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Composition, Distribution, and Conservation of the Herpetofauna of Santa Barbara Mountain, Honduras

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COMPOSITION, DISTRIBUTION, AND CONSERVATION OF THE HERPETOFAUNA OF SANTA BARBARA MOUNTAIN, HONDURAS

By

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ABSTRACT

Santa Barbara Mountain is an important and unique ecosystem in Honduras because of its topography and high proportion of endemic species. Despite its prospects for valuable discoveries and the profusion of threats to its biodiversity, there is almost no scientific information about Santa Barbara Mountain. This study is the first systematic investigation of hepetofauna species on the mountain. Research objectives included inventorying of the reptile and amphibian species present on Santa Barbara Mountain, identifying locations and microhabitat types where each species can be found, and determining if the amphibian disease chytridiomycosis is present and in which locations. A community education objective, which included training local people as field assistants, was also pursued as a means to promote conservation of amphibians and reptiles and Santa Barbara National Park. Research was conducted in four sites on Santa Barbara Mountain above 1000 meters, from March through August 2011. Two multi-day camping trips were carried out in each site during which survey transects were conducted, including both day and night work. Data from opportunistic collection of specimens were also included. Amphibian specimens were tested for chytridiomycosis. Twenty-two species were documented, 14 of which are new reports for the mountain. The species most commonly encountered in surveys was *Craugastor laticeps* followed by *Dendrotriton sanctibarbarus*. The results of the chytrid analysis were inconclusive but included potential positive detections of the disease at two locations. Local people were invaluable as field assistants and demonstrated an interest in the species as well as a willingness to change previous misconceptions about herpetofauna. This study has added greatly to the knowledge of Santa Barbara Mountain, nearly doubling the number of documented herpetofauna species; however, more comprehensive studies are needed. The window of opportunity to study and conserve this ecosystem may be brief given threats such as deforestation, climate change, and spread of chytridiomycosis.

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PREFACE

I served as a Protected Areas Management Volunteer with the Peace Corps from July 2nd, 2009 through September 5th, 2011. I was stationed in the town of El Dorado on Santa Barbara Mountain and had the privilege of working with the wonderful residents of the town on several community projects. It took about a year to establish the relationships and work routine we needed to take on the ambitious projects they had in mind, but by the end of my service, we could see the visible results of our success. The community achieved the construction and establishment of an over $20,000 library project, complete with computer lab and internet, and 100% owned and maintained by the people of El Dorado. We also founded an ecotourism group along with locals from two other neighboring towns (San Luis Planes and El Sauce) and accomplished many conservation-related projects. We gave seven environmental presentations in community meetings in each of the three towns, including topics such as climate change, water, agrochemicals, waste management, and biodiversity. Tourists have long been arriving to walk in the cloud forest and bird watch, but previously there was no infrastructure set up for tourism. The ecotourism group trained families to cook for and host tourists in their houses, and constructed a new hiking and bird watching trail on private property. We also formed a group of nine ecotourism guides, which underwent an extensive training on topics such as customer service, ecology, conservation, geology, caves, and identification of fauna, flora, and fungi. It was this group of motivated individuals that made possible the amphibian and reptile study I was interested in completing for my masters thesis. Without the curiosity and generous cooperation of the people in the ecotourism group, namely the guides, I would never have had the opportunity to do this project. It was an opportunity for them as well. Most of them had never been camping before, and the prospect of contributing to science was exciting. I'll never forget the moment when they first saw the endemic salamander that lives on their mountain. Everyone crowded around and peered down at it, and Denis said, "It's so beautiful!" Moments like that have, I hope, made a lasting impact on their outlook on the national park. They certainly have changed me. I cannot express my gratitude that I could rely on these people to show up on time (no small feat in Honduran culture!), in the rain, to go camping on a muddy, often treacherously steep mountainside. The success of this project is a testament to the trust they put in me and that I put in them. There are so many immeasurable impacts of this project that I cannot describe adequately in this format, but I hope this paper gives a glimpse into some of the possibilities that will grow out of the experience.

INTRODUCTION

Honduras has a high level of biodiversity and species endemism, with the greatest proportion of endemism in herpetofauna in all of Central America. Yet comparatively little research has been conducted in this country (Townsend & Wilson, 2010). Recent efforts in surveying herpetofauna have greatly expanded the number of documented species and their ranges. Since 2006, the published literature has documented at least two new snake species, one new anole species, one new frog species, three new salamanders species, and newly discovered populations of five different salamander species in Honduras (Townsend & Wilson, 2006; McCranie, 2006; McCranie & Smith, 2006; Townsend et al., 2008a; Townsend et al., 2009; Townsend & Wilson, 2009; Townsend et al., 2010; Townsend et al., 2011, McCranie & Townsend, 2011; McCranie et al., 2011). Unfortunately, the extent of habitat loss and degradation remains high in Honduras, as does the level of wildlife persecution (Wilson & McCranie, 2003). Opportunities to document and conserve important ecosystems and their resident species are being lost every day. With that in mind, this study was aimed at investigating the herpetofauna of one of the most unexplored and potentially endemic-rich ecosystems in Honduras.

Santa Barbara Mountain is a unique and important ecosystem in Honduras. It is part of the significant karst landscape of Central America and one of only three karst areas in Honduras (Kueny & Day, 2002). Karstlands contribute to the geological, topographical, and environmental heterogeneity of the region, and the IUCN World Commission on Protected Areas in 1997 recognized the great need of protecting karst areas worldwide (Kueny & Day, 2002; Watson et al., 1997). The limestone composition of Santa Barbara Mountain results in a topography riddled with caves, sinkholes and precipitous slopes, draining nearly all surface water into subterranean channels. It is the second highest mountain in Honduras and a large portion of the cloud forest is encompassed in Santa Barbara National Park. The few collecting trips conducted on this mountain have turned up numerous endemic species, yet, relatively little scientific attention has been focused on this ecosystem, perhaps because of the difficulty of traversing the terrain (McCranie & Wilson, 1996; House et al., 2002; Townsend et al., 2008a). A study of leaf-litter beetles concluded that Santa Barbara National Park was one of the highest priority areas for conservation out of 13 other cloud forests in Honduras because of its high numbers of endemic species (Anderson & Ashe, 2000). The steep, treacherous terrain serves as a natural barrier to human disturbance, leaving inaccessible areas free of human activities. As a result, this national park provides an opportunity to study a relatively intact ecosystem and to preserve it as a refuge for sensitive species in a country that has experienced widespread forest conversion and degradation.

Amphibians and reptiles, because of their biological and ecological characteristics, serve as good environmental indicators, providing an excellent starting point for inventorying and monitoring biodiversity. The few forays into the forests of Santa Barbara Mountain in search of herpetofauna occurred in April 1950, April 1951, July 1968, March 1994, May and August 1995, and February 2008 (McCranie & Wilson, 1996; Köhler et al., 1999; McCranie et al., 1998; McCranie & Wilson, 2002; Townsend et al., 2008a; Townsend et al., 2008b). These collecting trips were carried out upslope of San Luis Planes, El Cedral, and El Ocotillo

(Departamento de Santa Bárbara). Based on these trips, a list of 15 herpetofauna species on Santa Barbara Mountain was compiled (Table 1). This list includes four endemic species.

Table 1. List of herpetofauna species known to occur on Santa Barbara Mountain (SBM), Honduras prior to this study, including notes on endemic or range restricted species

Species	**Order/Family**	**Range Restrictions**
Dendrotriton sanctibarbarus	Caudata: Plethodontidae	Endemic to SBM
Nototriton limnospectator	Caudata: Plethodontidae	Endemic to SBM and neighboring mountain
Incilius valliceps	Anura: Bufonidae	
Craugastor laevissimus	Anura: Craugastoridae	Honduras and Nicaragua
Phrynohyas venulosa	Anura: Hylidae	
Ptychohyla hypomykter	Anura: Hylidae	
Smilisca baudinii	Anura: Hylidae	
Hypopachus variolosus	Anura: Microhylidae	
Lithobates brownorum	Anura: Ranidae	
Anolis laeviventris	Squamata: Polychrotidae	
Anolis rubribarbaris	Squamata: Polychrotidae	Endemic to SBM
Sceloperus malachiticus	Squamata: Phrynosomatidae	
Ninia sebae	Squamata: Colubridae	
Bothriechis thalassinus	Squamata: Viperidae	Honduras and Guatemala
Typhlops tycherus	Squamata: Typhlopidae	Endemic to SBM

Global and local disturbances add a level of urgency to the study of amphibians on Santa Barbara Mountain. The worldwide decline in amphibians has been linked to several causes. Habitat loss and degradation have long been sources of concern. They are occurring at the fastest rate in areas where amphibian species diversity is the greatest, which is in the tropics (Stuart et al., 2004). In Honduras, the rate of deforestation is estimated to be 2.3% per year (Wilson & McCranie, 2003) and is particularly pronounced around settlements near protected areas (Pfeffer et al., 2005; Southworth & Tucker, 2001). The deforestation is primarily because of the expansion of coffee farming into higher altitudes and steeper slopes as a result of the ever-increasing population pressure (Pfeffer et al., 2005; Southworth & Tucker, 2001). Habitat degradation affecting amphibians on Santa Barbara Mountain could include agrochemical residues and land cover change related to farming practices. Information regarding which species are present and where they are located can help determine whether habitat degradation is a contributing factor to amphibian decline on the mountain and where conservation efforts should be targeted.

Amphibians worldwide have also been experiencing rapid declines in pristine areas. One hypothesis is that amphibians are dying because of infection by a fungal pathogen, *Batrachochytrium dendrobatidis* (Berger et al., 1998). This fungal disease is referred to as chytridiomycosis or chytrid for short. Chytrid has already been detected in Honduras and neighboring El Salvador and Guatemala, and declines have been documented in some of Honduras' national parks (Putschendorf et al., 2006; Felger et al., 2007; Mendelson et al., 2004; Kolby et al., 2009). The prevailing theory is that chytrid followed the novel pathogen hypothesis, and that on the American continents, the wave of disease spread south from the United States, decimating naïve populations as it passed (Lips et al., 2006; Cheng et al., 2011). No studies have yet determined if chytrid spread to amphibian populations on Santa Barbara Mountain when it was introduced to Honduras. The vector of the disease is still unknown, but hypotheses such as resistant amphibians, birds, insects, or humans have been suggested (Fisher & Garner, 2007; Vredenburg et al., 2010; Walker et al., 2008). It is not known what mechanism affects the virulence of the disease since it is not fatal for all species or in all locations for the same species. Studies have linked pathogenicity to temperature, claiming that the effects of the fungus become lethal when chytrid is at its optimal temperature, 23°C (Daszak et al., 1999). This hypothesis is supported by greater mortality rates at high elevations (above 900 meters; Wilson & McCranie, 1998). This could have important implications as some studies have shown that global climate change causes complex alterations in orographic cloud formation, daily minimum temperatures, and other climate patterns, which move the temperature in amphibian habitat closer to the optimal temperature for chytrid (Pounds et al., 2006; Laurance, 2008). Much of the forested area on Santa Barbara Mountain occurs above 900 meters and is highly impacted by cloud cover, making this an area potentially susceptible to the effects of chytrid and climate change.

Reptile species provide a critical role in ecosystems as predators, and as a group show great diversity in the tropics. Reptile species in Honduras are also declining, but to a lesser extent than amphibians (Wilson & McCranie, 2003). Since reptiles are not as dependent on water as amphibians, this increases the amount of habitat where they can occur and leads to an improved conservation status. However, reptiles are often perceived to be more dangerous and thus face threats from excessive persecution, especially in the case of snake species (Wilson & McCranie, 2003). Protection of important reptile habitat as well as community education are important for the successful conservation of Honduran reptile species.

The majority of the forested landscape of Santa Barbara Mountain is encompassed in Santa Barbara National Park; however, the laws protecting national parks have not been enforced among the many communities located within the buffer zone of the park (Rodas V., 2002; Fernández, 2011). Management is theoretically divided between the Honduran Forest Service (Instituto de Conservación Forestal), the Natural Resource and Environment Department (Secretaría de Recursos Naturales y Ambiente), the National Army, and the Municipality of Santa Bárbara (a political entity), but there is no organization dedicated solely to managing this national park (Santos & Sánchez, 2010). Buffer zone inhabitants rely for the most part on coffee farming as their source of income, but beans, corn, potatoes, and other vegetable crops are also cultivated. By law, the local people retain the right to use regulated quantities of some natural resources from the park including lumber for construction of houses, furniture and, fence posts; firewood for cooking; water for human and animal consumption; water for crops; and medicinal plants (Rodas V., 2002).

Despite a handful of local people dedicated to conservation, the threats to the remaining forest on the mountain are imminent, leaving an opportunity of perhaps only a few years to study the species and ecosystems and to change the current trajectory to better preserve the park. Community education and the inclusion of locals in conservation projects can encourage changes in attitudes and behaviors, and local people are often more effective than foreigners at communicating the value of biodiversity to other locals (Danielsen et al., 2005; Novotny et al., 1997; Shanley & Rodrigues Gaia, 2002). While local participation in conservation projects may be fairly common in developing countries, the use of local people in scientific research has been infrequent. The National Institute of Biodiversity in Costa Rica was the first biodiversity inventory study to train and depend on local people for the majority of fieldwork, even creating a new term: parataxonomist (Janzen, 1991). This program has catalogued more than 1.3 million species of plants, fungi, arthropods, nematodes, and onychophoroans between 1989 and 2009 (Avila Solera, 2009), showing the potential effectiveness of this system of fieldwork. Other research projects in Papua New Guinea, Guyana, and Gabon found that the efficiency of fieldwork by local field assistants was comparable to that of professional biologists (Basset et al., 2004). More specifically, the moth study in Papua New Guinea showed that parabiologists had 97% accuracy in sorting moths into 1600 categories and that field collectors required only brief training to be able to work independently (Novotny et al., 1997). These authors emphasize that training and proper supervision and feedback are essential to ensuring quality fieldwork, but that the use of local people provides significant benefits. Because local residents in study areas can work full-time and for lower salaries, much greater quantities of data can be collected at a much faster rate, providing higher statistical power; surveying year round and spanning years can better capture variance, providing a more complete data set (Basset et al., 2004; Janzen, 2004; Okada et al., 2007). Any potential loss in accuracy by using parabiologists can be compensated for by the exponential amount of data and replicates that can be collected, which in the tropics can provide far more insight into highly biodiverse ecosystems where rare or endemic species are prevalent (Basset et al., 2004).

This paper presents the first systematic study of the herpetofauna to be carried out on Santa Barbara Mountain. The primary goal was to inventory the reptile and amphibian species present on the mountain and to catalog their locations. Descriptions of the microhabitat where species were encountered were also recorded in order to provide information about which microhabitat should be protected to best conserve herpetofauna. Amphibian specimens were tested for chytrid fungus infection to provide information on the level of threat to amphibian species. In order to raise awareness about conservation issues and to encourage a better understanding of reptiles and amphibians among buffer zone residents, this study involved local people as field assistants in the surveys and included a community education component.

MATERIALS AND METHODS

Description of Study Area

This investigation was carried out on Santa Barbara Mountain, Honduras. The upper half of the mountain is encompassed in Santa Barbara National Park, which is comprised of a nuclear zone and a buffer zone. The nuclear zone of Santa Barbara National Park includes all terrain from 1800 meters elevation to the summit of the mountain at 2744 meters, an area of 53.7 km^2. The buffer zone comprises of an area of 67.6 km^2 encircling the nuclear zone, giving the park a total area of 121.3 km^2. As many as 46 communities are located in the buffer zone, with an estimated 66,083 inhabitants in the year 2002 (Rodas V., 2002).

Santa Barbara Mountain is a large, wedge-shaped block tapering to the south with one of the thickest known sections of Atima Limestone in Honduras underlying the mountain (Finch, 1985; Figure 1). The thick limestone section is one of the reasons that the mountain is so prominent, making it the second highest mountain in Honduras at 2744 meters (Finch, 1985). The crest of Santa Barbara Mountain consists of karst topography. The karstic rock is highly soluble, allowing the high rainfall and acidity of the water (resulting from decomposing organic matter) to dissolve the limestone bedrock and to open fissures. These fissures form pathways in which water flows underground instead of flowing across the surface. As a result, there are very few streams or pools of water on Santa Barbara Mountain. The height of the mountain and the scarcity of surface water have influenced the plant and animal communities able to adapt to the environment.

Figure 1. Satellite image of Santa Barbara Mountain, Honduras. The city of Santa Barbara is located west of the mountain. Lake Yojoa and the city of El Mochito are to the east. The four buffer zone towns used as study sites are also shown. Although the boundary of Santa Barbara National Park is not marked on this image, the dark green triangle of forest cover visibly indicates where it is located.

The forest ecosystems of Santa Barbara Mountain are best documented in the Ecosystem Map of Honduras (Mejía & House, 2002). This map was produced using the modified UNESCO classification system which is based on physiognomic (vegetation structures) and ecological (climate, seasonality, human influence, etc.) data. This classification system is important in the tropics where seasonal distribution of precipitation can vary widely

(Vreugdenhil et al., 2002). The Ecosystem Map indicates five ecosystem types on Santa Barbara Mountain (Table 2), all of which exist only in this location in Honduras (House et al., 2002). The map has different categories for forests on karstic soils because the rapid soil drainage results in unique floral species composition. The two forest types of the lowest elevations are considered to be severely threatened, only surviving in small fragments. The two forest types found above 2300 meters are still considered to be intact because of the difficulty of access (House et al., 2002).

Table 2. The five forest ecosystem types found on Santa Barbara Mountain based on the Ecosystem Map of Honduras, with elevation range listed (Mejía & House, 2002; House et al., 2002)

Forest Ecosystem Type	Elevation Range (meters above sea level)
Evergreen Broadleaved Submontane forest on karstic soils	700 – 1200
Evergreen Broadleaved Lower Montane forest on karstic soils	1200 – 1800
Evergreen Mixed Upper Montane forest on karstic soils	1800 – 2300
Evergreen Broadleaved Altimontane forest on karstic soils	> 2300
Evergreen Broadleaved Mixed Altimontane forests on karstic soils	> 2300

Study Site Selection

Four study sites were selected based on availability of local guides and access to the upper mountain along known routes since the terrain is steep and dangerous. Randomized site selection was not possible given safety risks, accessibility issues, and transportation limitations. The sites were located around the towns of El Dorado, El Playon, El Cedral, and El Aguacatal (Figures 1 & 2). These sites were interspersed around the mountain, covering as much of the area as possible, and were at elevations above 1000 meters where conservation interest is greatest. These elevations are where endemic species are more likely to be found and where amphibian declines have been observed elsewhere in Honduras (Wilson & McCranie, 1998). Each study site had a local counterpart responsible for inviting community members to educational events and coordinating the local people participating in fieldwork.

Species Inventory Methods

To achieve the inventory of reptile and amphibian species, specimens were collected in two ways: survey transects (surveys) and opportunistic specimen collection. Both methods are described below and data are treated separately in the results section.

Survey transects were carried out between March 2011 and August 2011. The researcher, along with local participants, Peace Corps Volunteers, and biology students from the National University (Universidad Nacional Autónoma), conducted two camping trips on the upper mountain in each study site, once during the traditional dry season (January – May) and once during the traditional rainy season (June – December). Each camping trip lasted two to four days and multiple survey transects (three on average) were conducted on each trip. Surveys targeted higher elevations (over 1400 meters) where species endemism would potentially be higher and where there was less human disturbance. Surveys at different sites were completed within the same time period as much as possible to minimize differences arising from weather, seasonal, or other changes, and no surveys were conducted during very inclement weather. Each survey transect lasted at least two hours, weather permitting, and a day survey and a night survey were done on the same date, if possible.

Survey transects included searching both during the day and night along trails, watercourses, and off trail. The length of transect was not specified or measured. Searching consisted of all surveyors slowly progressing along the designated route and thoroughly examining an area approximately 2.5 meters wide (0.5 meter for the path and 1 meter on each side) and from the ground to above head height in the vegetation. Microhabitat in the mid to upper canopy or other unreachable places was not searched. Field assistants were directed to use hands, sticks or other implements to overturn rocks, logs, leaf litter, or other objects and to examine trunks, leaves (under and upper side), and branches of vegetation, including epiphytes. Survey routes were marked by GPS and altitude was recorded in order to describe locations on Santa Barbara Mountain where each species was found. The date, time, temperature, and weather during the surveys were recorded. The person-hours worked were recorded during each survey.

When an amphibian or reptile was detected, the specimen was photographed and, if possible, captured in order to test for chytrid in amphibians and to obtain better photographs. For each specimen found, the species, time, elevation, and GPS coordinates were noted. Routes walked in one survey were only repeated on the same trip if no specimens were detected there. If a detection was made, the route was avoided on the same trip in order to prevent recapture of a specimen that was detected and released.

Opportunistic collection was carried out within the towns and their surrounding areas with the help of local residents. During community meetings, the project was explained and the voluntary participation of locals was requested in collecting reptile and amphibian species, preferably alive, but also dead. Local custom is to kill most animals, especially snakes, so in order to take advantage of losses that would have occurred regardless, dead specimens were accepted. Participants were asked to provide date and location information for each specimen. The specific location where each specimen was found was marked by GPS if accurate information was available from participants. Some specimens were collected from a fifth town, San Luis Planes, which is contiguous with the town of El Dorado. Since opportunistic specimen collection was a result of coincidental discovery of specimens and not as a result of concerted search effort (such as during surveys), person-hours cannot be calculated for this collection method. This type of data was acquired from April 2010 to August 2011.

Regardless of collection method, if a specimen represented a species previously collected, the specimen was released. If it was a species not previously collected in this study, the specimen was retained and later euthanized by an injection of lidocaine. Tissue samples were taken for collaboration with a separate phylogenetic study and specimens were preserved with a 10% formalin solution and later stored in 70% ethanol. Specimens are currently housed in a small learning "museum" in the library in El Dorado. Species identification was confirmed by Josiah Townsend of the University of Florida, a leading expert in Honduran herpetology.

Microhabitat Analysis

For each specimen detected either on a survey or as an opportunistic collection, notes were taken on the microhabitat to help determine the conservation needs of each species. Microhabitat descriptions in the field notes included specific details such as physical characteristics (rocks, ledges, stream banks, on the ground, etc.) and associated vegetation, including the species name when possible. Later, these descriptions were grouped into more general categories such as leaf litter, rotting log, tree trunk, tree branches/leaves, ground cover vegetation, bromeliad tank, stream bed, stream bank, ephemeral pond, fossorial, etc. Because many specimens were opportunistic collections, human-made objects or buildings (such as houses or equipment in people's yards) and human-maintained vegetation (such as farms, gardens, or roadsides) were also used as microhabitat categories.

Chytrid Infection

Chytrid infection was tested by swabbing live amphibian specimens according to the methods described in Kriger et al. (2006). In order to improve detection probability, specimens were thoroughly swabbed in all locations detailed in the protocol. All amphibian species captured in this study were swabbed for chytrid detection. Swabs were stored in 70% ethanol in sterile vials. It was not possible to freeze swabs, so they were stored and transported at room temperature, until received by the Storfer Lab at Washington State University in November 2011, at which point they were frozen. Swabs were analyzed individually by PCR assay following the protocol described in Boyle et al. (2004).

Local Environmental Education

The educational component of this study involved both community education and specialized training for all participants in the field surveys. Prior to the start of the investigation, a presentation was given in each of the four communities that were designated as study sites. These presentations included information describing amphibians and reptiles in general, the species occurring on the mountain (including color photos), the importance of reptiles and amphibians, ways to promote conservation of reptiles and amphibians, and the goals and protocol for the study to be conducted. Common misconceptions were also addressed, such as which species actually have venom and what to do in the case of a snakebite. An open invitation was extended to members of these communities to contribute specimens to the study and to participate in surveys in their own community and in the other communities.

Volunteer field assistants were recruited from the locals attending the presentations, the ecotourism group in the San Luis Planes sector, the National University Biology Department, and the Peace Corps. Each participant received a basic training before aiding in field surveys. Participants learned to identify reptiles and amphibians generally (i.e. frog, salamander, lizard, turtle), searching techniques including which types of microhabitat to look in, the importance of continuous search effort during the surveys, and to immediately inform the principal investigator before trying to capture the specimen in the case a detection was made. Participants were corrected if any deviation from the protocol was made, and they were excluded from the calculations of person-hours if performance was not adequate. Many participants also chose to receive additional training in the use of topographic maps, GPS (Garmin eTrex), field data recording, digital photography of specimens, and specimen preservation. Many of the university students who participated already had knowledge of species identification and previous field experience in similar studies.

RESULTS

A total of 257 person-hours of surveying were completed in this study. The daytime surveys comprised 161 person-hours and the nighttime surveys 96 person-hours. An attempt was made to equalize effort between the four study sites, but because of difficulties with weather and unreliable participation, the number of person-hours surveyed in each site differed by a wide margin (El Dorado 91, El Cedral 61, El Aguacatal 52, El Playon 52). The length of the surveys averaged two hours with between two to nine people searching. Fewer person-hours were completed during the nighttime because of poor weather conditions and the unwillingness of some participants to work at night.

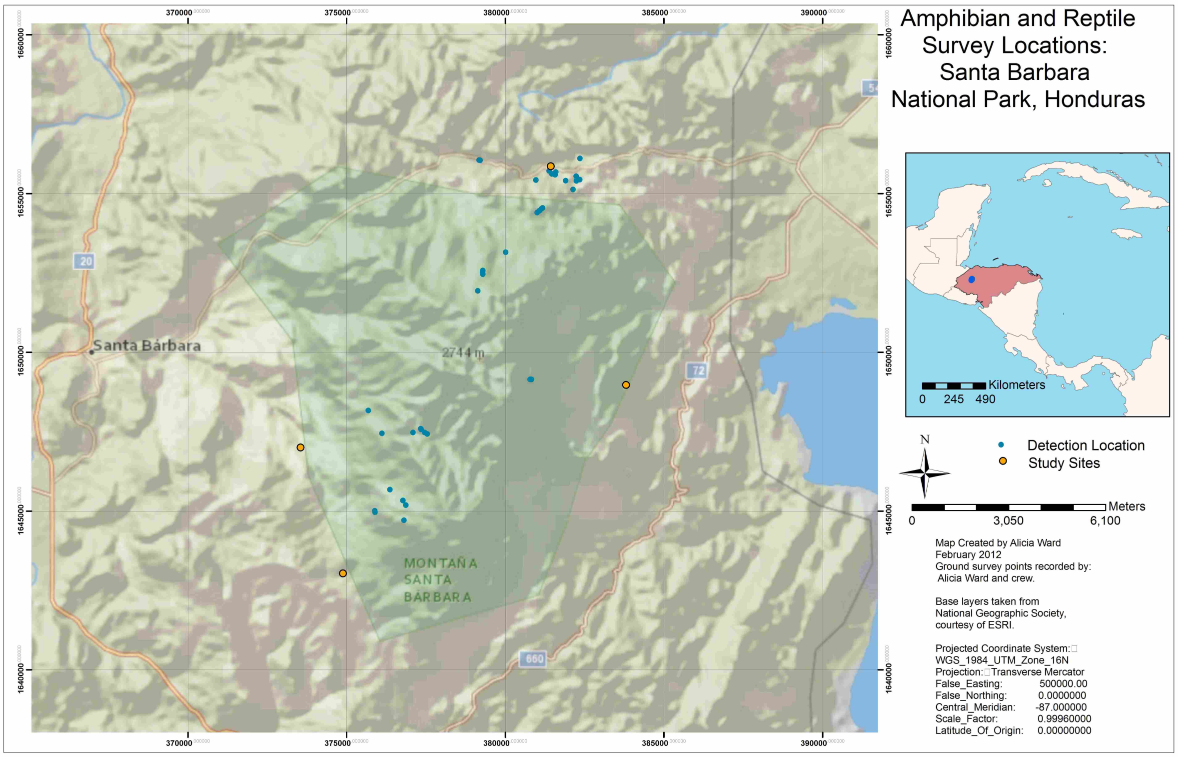
Species Inventory

The study documented 22 species (15 reptile species and 7 amphibian species), 14 of which are new reports for the mountain (Table 3). The new total of reptile and amphibian species known to occur on the mountain is 29 (17 reptile species and 12 amphibian species). Seventeen species were documented in the El Dorado area, eight in El Playon, four in El Aguacatal, and one in El Cedral. The species most commonly encountered in surveys was *Craugastor laticeps* followed by *Dendrotriton sanctibarbarus*. The greatest species diversity was documented between 1200 and 1300 meters in elevation, most likely as a result of the large number of opportunistic collections in the town of El Dorado.

The study documented 52 individual animal specimens (Figure 2). Of these, 21 specimens were detected during survey transects. Surveys covered an elevation range of 1480 – 2473 meters above sea level but specimens were only detected in the elevation range of 1510 – 2313 meters. The average number of specimens encountered per person-hour of searching was 0.09.

Thirty-one of the specimens documented in the study were not encountered during survey transects but as opportunistic collections. These specimens were detected within an elevation range of 1174 – 2351 meters above sea level. Most opportunistic collections were contributed by people in the town of El Dorado or found while on camping trips but not during the actual survey transects. Not all opportunistic specimens detected were included in the data set of the study since many species were very common in towns, but at least one specimen of each species was included for each study site where it was encountered.

Figure 2. Map of study sites and specimen detection locations on Santa Barbara Mountain, Honduras. The area of Santa Barbara National Park is shown in green. The summit, at 2477 meters in elevation, is also indicated.



Microhabitat Analysis

The types of microhabitat where species were detected included leaf litter, bromeliads (terrestrial, epiphytic, and fallen), tree trunks (standing or fallen), in or around small streams, ephemeral ponds, ground cover vegetation, human-made objects or buildings, and human-maintained vegetation (Table 3). Reptiles were most commonly detected in or around human-made buildings or human-maintained vegetation (such as farms, gardens, or roadsides). Amphibians were most commonly detected in leaf litter, bromeliads, or around water sources.

Table 3. Summary of species documented in this study, number of specimens detected, location, elevation, and microhabitat (**Locations:** A = El Aguacatal, C = El Cedral, D = El Dorado, P = El Playon, S = San Luis Planes. **Microhabitat:** Hu = Human-made objects or buildings, HV = Human-maintained vegetation, LL = Leaf litter, Br = Bromeliad, Tr = Tree trunk, St = Stream or on stream bank, EP = Ephemeral pond, GC = Ground cover)

Species Name	**Family**	**# Specimens**	**Locations**	**Elev. (m)**	**Microhabitat**
Adelphicos quadrivirgatum	Colubridae	2	D	1227 – 1248	HV
Anolis lemurinus	Polychrotidae	2	A, D	1174	HV
Anolis rubribarbaris	Polychrotidae	1	P	2153	GC
Basiliscus vittatus	Corytophanidae	1	D	1221	HV
Bolitoglossa mexicana	Plethodontidae	1	D	1189	HV
Bothriechis thalassinus	Vipiridae	1	P	2134	GC
Craugastor laticeps	Craugastoridae	8	A, D, P	1501 – 1600	LL
Dendrotriton sanctibarbarus	Plethodontidae	11	A, C, P, S	1876 – 2351	Br, Tr
Drymarchon melanurus	Colubridae	2	D, S	1222 – 1337	Hu, HV
Drymobius chloroticus	Colubridae	1	D	1225	HV
Drymobius margaritiferus	Colubridae	1	S	1335	Hu
Incilius valliceps	Bufonidae	2	D, P	1219 – 1600	HV, LL
Lampropeltis triangulum	Colubridae	1	P	1360	LL
Lithobates brownorum	Ranidae	2	D	1281	EP
Lithobates maculatus	Ranidae	5	A, P	1751 – 1912	St, Hu
Mastigodryas dorsalis	Colubridae	1	D	1218	HV
Mesaspis moreletii	Anguidae	1	P	2153	GC
Micrurus diastema	Elapidae	1	D	1227	Hu
Ninia sebae	Colubridae	2	D	1228	Hu, HV
Sceloperus malachiticus	Phrynosomatidae	1	D	1221	Hu
Smilisca baudinii	Hylidae	1	D	1221	Hu
Spilotes pullatus	Colubridae	1	D	*	*

*Data not provided by the person who contributed the specimen

Chytrid Infection

Twenty amphibian specimens were tested for chytrid fungus. Of these specimens, 16 had negative test results for chytrid infection. Four specimens had potential positive results with mean zoospore quantities from 0.00140 – 0.44863; however, these quantities are so low that the results cannot be considered conclusive (Kriger et al. 2006 showed mean zoospore quantities of 88.9 ± 56.4 SE for infected wild frogs). The four specimens with the potential positive results are two *Lithobates maculatus* (Highland Frog), one *Lithobates brownorum* (Brown's Leopard Frog), and one *Dendrotriton sanctibarbarus* (Santa Barbara Endemic Salamander). One specimen of the *L. maculatus* and the *D. sanctibarbarus* specimen were collected on the same day along a small stream at 1912 meters in elevation, above the community of El Playon. The second *L. maculatus* was collected the following day downstream of the previous location at 1880 meters in elevation. It was found in the open cement tank used for the community's water source. The *L. brownorum* specimen was collected within the community of El Dorado in an ephemeral pond alongside a road at 1281 meters in elevation. Other indicators of chytrid infection, such as deformed mouthparts in tadpoles, were not examined, and no obvious indicators, such as dead amphibians or amphibians shedding skin, were observed (Berger et al., 1998).

Local Environmental Education
A total of 34 people assisted in field surveys. These included 21 locals, 7 university students, and 6 Peace Corps Volunteers. After the fieldwork was concluded, a presentation of the preliminary results of the investigation was given in two of the participating communities. This included a review of the information in the pre-investigation presentation, many photos of the species detected and project participants, and a discussion of the data and results. In addition to the data collected on amphibian and reptile species, two of the university students used the field trips to collect plant and insect specimens to establish a baseline of these taxa for the mountain since no previous studies exist (Appendix A and B).

DISCUSSION
This study, while the first systematic investigation of herpetofauna to be carried out on Santa Barbara Mountain, was limited in its extent and is best considered as a starting point for further research. The number of field surveys and person-hours conducted were restricted by funds, logistical difficulties (no phone service, limited transportation, cultural issues), and time available for the study. Even so, the gains in knowledge of the fauna of this protected area have been considerable. The number of reptile and amphibian species documented on the mountain has nearly doubled, and useful information regarding species distribution and microhabitat was obtained.

Species Inventory
The area around El Dorado and San Luis Planes has shown an abundance of reptile and amphibian species, with 19 of the 29 documented species present and likely with many more still undocumented. During this study, fewer species were documented in the other sites. The number of species detected in each site most likely does not reflect any difference in diversity or habitat quality between sites, although differences may exist. Instead, it is more likely a result of differences in survey effort, weather conditions, and elevation. More person-hours were completed in the El Dorado area because of convenience and greater reliability of participants. Also, more opportunistic specimens were collected in El Dorado. Another factor could be that the surveys at each study site were conducted in different elevation ranges due to topography, accessibility, and human disturbance (El Dorado 1480 – 2352 m, El Aguacatal 1579 – 1876 m, El Cedral 2305 – 2473 m, El Playon 1860 – 2258 m). El Cedral, where only one species was documented and the fewest specimens detected, covered a much higher elevation range since human farming activities in this location passed the 1800-meter border of the national park and extended within the park up to 2000 meters in elevation. This site may have lesser habitat quality because of human intrusion, or fewer detections could be in part because only higher elevations were surveyed, but most likely the lack of detections were a result of cold and stormy weather conditions on both survey camping trips. In other sites, more species were detected over 2000 meters that were not detected in El Cedral, and in total 11 detections in all sites were made over 2000 meters (1/5 of all detections). In El Aguacatal, a much lower elevation range was surveyed because of limited accessibility. Experienced guides were unavailable in this town, so investigators were dependent on the participants who were available and familiar only with lower areas.

The average number of specimens encountered per person-hour of surveying in this study is low. As a comparison, a study of neotropical salamanders in Guatemala reported encounter rates as high as 4.87 specimens of a single species per person-hour in the 1970s (before dramatic declines), whereas the study on Santa Barbara Mountain only detected 0.09 specimens of any species per person-hour (Rovito et al., 2009). While there may be fewer animals present on this mountain because of its harsh environment compared to other locations in Honduras, most likely the elevation at which the surveys were conducted had more of an impact. The average number of specimens per person-hour could have been higher if more surveys had been conducted at lower elevations where animals are generally more abundant. Most surveys focused on higher elevations in order to cover areas not previously surveyed where the likelihood of encountering endemic species could potentially be higher.

Dendrotriton sanctibarbarus, the salamander endemic to Santa Barbara Mountain, had very few records previous to this study, and some with unreliable information (McCranie & Wilson, 2002). This study found 11 different specimens, and they were found at all four study sites (Figure 3). The specimens were encountered at elevations ranging from 1876 – 2351 meters, and a twelfth unconfirmed specimen was encountered at 1480 meters, potentially further expanding the range. The microhabitat where specimens were found included epiphytic bromeliads, fallen epiphytic bromeliads, large terrestrial bromeliads, bark and moss on fallen tree trunks, and one in a crevice of a split palm trunk. The widespread occurrence and elevation range of this endemic salamander, as well as its use of varied microhabitat, bode well for this species being able to withstand a certain level of environmental change. The IUCN Red List category for this species is Vulnerable (Cruz et al., 2004).

Figure 3. Specimen of *Dendrotriton sanctibarbarus*, the Santa Barbara Endemic Salamander, encountered at 2144 meters elevation in the cloud forest above the towns of El Dorado and San Luis Planes. (Photo by Alicia Ward)

One specimen of Merendon Palm-Pitviper, *Bothriechis thalassinus*, was encountered in the study, and this was during a hike from the community of El Playon to one of the campsites where surveys were conducted (Figure 4). The specimen was found along the footpath at 2134 meters in elevation in low ground cover vegetation. This elevation is far outside the normal range of this species, only up to 1730 meters, and the range of other similar species that occur throughout Central America (Köhler, 2003). The reason for its occurrence at a higher elevation can only be speculated, but it is possible that it is being driven by human disturbance at lower elevations. This species has been shown to be in decline primarily because of conversion of habitat to farmland and human persecution (Wilson & McCranie, 2003; Campbell & Muñoz-Alonso, 2007).

Figure 4. Specimen of *Bothriechis thalassinus*, the Merendon Palm-Pitviper, encountered at 2134 meters in elevation in the cloud forest above the town of El Playon. (Photo by Alicia Ward)

The study also had some significant non-detections. Only one specimen of the endemic anole, *Anolis rubribarbaris*, was documented in this study, and it was found at El Playon. *Typhlops tycherus*, the endemic blind snake, was not documented, although locals in El Cedral reported having seen "the two-headed snake," which may have been a specimen, but this was unconfirmed. This species has only been documented in El Cedral, and when photos were shown to people in other communities, they did not recognize the animal. This raises an interesting question as to what its actual range is. The salamander endemic to Santa Barbara and Cerro Azul Meambar, *Nototriton limnospectator*, was also not documented in this study.

Microhabitat Analysis

The microhabitat where specimens were detected on Santa Barbara Mountain differs from microhabitat in other locations because there is steep topography, karstic soils, and very little surface water. Many of the specimens documented in this study have human-made objects or buildings and human-maintained vegetation listed as their microhabitat because they were provided by local people who encountered these animals in their homes or on their farms. These specimens were included in the study as opportunistic collections outside of the formal surveys and, while not providing much information as to natural microhabitat preferred by these species, they greatly expand the list of species known to occur on the mountain and indicate that some species are able to adapt to a level of human disturbance.

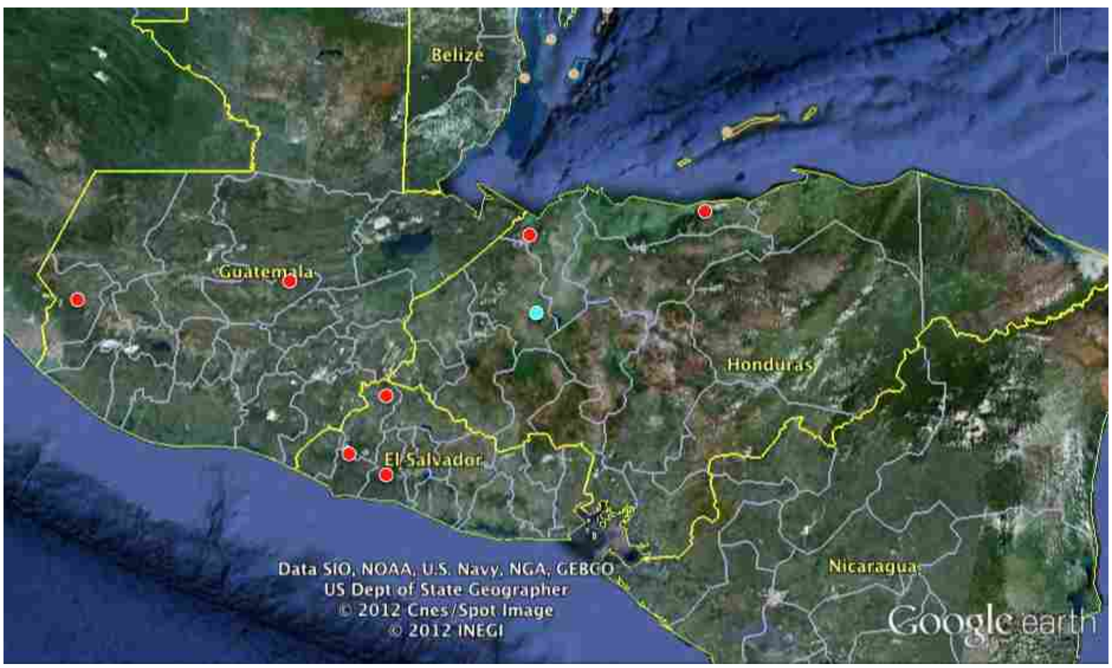
Chytrid Infection
The results of the chytrid swab analysis do not definitively confirm the presence of the disease in amphibian populations on Santa Barbara Mountain, but do indicate a potential concern. The species with two potential positive specimens and with the specimen with the highest mean zoospore quantity was *Lithobates maculatus*. This stream-breeding frog species already tested positive for chytrid in two other locations in Honduras (Puschendorf et al., 2006; Kolby et al., 2009; Figure 5). Stream-associated species in Latin America have been more affected by declines linked to chytrid infection compared to terrestrial species (Young et al., 2001). These factors support the possibility that chytrid infection is present in *L. maculatus* on Santa Barbara Mountain, specifically in the area of the water source used by the community of El Playon. The IUCN Red List category for this species is Least Concern because of its wide distribution (Santos-Barrera et al., 2004a).

Lithobates brownorum was the second species with a potential positive result and is a stream or pond-breeding frog. Neither of the previous studies of chytrid in Honduras showed positive results for infection in this species. This specimen was collected in a separate location from the *L. maculatus*, in the town of El Dorado, indicating a second locality with potential chytrid presence. This species has not yet been assessed by the IUCN Red List because of on-going debate about the taxonomic status of this species separate from *Lithobates berlandieri* (Santos-Barrera et al., 2004b).

The third species with a potential positive for chytrid infection was *D. sanctibarbarus*, the Santa Barbara Endemic Salamander. It is possible that the very low mean zoospore quantity in this specimen was a result of contamination. The *D. sanctibarbarus* was captured several minutes after the *L. maculatus* with the much higher mean zoospore quantity. Clean capture methods were not used when collecting specimens since initially the chytrid analysis was intended to be done as a batch for budget reasons. After the initial capture, a clean pair of gloves was used to handle each specimen when the swabbing was done, and disinfectant was used in between separate surveys, so none of the other specimens were affected by contamination.

Since very few records previous to this study are available, it is impossible to know if dramatic amphibian population declines have already taken place on Santa Barbara Mountain, as in other places in Honduras. It is possible that chytrid has just recently reached the mountain, indicated by evidence such as low mean zoospore quantities in only a few specimens and the absence of other indirect confirmations of chytrid (e.g. observations of dead amphibians or specimens with sloughing skin). When chytrid infection intensities are low, mortality in amphibian species can remain low, signifying there is the potential for dramatic population declines in the future even if chytrid is currently present (Briggs et al., 2010). Of the 12 amphibian species documented on the mountain, 8 are stream-breeding or stream-associated species, and are possibly more at risk of future population declines resulting from the spread of chytrid (McCranie & Wilson, 2002). In addition to the stream-associated amphibians, there are three species of plethodontid salamanders. These salamanders are direct-developing amphibians and use terrestrial, arboreal, and epiphytic bromeliad microhabitat where they are found at lower densities, potentially minimizing the threat of chytrid (McCranie & Wilson, 2002; Briggs et al., 2010). Population declines in salamanders have received less scientific attention than declines in frog populations; however, there is some evidence that chytrid could be a significant threat to salamanders as well. A study of field-collected specimens and museum specimens of plethodontid salamanders in Guatemala showed positive results for chytrid infection, and laboratory experiments with live specimens resulted in 100% mortality rates at high infection levels (Cheng et al., 2011). A study in a location in Panama with documented amphibian declines found chytrid zoospores in epiphytic bromeliad tanks where canopy frog species were detected (Cossel & Lindquist, 2009). Given that two of the plethodontids on Santa Barbara Mountain are Honduran endemic species with small distributions, chytrid could pose a definite risk of extinction.

Figure 5. Satellite image of Guatemala, El Salvador, and Honduras, with Santa Barbara Mountain marked by a blue dot. Red dots indicate locations where chytrid infection in amphibian species has been directly confirmed (Mendelson et al., 2004; Rovito et al., 2009; Felger et al.; 2007; Puschendorf et al., 2006; Kolby et al., 2009).



Local Environmental Education

The locals who participated as field assistants were eager to help on the surveys and curious to learn more about the investigation and backcountry skills. Through the training offered, a few participants became competent at using topographic maps and GPS to navigate and at using a digital camera to photograph specimens (Figure 6). They also became more familiar with different species of reptiles and amphibians, and expressed particular excitement at seeing the endemic salamander for the first time. These individuals, as a result of their experience with the project and their specialized training have the potential to become conservation leaders in their communities and to carry the message to their friends and neighbors. This could potentially have immediate impacts such as reduction in killing of salamanders and other herpetofauna species. Working alongside the university biology students, the local participants were able to forge connections that could be essential in future conservation efforts.

Figure 6. Two local field assistants, Jorge Mendoza and Sergio Sagastume, learning how to use a topographic map and GPS unit to navigate before starting an amphibian and reptile survey. (Photo by Kenyon Solecki)

It is unlikely that the results of the surveys were in any way compromised by incorporating local people instead of relying only on university-trained biologists. Local field assistants' performance in survey work was of equal or better quality as that of the Honduran university students (all biology undergraduates) and the Peace Corps volunteers (all of whom had university degrees, some in science). This has been shown in many other studies around the world where local field assistants were efficiently used as long as training and proper supervision were provided (Basset et al., 2004; Janzen, 2004; Danielsen et al., 2005). In the fieldwork conducted on Santa Barbara Mountain, local field assistants received brief training and were accompanied at all times by the primary investigator. All species identification was confirmed by the primary investigator as well as Josiah Townsend, an expert in Honduran herpetology.

The limitations of relying on local field assistants in this study were mostly logistical. Field assistants in this study were unpaid. They participated as volunteers, and this meant that in some cases they failed to fulfill their commitment to participate in surveys. The result, as described in previous sections, was that many more person-hours were completed in the town of El Dorado where the researcher had a closer relationship with locals and could depend on them. Communication and efficient transportation were perhaps two of the greatest challenges of this study. Given the limited budget available for this project, all participants in the surveys relied on public transportation to access study sites. This added one to two extra days to survey trips just for transportation and was likely a discouraging factor in obtaining more participants. Private transportation, such as a rented pick-up truck, would have been more time-efficient and could have helped with communication challenges as well. The lack of landline phones and cell phone reception made communication with locals in the study sites to set up the survey trips extremely difficult. Although the survey trips were scheduled far in advance, on two occasions the local counterparts had forgotten the date and failed to recruit other local participants. Direct face-to-face communication is often the only option available, and in this project, was a limited option because of the dependence on public transportation.

In terms of community education, this project had a certain amount of success, although no quantifiable data were gathered. Communities responded enthusiastically to educational presentations and individuals were receptive to changing their misconceptions about reptiles and amphibians. Some community members, after learning about salamanders in the presentations, decided to try holding a live specimen, overcoming the traditional belief that salamanders are poisonous (Figure 7). Other community members, rather than kill snakes found in their homes and farms, submitted them to the project as live opportunistic collections on at least six occasions, although they often avoided directly touching the animals (Figure 8). These are two examples of attitudes that were changed by the project. Locals were also interested to learn about the species that were endemic to their mountain and often expressed a sense of pride in knowing that it was such a unique ecosystem with unusual species. This pride for their home environment, if developed and encouraged, could produce an attitude of stewardship and responsibility for protecting the national park. Only time will tell if these attitude changes will translate into behavioral changes that help to protect herpetofauna and natural resource conservation.

Figure 7. Evelyn Chavez of El Dorado holding salamander specimen (*Bolitoglossa mexicana*) believed by locals to be very poisonous, evidence that some locals were influenced by educational presentations about reptiles and amphibians. (Photo by Alicia Ward)

Figure 8. Live specimen of Tiger Rat Snake, *Spilotes pullatus*, turned in as an opportunistic collection. Local people were able to change a lifetime of automatic snake killing behavior in order to collect specimens for the study. This snake was collected in a plastic bottle rather than by hand (Photo by Alicia Ward).

RECOMMENDATIONS AND CONCLUSIONS

This study shows the importance of further research on Santa Barbara Mountain and the potential for discovering new species. The investigation has generated a baseline for amphibians and reptiles on the mountain as well as recommendations for future research and conservation actions based on this preliminary survey.

A comprehensive inventory of the herpetofauna should be the first step to implementing a more rigorous research program on Santa Barbara Mountain. More data on the endemic species in particular are needed to competently assess their range and conservation status. Additional study sites should be included in the inventory covering a greater area, elevation range, and seasonal variation. Surveys in the northwest and southeast corners of the park would cover areas not investigated in this study. The northwest corner could be accessed by ascending from the town of Santa Rita de Oriente, or perhaps more easily from El Sauce (above San Luis Planes). Local counterparts and contacts are available in both of these towns from previous cooperation with other Peace Corps volunteers. The southeast corner of the park could be reached by the Wells Trail, which starts at Camp Wells (above the community of El Playon). This trail extends from the west side of the mountain, through a low valley, and down the east side of the mountain to the community of Lempira. Don Mario Orellana, the counterpart from El Playon that participated in this study, could guide a survey of this route. Exponentially more survey hours are needed in order to ensure that very rare and hard to find species are encountered, such as the fossorial endemic blind snake, or perhaps new species.

After the completion of the comprehensive inventory, a monitoring program could be initiated to continue the research program and provide relevant information for management and conservation decisions. The use of an occupancy model methodology to establish presence/absence data for amphibian and reptile species over repeated visits would be useful and appropriate (MacKenzie et al., 2002). This sampling method is more analytically powerful than an index and more feasible than a capture-mark-recapture design, which requires a high labor input and high detection rates that often are not possible for hard-to-detect herpetofauna species. While occupancy will not give an estimate of abundance, it is a suitable alternative variable to abundance, estimating the area of species distribution instead of number of individuals, and it can indicate any expansion or contraction of the distribution over time (MacKenzie et al., 2002). It also provides the benefit of having low-cost and low-labor requirements, facilitating local sustainability of the monitoring program.

Testing for chytrid infection could be carried out on a larger scale in order to confirm whether and where the disease is present on the mountain. The potential threat of chytrid also highlights the urgency of studying this ecosystem while the opportunity is still available, i.e. before the infection levels increase or before the disease is more widely introduced. Conservation actions to prevent population declines as a result of chytrid would be difficult to implement given that the vector of the disease is still unknown and the feasibility of treatments, such as antifungal drugs, only in select cases, such as in pond habitat (Parker et al., 2002).

Inventories of other taxa on Santa Barbara Mountain are also of conservation importance. Given the three forest ecosystem types that only exist in this location in Honduras, a comprehensive inventory of the plants could produce very interesting discoveries. During one four-day camping trip in this study, a university student specializing in plants was able to identify and/or collect 195 different plant species including six very rare species and four new species (Appendix A). The Lake Yojoa basin, which includes the eastern slope of Santa Barbara Mountain, is one of the most bird species-rich hotspots in Honduras (Gallardo & Gallardo, 2008). An inventory of the avian fauna of the mountain could turn up many more species that are presently known to occur there (Appendix C), and potentially expand the range of sensitive species already documented around Lake Yojoa. Investigation of the extensive cave system of Santa Barbara Mountain and an inventory of troglobite fauna could also lead to new discoveries. Inventories of this type are rare in caves in Central America and have provided only a hint of the possible diversity present. Cave ecosystems are very fragile, and minor disturbances can severely affect the fauna, making a study of Santa Barbara Mountain's cave system an urgent priority before widespread intrusion or contamination becomes a problem (Day & Koenig, 2002).

The continued use of local field assistants is invaluable for improving local attitudes towards herpetofauna and the national park by strengthening their knowledge and appreciation of these resources. Reliance on locals will greatly increase the sustainability and effectiveness of any future inventory or monitoring project. While training local people to work independently on scientific studies requires a large initial investment of time and resources for training, the outcome includes significant benefits such as enormous quantities of data that provide higher statistical power, a much faster rate of data collection, surveying year round and spanning years to better capture variance, and appreciable cost savings (Basset et al., 2004; Janzen, 2004; Okada et al., 2007). The use of parabiologists for long-term monitoring projects is another possibility. Professionals or university students are unlikely to relocate permanently to such a remote location for the long-term commitment needed for a monitoring project; whereas, local people are attracted to the job security and benefit from good salaries (Basset et al., 2000).

Based on the Santa Barbara Mountain study, suggestions for improving the performance of local field assistants include payment for participation in fieldwork, more training hours prior to the start of fieldwork, and improved communication and transportation between study sites such as by using a private vehicle. Payment for fieldwork would be fairer to locals, who often lost workdays on their farms to participate in surveys, and would increase reliability of attendance. More training hours prior to fieldwork would help to improve the local capacity to work with scientific equipment. Once fieldwork began, it was harder to focus on training, and this perhaps discouraged some people from mastering the more complicated equipment, such as the GPS unit. With the limited communication and transportation infrastructure, it is hard to see how either of these challenges could be improved other than by using a private vehicle and making more frequent visits to the study sites for communication purposes.

Research on the biodiversity of Santa Barbara Mountain is important for the sake of better understanding this unique tropical ecosystem and any benefits it provides to humans; however, the importance of conservation *actions* should not be overlooked by focusing solely on research. A valid criticism of many conservation projects is that "measuring is not protecting" and conservation opportunities can be missed by focusing too much on research (Sheil, 2001). The education component of this study suggests the potential for improving conservation by continuing community environmental education programs, especially if a program could expand the number of community members it was reaching. Only a portion of the community attended the educational presentations in this project, and only 4 of the 46 buffer zone communities were included. Strengthening park management and incorporating local people in decision-making could ensure that some of the benefits of the park are directed to the buffer zone communities, improving livelihoods, and that decision compliance is higher.

Janzen (1991) was one of the first to sound the alarm about the rapid loss of species in the tropics, species that have not even been cataloged, and to suggest that scientists ally themselves with local people to speed up the rate of inventory. He sums up the importance of conserving this biodiversity with the metaphor, "Humanity is pulping the Library of Congress to meet a newsprint shortage." Biological inventory studies, such as presented in this paper, are essential to identifying this natural wealth that enriches human life, and that may even be the key to survival in the future. Santa Barbara National Park provides an opportunity to conserve some of the most interesting ecosystems and biodiversity of Honduras, as well as to maintain a healthy environment for the residents of the buffer zone. This study gives just a small idea of the potential and the threats to this mountain, as well as a baseline and recommendations for implementing more comprehensive, long-term programs. If the deforestation rates and chytrid disease trends in the rest of Honduras are any indication, the clock is ticking on this unique and valuable ecological refuge.

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APPENDICES

Appendix A

Plants of Santa Barbara Mountain, Honduras
Summary and tables prepared by Hermes Vega of the Botanical Garden of the National University of Honduras
Translated by Alicia Ward

During the recent four-day expedition (July 15th to July 18th, 2011) to Santa Barbara National Park in the area of Camp Wells, a total of 195 plant species and 68 families were registered. Of the families, Orchidacea had the most species with 35 species, and of the genera *Perperomia* had the most species with 7 species.

The surveys turned up many species of interest including rare plants and plants that had never been documented before. *Oreopanax incanus* has a distribution limited to Celaque Mountain and Santa Barbara Mountain. *Pinus ayacahuite* and *Taxus globosa*, two rare gymnosperm species, are only found on the tallest of the Honduran mountain peaks. Another tree, *Ulmus mexicanus*, has only been collected a few times before in Honduras. *Matalea magnifolia* and *Liparis arnoglossophylla* were reported in Honduras only once prior to this trip. Four species (*Cyclopogon sp., Trichosalpinx sp. 1, Trichosalpinx sp. 2, and Erytrodes sp.*) are yet to be identified and are new species for the flora of Honduras.

A few species present on Santa Barbara Mountain are listed on the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). *Lycaste sp.* is reported in CITES Appendix I, and all species of orchids, bromeliads, cacti, and tree ferns are listed in CITES Appendix II (UNEP-WCMC, 2012). The IUCN Red List also includes three species listed as Vulnerable from Santa Barbara Mountain: *Quercus skinneri*, *Quercus bumelioides*, and *Persea schiedeana* (Nixon et al., 1998; World Conservation Monitoring Centre, 1998).

Table 4. List of plant species documented and collected for Santa Barbara National Park, Honduras

Family	Species	Plant Type
Actinidaceae	*Saurauia leucocarpa*	Tree
Actinidaceae	*Saurauia selerorum*	Tree
Alstroemiaceae	*Bomarea edulis*	Herbaceous
Alstroemiaceae	*Bomarea multiflora*	Herbaceous
Amaranthaceae	*Iresine celosia*	Herbaceous
Annoncaeae	*Annona 2*	Tree
Annoncaeae	*Annona cherimolla*	Tree
Apiaceae	*Sanicula liberta*	Herbaceous
Araceae	*Anthurium scandens*	Epiphyte
Araceae	*Monstera pertusa*	Epiphyte

Araceae	*Philodendrum*	Epiphyte
Araceae	*Syngonium*	Epiphyte
Araceae	*Anthurium bakeri*	Herbaceous
Araceae	*Anthurium huixtlense*	Herbaceous
Araliaceae	*Dendropanax arboreus*	Tree
Araliaceae	*Dendropanax capitatus*	Tree
Araliaceae	*Oreopanax incanus*	Tree
Arecaceae	*Calyptrogyne ghiesbreghtiana*	Palm
Arecaceae	*Chamaedorea tepejilote*	Palm
Aristolochiaceae	*Aristolochia grandiflora*	Vine
Aristolochiaceae	*Aristolochia littoralis*	Vine
Asclepiadaceae	*Matalea magnifolia*	Vine
Aspleniaceae	*Asplenium arpeodes*	Fern
Aspleniaceae	*Asplenium auriculatum*	Fern
Aspleniaceae	*Asplenium serra*	Fern
Asteraceae	*Perymenium gracile*	Tree
Asteraceae	*Bidens pilosa*	Herbaceous
Begoniaceae	*Begonia covallariodora*	Herbaceous
Blechnaceae	*Blechnum epifito*	Herbaceous
Bromeliaceae	*Catopsis hahnii*	Epiphyte
Bromeliaceae	*Catopsis montana*	Epiphyte
Bromeliaceae	*Tillandsia butzii*	Epiphyte
Bromeliaceae	*Tillandsia guatemalensis*	Epiphyte
Bromeliaceae	*Tillandsia leiboldiana*	Epiphyte
Bromeliaceae	*Tillandsia tricolor*	Epiphyte
Bromeliaceae	*Tillandsia vicentina*	Epiphyte
Bromeliaceae	*Tillandsia yunckeri*	Epiphyte
Bromeliaceae	*Werauhia nephrolepis*	Epiphyte
Bromeliaceae	*Werauhia werckleana*	Epiphyte
Bromeliaceae	*Griegia rohwederi*	Herbaceous
Bruneliaceae	*Brunellia mexicana*	Tree
Cactaceae	*Disocactus aurantiacus*	Cactus
Cactaceae	*Epiphyllum*	Cactus
Chloranthaceae	*Hedyosmum mexicanum*	Tree
Cibotiaceae	*Cibotium regale*	Tree Fern
Clethraceae	*Clethra suaveolens*	Tree
Clusiaceae	*Clusia salvinii*	Tree
Commelianacaee	*Commelina erecta*	Herbaceous
Commelianacaee	*Tradescantia zanonia*	Herbaceous
Cyatheaceae	*Cyathea 1*	Tree Fern
Cyatheaceae	*Cyathea 2*	Tree Fern
Dicksoniaceae	*Dicksonia sellowiana*	Tree Fern
Dryopteridaceae	*Elaphoglossum peltatum*	Fern
Dryopteridaceae	*Polystichum harwegii*	Fern

Dryopteridaceae	*Polystichum muricatum*	Fern
Dryopteridaceae	*Elaphoglossum mesoamericanum*	Fern
Ericaceae	*Agarista mexicana*	Shrub
Ericaceae	*Satyria warszewiczii*	Shrub
Ericaceae	*Cavendishia bracteata*	Epiphyte
Ericaceae	*Macleania insignis*	Epiphyte
Ericaceae	*Sphyrospermum cordifolium*	Epiphyte
Ericaceae	*Monotropa uniflora*	Herbaceous
Euphorbiaceae	*Alchornea latifolia*	Tree
Euphorbiaceae	*Acalipha firmula*	Shrub
Euphorbiaceae	*Acalipha arvensis*	Herbaceous
Fagaceae	*Quercus bumelioides*	Tree
Fagaceae	*Quercus cortesii*	Tree
Fagaceae	*Quercus insignis*	Tree
Fagaceae	*Quercus lancifolia*	Tree
Fagaceae	*Quercus salicifolia*	Tree
Fagaceae	*Quercus skinneri*	Tree
Gesneriaceae	*Drymonia sp.*	Shrub
Gesneriaceae	*Kohleria spicarata*	Shrub
Gesneriaceae	*Selenophora obscura*	Shrub
Gesneriaceae	*Besleria solanoides*	Herbaceous
Heliconiaceae	*Heliconia lathispatha*	Shrub
Hymenophyllaceae	*Hymenophyllum fucoides*	Fern
Lauraceae	*Drimys granadensis*	Tree
Lauraceae	*Nectandra sp.*	Tree
Lauraceae	*Ocotea helicterifolia*	Tree
Lauraceae	*Persea schiedeana*	Tree
Lobeliaceae	*Lobelia laxiflora*	Herbaceous
Loranthaceae	*Dendrophtora terminalis*	Epiphyte
Loranthaceae	*Psittacanthus mayanus*	Epiphyte
Lycopodiaceae	*Huperzia filiformis*	Fern
Lycopodiaceae	*Lycopodiella cernua*	Fern
Lygodiaceae	*Lygodium venustum*	Fern
Lythraceae	*Poikilacanthus macranthus*	Shrub
Malvaceae	*Hibiscus sp.*	Shrub
Maranthaceae	*Stromanthe hjalmarsonii*	Shrub
Marattiaceae	*Marattia excavata*	Tree Fern
Melastomataceae	*Clidemia dentata*	Herbaceous
Melastomataceae	*Conostegia volcanalis*	Herbaceous
Melastomataceae	*Heterocentrum hondurense*	Herbaceous
Melastomataceae	*Miconia guatemalensis*	Herbaceous
Myrsinaceae	*Synardisia venosa*	Tree
Myrsinaceae	*Ardisia revoluta*	Shrub
Myrsinaceae	*Gentlea micranthera*	Shrub

Myrtaceae	*Eugenia guatemalensis*	Tree
Myrtaceae	*Eugenia monticola*	Shrub
Onagraceae	*Fuchsia paniculata*	Shrub
Orchidaceae	*Arpophyllum medium*	Epiphyte
Orchidaceae	*Dichaea glauca*	Epiphyte
Orchidaceae	*Dichaea muricatoides*	Epiphyte
Orchidaceae	*Epidendrum chloe*	Epiphyte
Orchidaceae	*Epidendrum laucheanum*	Epiphyte
Orchidaceae	*Epidendrum repens*	Epiphyte
Orchidaceae	*Goodyera striata*	Epiphyte
Orchidaceae	*Isochillus aurantiacus*	Epiphyte
Orchidaceae	*Jacquiniella cobanensis*	Epiphyte
Orchidaceae	*Lepanthes appendiculata*	Epiphyte
Orchidaceae	*Lycaste sp.*	Epiphyte
Orchidaceae	*Maxillaria cuculata*	Epiphyte
Orchidaceae	*Maxillaria densa*	Epiphyte
Orchidaceae	*Maxillaria neglecta*	Epiphyte
Orchidaceae	*Platystele sp.*	Epiphyte
Orchidaceae	*Pleurothallis cardiothallis*	Epiphyte
Orchidaceae	*Pleurothallis matudana*	Epiphyte
Orchidaceae	*Pleurothallis tuerckheimii*	Epiphyte
Orchidaceae	*Prosthechea brassavolae*	Epiphyte
Orchidaceae	*Prosthechea vespa*	Epiphyte
Orchidaceae	*Prosthechea vitellina*	Epiphyte
Orchidaceae	*Rhynchostele sp.*	Epiphyte
Orchidaceae	*Scaphyglottis procumbens*	Epiphyte
Orchidaceae	*Sobralia macrantha*	Epiphyte
Orchidaceae	*Stanhopea ocullata*	Epiphyte
Orchidaceae	*Stanhopea saccata*	Epiphyte
Orchidaceae	*Trichosalpinx 1*	Epiphyte
Orchidaceae	*Trichosalpinx 2*	Epiphyte
Orchidaceae	*Calanthe calanthoides*	Herbaceous
Orchidaceae	*Coelia densa*	Herbaceous
Orchidaceae	*Cranichis sylvatica*	Herbaceous
Orchidaceae	*Cyclopogon sp.*	Herbaceous
Orchidaceae	*Erytrodes sp.*	Herbaceous
Orchidaceae	*Govenia liliacea*	Herbaceous
Orchidaceae	*Liparis arnoglossophylla*	Herbaceous
Orchidaceae	*Malaxis lepanthiflora*	Herbaceous
Passifloraceae	*Passiflora biflora*	Vine
Phyllonomaceae	*Phyllonoma laticustris*	Shrub
Pinaceae	*Pinus ayacahuite*	Tree
Pinaceae	*Pinus maximinoi*	Tree
Pinaceae	*Pinus pseudostrobus*	Tree

Piperaceae	*Peperomia aggravascens*	Epiphyte
Piperaceae	*Peperomia galeoides*	Epiphyte
Piperaceae	*Peperomia quadrifolia*	Epiphyte
Piperaceae	*Peperomia tetraphylla*	Epiphyte
Piperaceae	*Peperomia claytonioides*	Herbaceous
Piperaceae	*Peperomia cobana*	Herbaceous
Piperaceae	*Peperomia tenella*	Herbaceous
Piperaceae	*Piper aequale*	Herbaceous
Piperaceae	*Piper auritum*	Herbaceous
Piperaceae	*Piper obliquum*	Herbaceous
Poaceae	*Dichantelium acuminatum*	Herbaceous
Poaceae	*Ischnanthus tenuis*	Herbaceous
Poaceae	*Merostachys latifolia*	Herbaceous
Poaceae	*Oplismenus setarius*	Herbaceous
Poaceae	*Uncinia hamata*	Herbaceous
Podocarpaceae	*Podocarpus guatemalensis*	Tree
Polygonaceae	*Muehlenbeckia tamnifolia*	Shrub
Polypodiaceae	*Grammitis anfractuosa*	Fern
Polypodiaceae	*Grammitis xiphopteroides*	Fern
Polypodiaceae	*Niphidium crassifolium*	Fern
Polypodiaceae	*Pleopeltis angusta*	Fern
Polypodiaceae	*Polypodium loriceum*	Fern
Polypodiaceae	*Polypodium polypodioides*	Fern
Polypodiaceae	*Terpsichore cultrata*	Fern
Pteridaceae	*Adiantum andicola*	Fern
Pteridaceae	*Arachnioides denticulata*	Fern
Pteridaceae	*Pteris podophylla*	Fern
Pteridaceae	*Scoliosorus ensiformis*	Fern
Rubiaceae	*Arachnotrhix rufescens*	Tree
Rubiaceae	*Palicourea crocea*	Shrub
Rubiaceae	*Psychotria ulliginosa*	Shrub
Rubiaceae	*Randia aculeata*	Shrub
Rubiaceae	*Hoffmania culminicola*	Herbaceous
Rubiaceae	*Psychotria aubletiana*	Herbaceous
Ruscaceae	*Maianthemum flexuosum*	Herbaceous
Ruscaceae	*Maianthemum paniculatum*	Herbaceous
Rutaceae	*Zanthoxylum melanostictum*	Tree
Rutaceae	*Zanthoxylum mollisimum*	Vine
Salicaceae	*Olmediella betschleriana*	Tree
Sapindaceae	*Serjania racemosa*	Vine
Sellaginellaceae	*Sellaginella pallescens*	Fern
Siparunaceae	*Siparuna nicaraguensis*	Tree
Smilacaceae	*Smilax jalapensis*	Vine
Smilacaceae	*Smilax subpubescens*	Vine

Styracaceae	*Styrax glaucescens*	Tree
Taxaceae	*Taxus globosa*	Tree
Tectariaceae	*Tectaria heracleifolia*	Fern
Theaceae	*Symplococarpum brenesii*	Shrub
Ulmaceae	*Trema micrantha*	Tree
Ulmaceae	*Ulmus mexicanus*	Tree
Urticaceae	*Trichospermum greviifolium*	Tree
Urticaceae	*Bohemeria caudata*	Shrub
Urticaceae	*Phenax hirtus*	Herbaceous
Urticaceae	*Pilea microphylla*	Herbaceous

Appendix B

Insects of Santa Barbara Mountain, Honduras
Specimen identification and table prepared by José Anibal Vindel of the National University of Honduras
Summary by Alicia Ward

During two reptile and amphibian survey trips (a period of about six days) on Santa Barbara Mountain, insects were opportunistically collected by hand. These specimens were taken to the National University in Tegucigalpa, Honduras for identification. The specimens have been classified to the family level and will be identified at the species level in the future.

A total of 55 specimens were collected, pertaining to 5 insect orders. The order with the most specimens collected was the order Coleoptera (beetles) with 26 specimens, and the next was the order Orthoptera (grasshoppers, crickets, and locusts) with 20 specimens. Twenty-three families were represented in the collection. The family with the most specimens was the Acrididae family (grasshoppers and locusts) and the family with the next greatest number of specimens was the Scarabaeidae family (scarab beetles).

Table 5. List of insect orders and families documented on Santa Barbara Mountain, Honduras with the number of specimens collected

Order	Family	# Specimens
Coleoptera	Passalidae	2
Coleoptera	Carabidae	5
Coleoptera	Tenebrionidae	1
Coleoptera	Lampiridae	2
Coleoptera	Chrysomelidae	3
Coleoptera	Scarabaeidae	7
Coleoptera	Cerambicidae	2
Coleoptera	Curculionidae	3
Coleoptera	Staphylinidae	1

Diptera	Neridae	1
Diptera	Muscidae	1
Diptera	Tefritidae	1
Diptera	Assilidae	1
Diptera	Sarcophagidae	1
Hemyptera	Ligaeidae	1
Hymenoptera	Apidae	1
Hymenoptera	Vespidae	2
Orthoptera	Blatelidae	2
Orthoptera	Blattidae	2
Orthoptera	Acrididae	9
Orthoptera	Tetygonidae	3
Orthoptera	Phasmidae	3
Orthoptera	Mantidae	1

Appendix C

Birds of Santa Barbara Mountain, Honduras
List compiled by Malcolm Glasgow, naturalist and tour guide at the D&D Brewery in Los Naranjos, Honduras
With the collaboration of Adan Teruel of San Luis Planes
Summary and table prepared by Alicia Ward

This list of bird species for the San Luis Planes sector of Santa Barbara Mountain was largely compiled during guided bird tours in the towns and farms, in secondary forest, and in the cloud forest in Santa Barbara National Park. These observations have been recorded for the period between January 2008 and July 2011.

At least 31 bird families are represented on Santa Barbara Mountain. The family with the most species is the Parulidae family (New World warblers) with 17 species, and following is the Tyrannidae family (tyrant flycatchers) with 15 species.

Many rare or interesting bird species have been documented on the mountain. The resplendent quetzal is listed on the IUCN Red List as Near Threatened because of moderately rapid population declines resulting from deforestation (BirdLife International, 2008a). The golden-winged warbler is also listed as Near Threatened and could soon be downgraded to Vulnerable (BirdLife International, 2008b). The fulvous owl is listed as Least Concern because of its large range, but it is noted that its population is in decline (BirdLife International, 2009). On November 8th, 2010, an audio recording of a male and a female fulvous owl was made at Camp Wells on Santa Barbara Mountain. Bird species of interest, particularly for tourism, that have been documented on the mountain include the bushy-crested jay, olive-throated parakeet, white-crowned parrot, white-fronted parrot, emerald toucanet, collared aracari, keel-billed toucan, mountain trogon, slaty-tailed trogon, mountain pygmy owl, ferruginous pygmy owl, blue-and-white mockingbird, blue-crowned motmot, turquoise-browed motmot, Prevost's ground sparrow, and others.

Table 6. List of bird species on Santa Barbara Mountain, Honduras documented in the area of San Luis Planes and El Dorado between January 2008 and July 2011.

Family	**Common Name**	**Species**
Ardeidae	Cattle Egret	*Bubulcus ibis*
Accipitridae	Swallow-tailed Kite	*Elanoides forficatus*
Accipitridae	White-tailed Kite	*Elanus leucurus*
Accipitridae	Mississippi Kite	*Ictinia mississippiensis*
Accipitridae	Sharp-shinned Hawk	*Accipter striatus chionogaster*
Accipitridae	Great Black Hawk	*Buteogallus urubitinga*
Accipitridae	Roadside Hawk	*Buteo magnirostris*
Accipitridae	Red-tailed Hawk	*Buteo jamaicensis*
Accipitridae	Ornate Hawk-Eagle	*Spizaetus ornatus*
Apodidae	White-collared Swift	*Streptoprocne zonaris*
Apodidae	Chimney Swift	*Chaeturo pelagica*
Apodidae	Vaux's Swift	*Chaetura vauxi*
Cardinalidae	Red-throated Ant-Tanager	*Habia fuscicauda*
Cardinalidae	Summer Tanager	*Piranga Rubra*
Cardinalidae	Flame-colored Tanager	*Piranga bidentata*
Cardinalidae	White-winged Tanager	*Piranga leucoptera*
Cardinalidae	Rose-breasted Grosbeak	*Pheuctitus ludoviscianus*
Cathartidae	Black Vulture	*Coragyps atratus*
Cathartidae	Turkey Vulture	*Carthartes aura*
Columbidae	Red-billed Pigeon	*Patagioenas flavirostrus*
Columbidae	Short-billed Pigeon	*Patagioenas nigrirostris*
Columbidae	White-winged Dove	*Zenaida asiatica*
Columbidae	Ruddy Ground Dove	*Columbina talpacoti*
Columbidae	White-tipped Dove	*Leptotila verreauxi*
Corvidae	White-throated Magpie-Jay	*Calocitta formosa*
Corvidae	Brown Jay	*Cynocorax morio*
Corvidae	Bushy-Crested Jay	*Cyanocorax melanocyaneus*
Corvidae	Azure-Hooded Jay	*Cynolyca cucullata*
Corvidae	Unicolored Jay	*Aphelocoma unicolor*
Cuculidae	Squirrel Cuckoo	*Piaya cayana*
Cuculidae	Groove-billed Ani	*Crotophaga sulcirostris*
Cuculidae	Lesser Roadrunner	*Geococcyx velox*
Emberizidae	Common Bush-Tanager	*Chlorospingus opthalmicus*
Emberizidae	White-naped Brush-Finch	*Atlapetes albinucha*
Emberizidae	Chestnut-capped Brush-Finch	*Buarremon brunneinucha*
Emberizidae	Prevost's Ground-Sparrow	*Melozone biarcuata*
Emberizidae	Rusty Sparrow	*Aimophila rufescens*
Emberizidae	Lincoln's Sparrow	*Melospiza lincolnii*
Emberizidae	Rufous-collared Sparrow	*Zonotrichia capensis*
Falconidae	American Kestrel	*Falco sparverius*
Formicariidae	Mexican Antthrush	*Formicarius monileger*
Formicariidae	Scaled Antpitta	*Grallaria guatimalensis*

Fringillidae	Black-headed Siskin	*Carduelis notata*
Furnariidae	Scaly-throated Foliage-gleaner	*Anabacerthia variegaticeps*
Furnariidae	Ruddy Foliage-Gleaner	*Automolus rubiginosus*
Furnariidae	Olivaceous Woodcreeper	*Sittasomus griseicapillus*
Furnariidae	Northern Barred Woodcreeper	*Dendrocolaptes sanctithomae*
Furnariidae	Black-banded Woodcreeper	*Dendrocolaptes picumnus*
Furnariidae	Ivory-billed Woodcreeper	*Xiphorynchus flavigaster*
Furnariidae	Spotted Woodcreeper	*Xiphorynchus erythropygious*
Furnariidae	Spot-crowned Woodcreeper	*Lepidocolaptes affinus*
Furnariidae	Streak-headed Woodcreeper	*Lepidocolaptes souleyetii*
Hirundinidae	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Icteridae	Melodious Blackbird	*Dives dives*
Icteridae	Great-Tailed Grackle	*Quiscalus mexicanus*
Icteridae	Bronzed Cowbird	*Molothrus aenus*
Icteridae	Giant Cowbird	*Molothrus oryziivorous*
Icteridae	Yellow-Backed Oriole	*Icterus chrsater*
Icteridae	Spot-Breasted Oriole	*Icterus pectoralis*
Icteridae	Altamira Oriole	*Icterus gularis*
Icteridae	Baltimore Oriole	*Icterus galbula*
Icteridae	Orchard Oriole	*Icterus spurius*
Icteridae	Chestnut-headed Oropendola	*Psarocolius guatimozinus*
Icteridae	Montezuma Oropendola	*Psarocolius montezuma*
Mimidae	Grey Catbird	*Dumetella carolinensis*
Mimidae	Blue-and-white Mockingbird	*Melanotis hypoleucus*
Momotidae	Blue-crowned Motmot	*Momotus momota*
Momotidae	Turquoise-browed Motmot	*Eumomota superciliosa*
Parulidae	Golden-Winged Warbler	*Vermivora chrysoptera*
Parulidae	Tennessee Warbler	*Vermivora peregrina*
Parulidae	Tropical Parula	*Parula pitiayumi*
Parulidae	Yellow Warbler	*Dendroica petechia*
Parulidae	Chestnut-Sided Warbler	*Dendroica pensylvanica*
Parulidae	Magnolia Warbler	*Dendroica magnolia*
Parulidae	Black-Throated Green Warbler	*Dendroica virens*
Parulidae	Black-and-White Warbler	*Mniotilta varia*
Parulidae	American Redstart	*Setophagaruticilla*
Parulidae	Worm-Eating Warbler	*Helmitheros vermivoron*
Parulidae	Ovenbird	*Seiuris aurocapilla*
Parulidae	Hooded Warbler	*Wilsonia citrina*
Parulidae	Wilson's Warbler	*Wilsonia pusilla*
Parulidae	Slate-Throated Redstart	*Myioborus miniatus*
Parulidae	Golden-Crowned Warbler	*Basileuterus culicivorous*
Parulidae	Rufous-Capped Warbler	*Basileuterus rufifrons*
Parulidae	Golden-Browed Warbler	*Basileuterus belli*
Picidae	Golden-Fronted Woodpecker	*Melanerpes aurifrons*
Picidae	Yellow-Bellied Sapsucker	*Sphyrapicus varius*
Picidae	Hairy Woodpecker	*Picoides villosis*
Picidae	Smoky-brown Woodpecker	*Veniliornis fumigatus*

Picidae	Golden-olive Woodpecker	*Piculus rubiginosus*
Psittacidae	Olive-throated Parakeet	*Aratinga nana*
Psittacidae	White-crowned Parrot	*Pionus senilis*
Psittacidae	White-fronted Parrot	*Amazona albifrons*
Ramphastidae	Emerald Toucanet	*Aulacorhynchus prasinus*
Ramphastidae	Collared Aracari	*Pteroglossus torquatus*
Ramphastidae	Keel-billed Toucan	*Ramphastos sulfuratus*
Strigidae	Mountain Pygmy Owl	*Glaucidium gnoma*
Strigidae	Ferruginous Pygmy Owl	*Glaucidium brasilianum*
Strigidae	Mottled Owl*	*Strix virgata*
Strigidae	Fulvous Owl*	*Strix fulvescens*
Thamnophilidae	Barred Antshrike	*Thamnophilus Doliatus*
Thamnophilidae	Slaty Antwren	*Myrmotherula schisticolor*
Thraupidae	Scrub Euphonia	*Euphonia affinus*
Thraupidae	Yellow-throated Euphonia	*Euphonia hirundinacea*
Thraupidae	Elegant Euphonia	*Euphonia elegantissima*
Thraupidae	Bananaquit	*Coerebidae flavola*
Thraupidae	Crimson-collared Tanager	*Ramphocelus dimidiatus*
Thraupidae	Blue-grey Tanager	*Thraupus episcopus*
Thraupidae	Yellow-winged Tanager	*Thraupus abbas*
Thraupidae	Red-legged Honeycreeper	*Cyanerpes cyneus*
Thraupidae	Blue-black Grassquit	*Volatinia jacarina*
Thraupidae	White-collared Seedeater	*Sporophila corvina*
Thraupidae	Yellow-faced Grassquit	*Tiaris olivaceous*
Thraupidae	Grayish Saltator	*Saltator coerulescens*
Thraupidae	Buff-throated Saltator	*Saltator maximus*
Thraupidae	Black-headed Saltator	*Saltator atriceps*
Tityridae	Masked Tityra	*Tityra semifasciata*
Trochilidae	Western Long-tailed Hermit	*Phaethornis longirostris*
Trochilidae	Stripe-throated Hermit	*Phaethornis Striigularis*
Trochilidae	Violet Sabrewing	*Campilopterus hemilleucorus*
Trochilidae	Emerald-chinned Hummingbird	*Abeilliia abeilla*
Trochilidae	Stripe-tailed Hummingbird	*Eupheurusa eximia*
Trochilidae	White-eared Hummingbird	*Hylocharis leucotis*
Trochilidae	Rufous-railed Hummingbird	*Amazilia tzacatl*
Trochilidae	Cinnamon Hummingbird	*Amazilia rutila*
Trochilidae	Berylline Hummingbird	*Saucerottia beryllina*
Trochilidae	Amethyst-throated Hummingbird	*Lampornis amethystinus*
Trochilidae	Green-throated Mountain Gem	*Lampornis viridipallens*
Troglodytidae	Spot-breasted Wren	*Thryothorus coraya*
Troglodytidae	House Wren	*Troglodytes aedon*
Troglodytidae	Rufous-browed Wren	*Troglodytes rufociliatus*
Troglodytidae	Grey-breasted Wood Wren	*Henicorhina leucophrys*
Trogonidae	Mountain Trogon	*Trogon mexicanus*
Trogonidae	Collared Trogon	*Trogon collaris*
Trogonidae	Slaty-tailed Trogon	*Trogon massena*
Trogonidae	Resplendent Quetzal	*Pharomachrus mocinno*

Turdidae	Slate-colored Solitaire	*Myadestes unicolor*
Turdidae	Ruddy-capped Nightingale-Thrush	*Catharus frantzi*
Turdidae	Black-headed Nightingale-Thrush	*Catharus mexicanus*
Turdidae	Wood Thrush	*Hylocichla mustelina*
Turdidae	Clay-Colored Robin	*Turdus grayi*
Tyrannidae	Yellow-bellied Elaenia	*Elaenia flavogaster*
Tyrannidae	Common Tody-Flycatcher	*Todirostrum cinereum*
Tyrannidae	Eye-ringed Flatbill	*Rhynchocyclus olivaceus*
Tyrannidae	Stub-tailed Spadebill	*Platyrinchus cancrominus*
Tyrannidae	Yellow-bellied Flycatcher	*Empidonax flaviventris*
Tyrannidae	Yellowish Flycatcher	*Empidonax flavescens*
Tyrannidae	Olive-sided Flycatcher	*Contopus cooperii*
Tyrannidae	Western Wood Pewee	*Contopus sordidulous*
Tyrannidae	Tufted Flycatcher	*Mitrephanes phaeocercus*
Tyrannidae	Social Flycatcher	*Myiozetetes similis*
Tyrannidae	Great Kiskadee	*Pitangus sulphurates*
Tyrannidae	Sulfur-Bellied Flycatcher	*Myiodynastes maculatus*
Tyrannidae	Tropical Kingbird	*Tyrannus melancholicus*
Tyrannidae	Dusky-capped Flycatcher	*Myiarchus tuberclifer*
Tyrannidae	Brown-crested Flycatcher	*Myiarchus tyrannulus*
Vireonidae	Yellow-throated Vireo	*Vireo flavifrons*
Vireonidae	Blue-headed Vireo	*Vireo solitarius*
Vireonidae	Plumbeous Vireo	*Vireo plumbeus*
Vireonidae	Philadelphia Vireo	*Vireo philadelphicus*
Vireonidae	Tawny-crowned Greenlet	*Hylophylus hypoxanthus*

*Heard but not seen