
Pine habitat	10,840.17	1,600.10	27,631
Other habitat types	2,798.75	0	7,477

29 August 2003 to 29 July 2004. The south Abaco study area comprised 41,148 ha. Location points for parrots were obtained in one of two ways: first, by taking GPS points at the site a radio-tagged bird was seen or homed-in on; and second, by triangulating bearings from various locations using Locate II (Nams 1990). One observer was used to record most of the bearings. Points were triangulated only when the time span between readings was 30 min or less.

Home range and movements. I calculated home ranges for each parrot meeting the inclusion criteria using location points to create minimum convex polygons (MCP) (Mohr 1947). In the analysis, I included birds that had location information for at least 6 months during at least 3 seasons. MCPs were calculated using Hawth's tools extension within ArcGIS 9.1 (Byer 2005). Due to the shape of the island, some polygons included ocean areas; these portions were cut out of the MCP home range. Therefore, home range was constrained by island shape.

I also calculated a single 95% (homerange) and 50% (hotspots) fixed-kernel estimates using the non-breeding season (mid-September to early April) location points of all radio-tagged parrots (Worton 1989). Since parrots are gregarious, I was interested in determining areas of high use during the non-breeding season on Great Abaco. I limited my analysis to this season because the breeding season habitat use is well documented, particularly as it relates to nest-site locations (Snyder 1986, Gnam & Rockwell 1991a, Stahala 2005, Mori 2006). The kernels extended over ocean boundaries thus as with the MCP, I constrained the kernals to the island boundaries using ArcTools. I overlaid MCP and kernel-estimate layers on a landcover vegetation map (provided by the Nature Conservancy's Bahamas Country Program) to determine habitat type within the 50% and the 95% kernel areas.

Proportions of habitat varied throughout the study area. I analyzed differences in habitat use with the chi-square test for independence. I calculated Manly's (α) to determine the preferences for the three habitat categories, i.e., pine, coppice and others (altered land, swamp, inland water, mangrove, wetland) on Abaco used by parrots (Manly 1974). Data are presented as mean ± SE.

RESULTS

Minimum convex polygon home ranges were calculated for each of 15 radio-tagged birds, two adults and thirteen chicks that met the inclusion criteria. The mean area of the MCP home ranges was 18,593 ± 1947 ha (range: 5568 ha to 30,573 ha). One parrot was documented traveling 28 km in one day, and a total of 44 km over a 3-day period.

A total of 481 location points over the non-breeding season were used from 30 radio-tagged birds to determine the 95% and 50 % kernel estimates of the Abaco parrot population. Six radio-tagged parrots were excluded from the kernel analysis because birds either died early in the study or their signal was not detected. The 95% kernel was estimated to be 16,875 ha (Table 1). Twenty-five percent of the 95% kernel estimate was located within the park. Twenty-two percent of the 50% kernel estimate or hotspots were found within Abaco National Park boundaries. Additional kernel estimates by habitat are found in Table 1.

Habitat use was compared between coppice, pine and other habitats. Coppice habitat was used significantly more than pine habitat in 95% and 50% kernel estimates when proportion of availability was taken into account (95% $\chi^2_c = 237$, df = 1, $p < 0.001$, 50% $\chi^2_c = 1564$, df = 1, $p < 0.001$). Coppice was used significantly more than the "other habitat" categories (95% $\chi^2_c = 209$, df = 1, $p < 0.001$).

The analysis for the 95% estimate revealed a preference for coppice ($\alpha = 0.4$). Two habitat categories, pine ($\alpha = 0.3$) and "others" ($\alpha = 0.3$) were used as expected. The analysis for the 50% kernel hotspots resulted in a strong preference for Coppice ($\alpha = 0.78$) and avoidance of pine ($\alpha = 0.22$) and other habitat ($\alpha = 0.0$).

Parrots made their way to the coppice habitat within days of fledging. I tracked four radio-tagged adults whose chick(s) were also radio-tagged. In these cases, separation between parents and chicks occurred between 13 October and 6 November 2003. In one case, two chicks were tracked with a radio-tagged adult. In this situation the chicks separated from the parent within 3 days of each other.

DISCUSSION

Telemetry was the method used to obtain lacking information on habitat use for the Bahama Parrot. A tower array permitted access to areas above the canopy. Although not quantified, the towers increased the detection range of radio-tagged birds when ground readings did not detect signals from radio-tagged parrots. The results from the telemetry data reveal that parrots do not use available habitats randomly. Parrots show preference for coppice habitat throughout the home range. However, there is a strong preference for the coppice habitat during the non-breeding season, and an avoidance of pine and other habitats within the hotspot areas.

Many parrot species are reported using various habitat types depending on season and food availability (Saunders 1980, MacGrath & Lill 1985, McFarland 1991, Gilardi & Munn 1998, Renton 2002, Karubian *et al.* 2005). The Bahama parrot's seasonal use of pine and coppice habitats is consistent with seasonal-habitat preferences in many psittacine species. The most likely reason for the movement between pine forest and coppice habitats is availability of food resources. Seeds from green pinecones are the parrots' primary food during the breeding season (Gnam & Rockwell 1991a, 1991b). The pine forest is a monoculture of Caribbean pine which produce large quantities of green pinecones during the same period as the parrot breeding season. After the fall season, pine trees are no longer suitable for foraging parrots. This makes it necessary for parrots to move to areas of higher food availability such as the coppice areas.

The 95% kernel-use area (16,875 ha) which assessed home range for all radio-tagged parrots and MCP individual home range estimate (18,593 ha) both exceed the ANP area currently protected for the species. The individual MCP for each individual bird also exceeds the 95% kernel estimate, or home range, for the population. Home range overestimation by the MCP method could be due to the distance between individual hotspots. The area between hotspots are included within the MCP even if these intermediate areas may not be heavily used if used at all.

The location points from telemetry may support higher food densities, and thus should be considered of great importance for parrots and included in protected areas. These areas need to be assessed to determine what makes them of interest to parrots to determine management needs for already protected areas. The area within the 95% kernel home range is used by the parrots and should receive special consideration before land use changes are implemented. The 50% kernel home range areas are considered hotspots for parrots due to the density of points where they were detected and should receive intensive protection.

The period when parrots were radio-tracked (2003–2004) represents a year without natural disturbance or unusual environmental stress. No hurricanes or fires occurred during this monitoring period. Years with additional stresses, such as hurricanes, will force the parrots to forage on broader areas, or more varied habitat types (White *et al.* 2005). This was demonstrated following the 2004 hurricane season when hurricane Frances and Jeanne made landfall on Great Abaco Island. The presence of Bahama Parrots was reported from Marsh Harbour and Man-O-War cays during fall and winter 2004 (Anita Knowles and Nancy Albury pers. com).

CONCLUSIONS

Reserves can play an important role in parrot conservation (Marsden *et al.* 2000). The Abaco National Park was delineated to include known breeding and foraging areas for Bahama Parrots. At the time of the park's foundation, the documented parrot habitat consisted of limestone solution cavities within the pine forest. Mature green cones from the Caribbean pine result to be an important foraging source during the breeding season (Gnam & Rockwell 1991b). However, this study demonstrates bird movements from the pine forest to the coppice habitat during non-breeding months and the importance of protecting the coppice habitat in addition to the pine forest breeding areas.

The present study reveals that conserving the Bahama Parrot will require protecting hardwood coppice habitat on Great Abaco Island. This can be done by annexing adjacent hotspot coppice areas to the Abaco National Park. Hotspot areas are also found in Sandy Point, 35 km from the current park boundaries. These areas should be given the status of satellite preserves within an Abaco National Park complex. Conversion of current pineyards within the park boundaries to coppice habitat through fire exclusion is also an option, although such areas will require many years to convert to mature coppice habitats. Critical areas within hotspots in Sandy Point, Crossing Rocks area, and east of the park are currently slated for development and settlement. Bahama Parrots are adaptable creatures, and often inhabit areas containing human settlements, such as Bahamas Palm Shores, Sandy Point and Island Homes developments. Note that large tracks of mature coppice habitat are found within all of these developments. Ecologically sound building techniques should be used to prevent the destruction of foraging areas during the construction process to protect remaining parrot habitat.

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