Project Title: Impact of Urbanization and Fragmentation on Bat Assemblages

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Project Summary: The West Indian archipelago forms a biogeographically distinct region within the Neotropics with a high level of endemism. The structure of this archipelago's bat faunas are not random assemblages from tropical mainland source pools (Fleming, 1982; Rodríguez-Durán and Kunz, 2001). For instance, whereas 46% of bats in northern South America are fruit-eating species, only 33% feed on fruits in the West Indies (Silva-Taboada, 1979). These insular phytophagous species are particularly sensitive to the regular disturbances caused by hurricanes (Rodríguez-Durán and Vázquez, 2001), but neither their importance on the recovery and reforestation of disturbed areas, nor the impact of anthropogenic disturbances on their populations, have been thoroughly examined. Moreover, the effect on non-target species of changes to the landscape due to management is not well known (Conner et al., 2002). These conditions contribute to make the region a Hotspot for biodiversity, prone to loosing species of bats and the concomitant ecosystem services that these provide. The value of these services has been estimated at billions of dollars (Boyles et al., 2011).

Bats have an important influence on the density and distribution of many plant species, and a significant effect on the ecosystem. It has been calculated that the bat *Artibeus jamaicensis* disperses at least 7% of the annual fig crop on Barro Colorado Island, Panama (Morrison, 1978). Thus, we set out to carry an extended and comparative examination of the assemblage of bats at Río Encantado (RE), following the protocol developed at Hacienda La Esperanza (HLE) in Manatí, Puerto Rico. This site is located within the Puerto Rican northern karst belt. The two locations show different degrees of urban encroachment: 1. RE is a wilderness area within the least populated region of the Island; 2. HLE is a nature reserve partly encroached by the rapid urban sprawl that characterizes the Island, but with significant connection to the main karst region. A third location severely encroached within an urban area will be identified and evaluated as part of this study.

Funds will be used to pay salaries, stipends and expenses for volunteers and assistants working in the project, and supplies in the form of nets and poles to capture the bats, and bat detectors. These funds will be used to initiate the project, but the protocol was developed, and baseline data for comparison has already been gathered, at HLE through a project sponsored by the Puerto Rico Conservation Trust and NSF.

Project Justification: After studying the bat faunas of small islands in Lake Gatún, in the Panamá Canal, Meyer and Kalko (2008) showed the potentially high conservation value of small habitat remnants. By 1940 forests represented 6% of the surface of Puerto Rico, one of the major islands in the Archipelago; that number had increased to 34% by 1985 (Birdsey and Weaver, 1987), mostly due to abandonment of agricultural lands. However, at almost four million human inhabitants, Puerto Rico is a very densely populated island, and while the population increased by 286% from 1935 to 1990, the amount of urbanized land increased by 1,285% (Moreno-Viqueira, 2006). This accelerated urbanization, with its concomitant problems, can be increasingly seen elsewhere in the underdeveloped tropics (Wright, 2005), and may place the

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Island in the position of serving as a platform to better understand the consequences of urbanization and fragmentation of natural ecosystems.

The rugged portions of the northern karst belt of Puerto Rico have remained forested amid increased urbanization and development of the surrounding areas. Land uses within the region include fresh water production, wilderness, wildlife restoration, conservation of biodiversity, passive recreation, eco-tourism, education, and research (Lugo et al., 2001). Research in the karst region has relevance to its own conservation and to the karst problems in the United States and the rest of the world; while at the same time the landscapes to be studied and protected have unique features not found anywhere else within the United States. However, and in spite of its importance and extension, karst forests have been little studied when compared to other forests. Thus, the island of Puerto Rico offers a model system on which to examine the impact of urban sprawl on ecosystems. As with most islands of the West Indian archipelago, bats are the only native mammals on the Island, and represent a very important component of its ecosystems (Gannon, et al., 2005). The large congregations of bats in caves are important not only in seed dispersal, pollination and pest control, but are also a significant component in the flux of energy and nutrients through the ecosystems (Gannon, et al., 2005; Rodríguez-Durán, 2009).

By involving volunteers as research assistants in this project, we will contribute to build a cadre of citizens prepared to understand the complex problems faced by our nation's ecosystems. In addition to these volunteers, the project's audiences consist of conservation organizations and agencies. It is important to address all these constituents in order to bring awareness about the impact of urbanization and fragmentation of ecosystems.

Scope of Work:

1. The goal of this project is to assess and contribute to the understanding and mitigation of the impact of urban growth upon natural tropical ecosystems; and to educate citizens capable of contributing to the study and mitigation of impacts caused by urbanization. Specific objectives to reach these goals include: A. Measuring species richness and diversity of the bat assemblage in the karst region of Puerto Rico subject to various degrees of urban encroachment and fragmentation; B. Evaluate dispersal routes of bats departing from caves with large assemblages to estimate area of activity; C. Train citizens in the science and the techniques necessary to assess these impacts; D. Develop local bat conservation groups that will remain after the completion of the project; E. Provide information to conservation organizations that will contribute to their education programs.
2. Major tasks include: A. Identification of sampling areas; B. Capture, sexing, and release of bats; C. Analysis of data gathered; D. Dissemination of the information.
3. Both the PI and the volunteers will be involved in tasks A through C. The PRCT will be responsible for task D. Field work will be carried out twice a week every month at each one of the sites.

Project Methodology:

FIELD SAMPLING - Field work will be conducted over two years, for a total of 24 consecutive months of sampling and 48 sampling nights. Seventy-two meters of mist nets, 2.5 m high, will be set for two nights each month in a standardized manner. As often as possible, the two nights will be consecutive. Location of mist nets will be displaced several meters among the two consecutive nights of sampling, but always within the same general area. Nets will be opened at

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sunset and remain open for four hours. All bats captured will be sexed and their reproductive status assessed. Weather conditions and moon phase will be noted by volunteers, although moon phobia is not expected to pose a problem at this study site (Rodríguez-Durán and Vázquez, 2001), especially when mist netting under a closed canopy. In addition to mist netting, acoustic monitoring will be carried out during the capture sessions using an ANABAT Ultrasound System.

DATA ANALYSIS - Given its preponderance in the literature, we will train volunteers to calculate and understand the Shannon-Wiener index (H_s) to provide a basis for comparison with previous studies (e.g. Rex et al. 2008). Thorough knowledge about the local bat fauna (Gannon et al., 2005), allows the species accumulation curve to be compared to the known bat assemblage rather than to an estimate predicted by a model. The Mann-Whitney U test (Sokal and Rohlf, 1981) will be used to test for significant differences between the first and second consecutive day of captures. Capture data will be related to habitat fragmentation.

Deliverables: By the end of the two year period we will have species richness and diversity measurements for three different localities within the karst region of a tropical island. The locations present different degrees of urban encroachment and fragmentation, thus allowing for an evaluation of the impact of urbanization on this ecosystem. In addition, citizens will have been trained on the science and techniques necessary to assess these impacts. Local bat conservation groups will have been established after the completion of the project. The information will be provided to conservation organizations for further dissemination, providing in this way for a broader impact of the project. These results may serve as a model on which to examine the impact of urban sprawl on tropical ecosystems.

Tool Kit: A tool kit will be produced with field guide to bats, posters about the importance of bats and karst, and links to organizations such as Bat Conservation International and Red Latinoamericana de Conservación De Murciélagos.

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