A RAPID MULTI-TAXA ASSESSMENT OF "OAK RIDGE"

AN UNUSUAL RIDGE SYSTEM IN THE NORTH-CENTRAL BLADEN NATURE RESERVE

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and

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INTRODUCTION AND RATIONALE

The Maya Mountain massif is the largest intact tropical forest within the Maya Forest block, itself the largest intact rainforest north of South America. Most of the forests of Central America south of northeastern Guatemala – including those at the highest elevations – have been highly degraded, fragmented, or destroyed. Upper-elevation forests typically are relatively narrow ecosystems with relatively low total area at large scales. Having small areas that occupy a narrow band of unique conditions makes upper-elevation forests ecological islands vulnerable to disturbance, including human-induced fire and climate change.

The upper-elevation ecosystems of the Maya Mountain massif (MMM) are unique in that they are unpopulated, remote, and rugged and are therefore currently difficult to access. Consequently, most of the upper-elevation forest of the MMM are relatively intact and free of intensive, human-induced disturbance found elsewhere in Central America and Mexico. Unfortunately, the remaining upper-elevation forests in Central America, including those of the MMM, are poorly studied. With proper protection and understanding of their composition and function, intact upper elevation forests such as the MMM may serve as reference ecosystems for restoration and monitoring of those areas that have potential to be restored.

In the MMM in particular, only a very few upper-elevation forests have been visited by scientists for periods of time long enough to assess some components of biological diversity and general physiognomy. These areas include Doyle’s Delight (and immediate surroundings), the highest point in Belize, small portions of the Little Quartz Ridge, and minor expeditions to Victoria Peak in the Cockscomb Range and a small portion of the northwestern Cockscomb Basin where it meets the Maya Mountain divide. Other visits to the elevations close to the Maya Mountain divide have been brief and with limited sampling of biodiversity.

The purpose of this expedition was to sample biological diversity of a large ridge formation in the north-central Bladen Nature Reserve. This area was selected in part because of its proximity to the Maya Mountain divide – an area of the MMM presumably of the highest amount of rainfall in the massif. The area, later known informally as “Oak Ridge”, is also rather unusual and appealing for biodiversity sampling because of its broad, relatively flat (at the scale of tens of kilometers) and high (>900m) topography. Such areas are rare for the southeastern-face of the MMM, although adjacent areas northwest of the divide such ‘flat’ or ‘rolling’ topography is more common.

GENERAL METHODS

During early March of 2012, an expedition team comprised of biologists and rangers from the Ya'axché Conservation Trust, the Belize Foundation for Research and Environmental Education (BFREE), and Copperhead Environmental Consulting accompanied by porters from the village of Golden Stream, hiked from Golden Stream village over two days to the a site designated as Oak Ridge at 1,000 m elevation, c. 26 km due north of San Miguel village in the Toledo District of Belize (Figure 1). Opportunistic and systematic samplings were employed for vascular plant species and vegetation, bats, and snails over a period of approximately seven days. Specific methods are divided into three sections by major taxonomic group

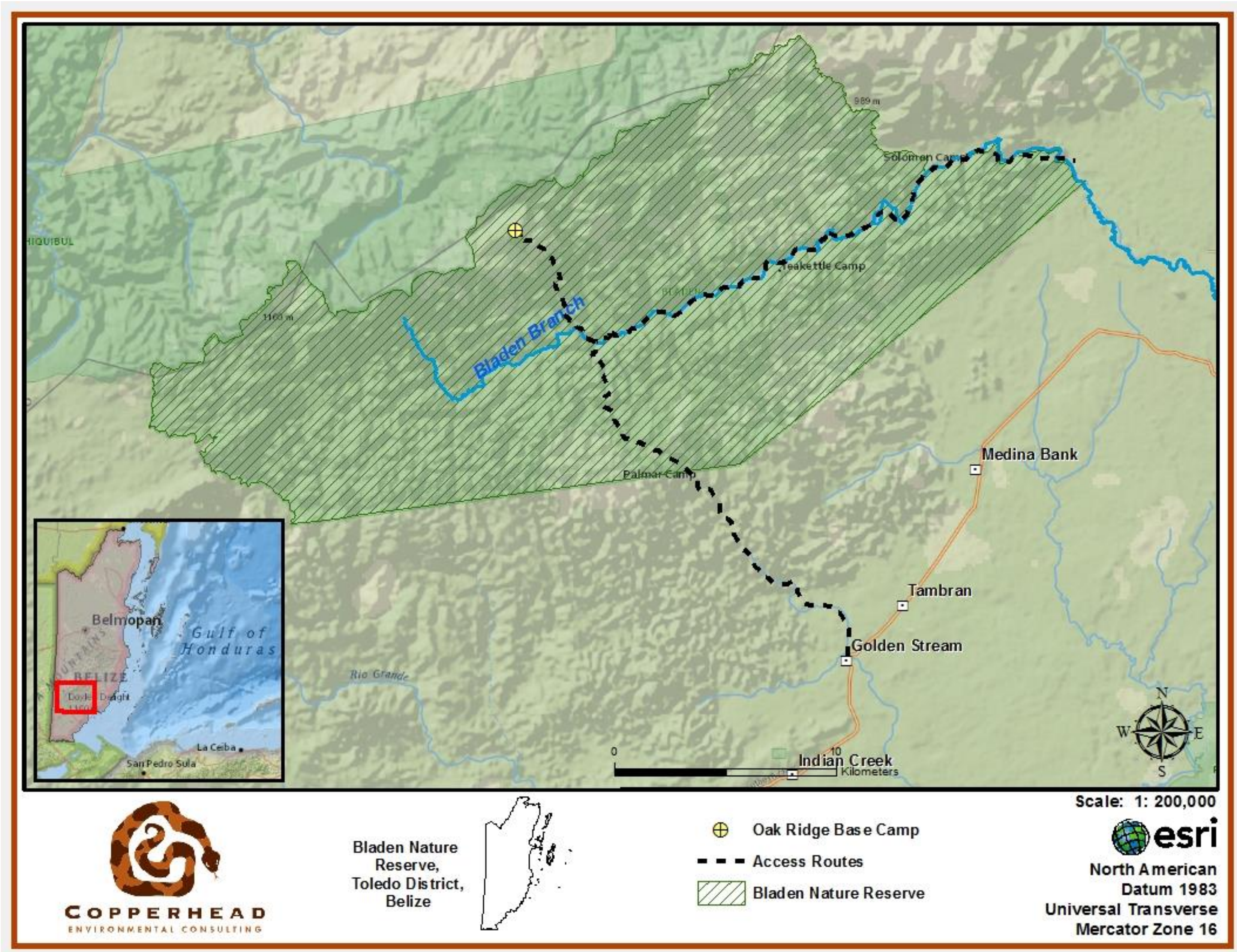

Figure 1. Routes to the Oak Ridge base camp from Golden Stream Village, returning to BFREE via the Bladen branch, 2012.

SECTION 1: PLANT DIVERSITY AND VEGETATION

Quercus lancifolia, an oak tree species endemic to the upper elevations of Central America, exchanging leaves as dry season sets in.

OBJECTIVES

The primary objectives of this portion of the expedition were to (1) quantify tree species diversity on Oak Ridge by documenting tree composition and relative abundance, and (2) document the presence of lesser-known and new taxa (to science and/or Belize).

METHODS

The first objective was achieved by placing a 2m X 500m transect along a portion of the spine of Oak Ridge. This transect is essentially a belt plot designed to cover as much heterogeneity within a vegetation type as possible. Consequently, the transect meandered along the spine rather than being placed as a straight line on the ground, without overlap of sampling space. Trees ≥ 5 cm diameter at breast height (DBH, 1.3m above ground) were measured for DBH, distance along the transect, and were identified to species (or morphological species, then vouchered) when possible. Most species were photographed at least once.

Achieving both objectives required collecting "voucher specimens" that serve as reference specimens for those species present in the study. In some cases where species identity was clear and unmistakable, voucher specimens were not required. Vascular plant species were collected both by targeting representative micro-habitats after reconnaissance of the area and opportunistically by collecting those species along access routes to the site and during travel to and from target areas. Collections were made at least in duplicate, whenever possible, with representative specimens of each species reserved for the Belize National Herbarium at Belmopan (BRH). Remaining duplicates were deposited at the Missouri Botanical Gardens (MO) under the care of Gerrit Davidse, who distributes duplicates to other, tropical-American institutions as part of MO's policy of building botanical capacity in developing countries.

RESULTS & DISCUSSION

Much of the results from Oak Ridge are compared below to the results from a transect placed on the ridge of Doyle's Delight (Brewer, unpubl. data), the only other place along the Maya Mountain divide where forest structure has been quantified at high elevations (>700m). The two areas are separated by only c. 10-15 km and are similar in elevation.

PHYSICAL STRUCTURE

One tradeoff for the speed and simplicity of the type of transects used here (and most forest plots) is that very large trees (c. 70-80+ cm DBH) tend to be under-represented. Larger trees simply function (in dispersal, spacing due to competition, and physical limitations, etc.) at much larger scales than trees of smaller size. [Note that as DBH increases as a simple linear function in one dimension, tree volume increases exponentially as a cubic function in three dimensions. Small, same-size increases in DBH therefore result in increasingly larger amounts of volume of tree mass and volume.]

Nevertheless, the Oak Ridge forest has a relatively high proportion (45%) of stems larger than 20cm DBH compared to the forests on Doyle's Delight ridge (23%) (Figure 2). The forests on Oak Ridge were tall, with emergent oaks and a few other species reaching well over 40 m in height, though most of the canopy was around 30-35m in height. Although DBH is a coarse estimator of mass and height, based on personal observations, the general cutoff for maximum size of sub-canopy and understory trees in Maya Mountain forests is approximately 20-25 cm DBH. (Exceptions include highly-exposed and/or frequently disturbed ridges on poor soils).

Palms, notably *Colpothrinax cookii* and *Euterpe precatoria*, on both Oak Ridge and Doyle's Delight are frequent. The presence of these canopy palm species is likely due in part to the exposure of the high ridges to hurricanes and other storms, as palms are generally much more resistant to wind disturbance than are most dicot trees. Therefore, palms probably have an inherent recruitment advantage, once established, over most other forest tree species. Based on observation from helicopter and plane flights over the upper elevations of the Maya Mountains, the patchy nature of populations of these palms is likely due, at least in part, to the patchy nature of disturbance and conditions beneficial to palm recruitment. It seems that Oak Ridge has, by comparison to Doyle's Delight, experienced much less disturbance over long periods of time than Doyle's delight: tall palms make up 50% of the canopy of Doyle's Delight (measured in stems or as basal area), but only 20-28% of the canopy of Oak Ridge. Two important environmental differences between Doyle's Delight and Oak Ridge lie in geological substrate and topography: Doyle's Delight is based on metasediments of high quartz content and lies on a narrower, steeper ridge system that that of Oak Ridge. Therefore the soils are presumably poorer than those on Oak Ridge. It is unclear to what extent topography versus soils influences how prone to disturbance are forests in the area.

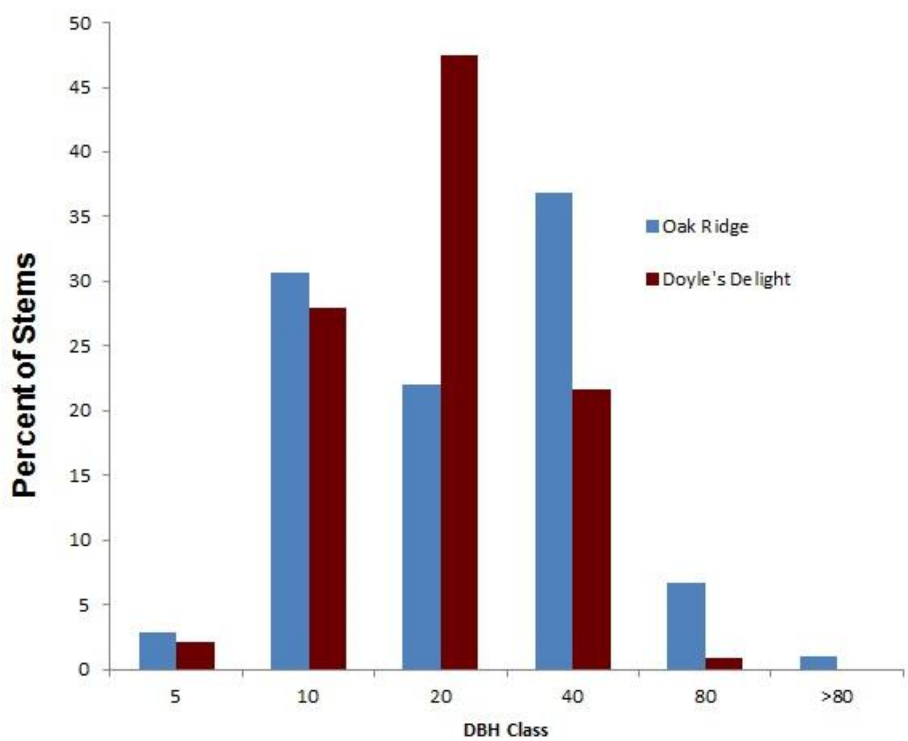

Figure 2. Frequency distribution of tree sizes by stem diameter (DBH) on Oak Ridge and Doyle's Delight, with frequency standardized as percent of stems. Values on the independent (bottom, or "X") axis are equal to the upper limits of that size class. Note that size class values double with increasing size class.

DIVERSITY

By all comparisons, Oak Ridge is significantly more diverse than Doyle's Delight (Table 1). By comparison across forests in the BNR, and on other ridges (200-500m+) Oak Ridge is about of average tree species diversity. However, for high-elevation ridges in the BNR, Oak Ridge appears to be relatively richer than most, but other ridge systems have not been properly sampled for plant diversity. Species diversity can be measured in many ways, but diversity indices are the most commonly used approaches to measuring diversity. Different indices weight relative abundance and numbers of species differently and therefore have utility for comparing plots based on different ecological qualities. (Other approaches, such as rarefaction- and diversity-curves encompass much more information but are more difficult to summarize when making comparisons among plots. A future report is planned that will comprehensively compare data from temporary sample plots in the Bladen Nature Reserve.)

Table 1. Species diversity indices for Oak Ridge Trees.
Effective S represents the number of equally-abundant species needed to obtain the same mean proportional species abundance as the original community. For this study, it is calculated as is the base of the natural logarithm, e, raised to Shannon's H. Any diversity index can be transformed into Effective S, based on different calculations. Higher values of each index correspond to higher species diversity.

Index	Oak Ridge	Doyle's Delight
N	208	233
S	43	33
'Effective S'	25.3	13.7
Fisher's alpha	16.46	10.5
Shannon's H	3.229	2.615
Simpson	0.9357	0.8767

S = Number of species; N = number of trees ≥ 5 cm DBH; Effective S is the effective number of species; Fisher's alpha is derived from S and N assuming a log-series distribution of relative abundances of species; Shannon's H and Simpsons index are two commonly used indices -- the former weights species richness than the latter, which weights species dominance more heavily.

SPECIES COMPOSITION: TRANSECTS

The Oak Ridge transect has 43 species among 27 plant families including tree ferns. The dominant tree species on Oak Ridge is *Quercus lancifolia*, previously known in Belize as *Quercus corrugata*. Although it is not the most frequent tree species, *Q. lancifolia* has nearly a third of the total biomass (as approximated by basal area) or trees in the transect. Palms are the most frequent 'trees' (collectively 26% of the stems, 20% of the basal area) in the transect, including *Colpothrinax cookii* and *Euterpe precatoria*, which are nearly ubiquitous above 700m (occasionally one or both species may be common at 500-700m) elevation in the Maya Mountains.

Table 2. Species in descending order of basal area as a percent of the total for the 2m X 500m transect. (N = number of stems)

Species	Family	%BA	BA (cm^2)	N	%N
Quercus lancifolia	Fagaceae	30	27,835	11	5.3
Colpothrinax cookii	Arecaceae	18	16,795	39	18.8
Magnolia yoroconte	Magnoliaceae	6	5,200	6	2.9
Calatola costaricensis	Icacinaceae	6	5,166	15	7.2
Randia matudae	Rubiaceae	5	4,946	7	3.4
Ficus insipida	Moraceae	4	3,848	1	0.5
Ficus popenoei	Moraceae	4	3,848	1	0.5
Zanthoxylum juniperinum	Rutaceae	3	2,644	3	1.4
Lauraceae	Lauraceae	3	2,638	6	2.9
Hieronyma alchorneoides	Euphorbiaceae	3	2,622	3	1.4
Roupala glaberrima	Proteaceae	2	1,662	9	4.3
Myrcianthes fragrans	Myrtaceae	2	1,553	10	4.8
Nectandra cuspidata	Lauraceae	1	1,312	3	1.4
Euterpe precatoria	Arecaceae	1	1,192	15	7.2
Alchornea latifolia	Euphorbiaceae	1	1,167	3	1.4
Hedyosmum mexicanum	Chloranthaceae	1	837	2	1.0
Cassipourea guianensis	Rhizophoraceae	1	749	2	1.0
Macrohasseltia macroterantha	Salicaceae	1	726	2	1.0
Sloanea schippii	Elaeocarpaceae	1	652	4	1.9
Cyathea schiedeana	Cyatheaceae	1	624	5	2.4
Dendropanax arboreus	Araliaceae	1	560	11	5.3
Cyathea divergens	Cyatheaceae	1	523	6	2.9
Lacistema aggregatum	Lacistemataceae	1	523	2	1.0
Cinnamomum triplinerve	Lauraceae	0.5	423	4	1.9
Symplocos jurgensenii	Symplocaceae	0.5	415	1	0.5
Cecropia obtusifolia	Urticaceae	0.4	346	1	0.5
Guatteria amplifolia	Annonaceae	0.4	346	1	0.5
Miconia elata	Melastomataceae	0.4	346	1	0.5
Cupania scrobiculata	Sapindaceae	0.3	291	2	1.0
Ficus sp.	Moraceae	0.3	254	1	0.5
Psychotria panamensis	Rubiaceae	0.2	222	5	2.4
Clusia sp.	Clusiaceae	0.2	205	2	1.0
Sloanea meianthera	Elaeocarpaceae	0.2	201	1	0.5
Ardisia compressa	Primulaceae	0.2	200	2	1.0
Psychotria elata	Rubiaceae	0.2	181	7	3.4
Pseudolmedia spuria	Moraceae	0.1	137	2	1.0
Posoqueria latifolia	Rubiaceae	0.1	113	1	0.5
Mollinedia viridiflora	Monimiaceae	0.1	97	3	1.4

Table 2 (continued). Species in descending order of basal area as a percent of the total for the 2m X 500m transect. (N = number of stems)

Species	Family	%BA	BA (cm^2)	N	%N
Beilschmiedia mexicana	Lauraceae	0.1	95	1	0.5
Miconia sp.	Melastomataceae	0.1	95	3	1.4
Inga sp.	Fabaceae	0.1	87	1	0.5
Siparuna thecaphora	Siparunaceae	0.1	64	1	0.5
Astrocaryum mexicanum	Arecaceae	0.1	48	2	1.0

Forest types in the Oak Ridge area, as far as the forests of the divide have been explored, were generally representative of the forests on the SE face of the upper-elevation Maya Mountain massif in terms of physical structure and species composition. Most of these upper-elevation forests tend to have a flora that is nearly unique and relatively insular compared to the surrounding forest of lower elevations, which have a higher proportion of generalist and wider-spread species (at the scale of the Maya Mountains). What makes this area unique are the high proportion of oaks in the canopy, and the presence of other large, nutrient-demanding taxa such as *Ficus* (figs). It seems reasonable to reach a conclusion that the soils of the area are rich enough to support high primary production.

The Oak Ridge camp area was adjacent to a narrow valley with a flat, nearly level bottom that supported a large marsh and had an open canopy. Exploration of this area revealed more marshes of various size. Based on previous exploration of several portions of the Maya Mountain divide area, such wetlands are common, even frequent, on the immediate NW side of the divide where the terrain has gentler, rolling slopes dissected by small streams and seeps. In contrast, on the SE side of the divide, most of the southern Maya Mountains have steep faces, sharp and narrow ridges, and narrow ravines incapable of supporting marshes. The Oak Ridge, however, is unusual for the SE-facing slopes of the Maya Mountains in its rather rolling, upper-elevation terrain. These small pockets of wetlands at these higher elevations may support amphibians and fauna that are isolated, existing essentially on islands. Such ecological islands deserve further study.

SPECIES COMPOSITION: GENERAL COLLECTIONS

Approximately 96 species represented by 112 specimens were collected during the Oak Ridge expedition (Table 3). Of the species collected, 40% have yet to be determined to species; 20% of the 96 species have not been determined to genus, and only 1 species has not yet been determined to family. (The undetermined species will be addressed during early January 2014 by Brewer.)

(Notable species are presented after table 3)

Table 3. Species of plants collected during the Oak Ridge Expedition (c. 96 species from 112 collections).

Collection no.	Species	Higher Taxon
6522	Indet. liverwort	"Bryophyte"
6506	*Tassadia obovata* Decne.	Apocynaceae
6565, 6588	*Chamaedorea costaricana* Oerst.	Arecaceae
6525	*Asplenium juglandifolium* Lam.	Aspleniaceae
6507	*Asplenium pteropus* Kaulf.	Aspleniaceae
6596	*Asplenium* sp.	Aspleniaceae
6611	*Telanthophora bartlettii* H. Rob. & Brettell	Asteraceae
6503	*Begonia glabra* Aubl.	Begoniaceae
6607		Burmanniaceae
6500	*Hedyosmum mexicanum* C. Cordem.	Chloranthaceae
6502		Commelinaceae
6517	*Tradescantia* sp.	Commelinaceae
6609, 6536, 6553	*Cyathea divergens* Kunze	Cyatheaceae
6533, 6539, 6555, 6567	*Cyathea schiedeana* (C. Presl) Domin	Cyatheaceae
6501	*Hypolepis repens* (L.) C. Presl	Dennstaedtiaceae
6595	*Lindsaea lancea* (L.) Bedd.	Dennstaedtiaceae
6563	cf. *Dichapetalum*	Dichapetalaceae
6542, 6597	*Alsophila firma* (Baker) D.S. Conant	Dicksoniaceae
6538, 6541	*Sphaeropteris horrida* (Liebm.) R.M. Tryon	Dicksoniaceae
6584	*Didymochlaena truncatula* (Sw.) J. Sm.	Dryopteridaceae
6540	*Polybotrya polybotryoides* (Baker) Christ	Dryopteridaceae
6552	*Sloanea schippii* Standl.	Elaeocarpaceae
6561	*Satyria meiantha* Donn. Sm.	Ericaceae
6511	*Inga cocleensis* Pittier	Fabaceae
6505	*Inga* sp. 1	Fabaceae
6610	*Inga* sp. 2	Fabaceae
6530	*Macrohasseltia macroterantha* (Standl. & L.O. Williams) L.O. Williams	Flacourtiaceae
6524	*Columnea purpurata* Hanst.	Gesneriaceae
6612	*Sticherus palmatus* (W. Schaffn. ex E. Fourn.) Copel.	Gleicheniaceae
6513	*Terpsichore asplenifolia* (L.) A.R. Sm.	Grammitidaceae
6579	cf. H*ymenophyllum* sp.	Hymenophyllaceae
6548	*Hymenophyllum* cf. *hirsutum* (L.) Sw.	Hymenophyllaceae
6545, 6548, 6575, 6581	*Hymenophyllum fucoides* (Sw.) Sw.	Hymenophyllaceae
6514, 6581, 6593	*Hymenophyllum hirsutum* (L.) Sw.	Hymenophyllaceae
6515	*Hymenophyllum* sp.	Hymenophyllaceae
6600	*Hymenophyllum* sp.	Hymenophyllaceae

Table 3 (continued). Species of plants collected during the Oak Ridge Expedition.

Collection no.	Species	Higher Taxon
6535	*Trichomanes capillaceum* L.	Hymenophyllaceae
6594	*Trichomanes rigidum* Sw.	Hymenophyllaceae
6592	*Trichomanes* sp. 1	Hymenophyllaceae
6577	*Trichomanes* sp. 2	Hymenophyllaceae
6510	*Calatola costaricensis* Standl.	Icacinaceae
6571	Indet liana	Indet
6604	*Scutellaria orichalcea* Donn. Sm.	Lamiaceae
6568	*Beilschmiedia mexicana* (Mez) Kosterm.	Lauraceae
6599	*Cinnamomum* sp.,	Lauraceae
6558	*Cinnamomum triplinerve* (Ruiz & Pav.) Kosterm.	Lauraceae
6560	Lauraceae, not *Nectandra*	Lauraceae
6574	*Nectandra cuspidata* Nees & Mart.	Lauraceae
6559	*Ocotea macrophylla* Kunth	Lauraceae
6543	*Spigelia humboldtiana* Cham. & Schltdl.	Loganiaceae
6534	*Bolbitis hemiotis* (Maxon) Ching	Lomariopsidaceae
6531	*Danaea elliptica* Sm.	Marattiaceae
6544	*Danaea nodosa* (L.) Sm.	Marattiaceae
6546	*Marcgravia nepenthoides* Seem.	Marcgraviaceae
6551	Melastomataceae 1	Melastomataceae
6554	Melastomataceae 2	Melastomataceae
6585	Melastomataceae 3	Melastomataceae
6586	Melastomataceae 4	Melastomataceae
6587	Melastomataceae 5	Melastomataceae
6504	Melastomataceae 6	Melastomataceae
6527	Melastomataceae 7	Melastomataceae
6529	Melastomataceae 8	Melastomataceae
6578	*Miconia punctata* (Desr.) D. Don ex DC.	Melastomataceae
6590	*Ficus* sp. 1	Moraceae
6549	*Ficus popenoei* Standl.	Moraceae
6570	*Ficus* sp. 2	Moraceae
6550	*Myrcianthes fragrans* (Sw.) McVaugh	Myrtaceae
6512	Orchidaceae 1	Orchidaceae
6566	Orchidaceae 2	Orchidaceae
6518	*Peperomia* sp. 1	Piperaceae
6521	*Peperomia* sp. 2	Piperaceae
6598	*Lasiacis standleyi* Hitchc.	Poaceae
6528	*Niphidium crassifolium* (L.) Lellinger	Polypodiaceae
6509	*Pecluma atra* (A.M. Evans) M.G. Price	Polypodiaceae
6547	*Serpocaulon fraxinifolium* (Jacq.) A.R. Sm.	Polypodiaceae
6572, 6576	*Ardisia compressa* Kunth	Primulaceae

Table 3 (continued). Species of plants collected during the Oak Ridge Expedition.

Collection no.	Species	Higher Taxon
6519	Indet fern. 1	Pteridophyta
6526	Indet fern. 2	Pteridophyta
6580	Indet fern. 3	Pteridophyta
6516	*Coccocypselum herbaceum* Aubl.	Rubiaceae
6582	*Faramea occidentalis* (L.) A. Rich.	Rubiaceae
6589	*Notopleura guadalupensis* (DC.) C.M. Taylor	Rubiaceae
6537	*Notopleura uliginosa* (Sw.) Bremek.	Rubiaceae
6557	*Psychotria berteroana* DC.	Rubiaceae
6556	*Psychotria panamensis* Standl.	Rubiaceae
6520	*Selaginella* sp. 1	Selaginellaceae
6602	*Selaginella* sp. 2	Selaginellaceae
6508	*Cestrum* sp.	Solanaceae
6573	*Styrax glabrescens* Benth.	Styracaceae
6569	*Symplocos jurgensenii* Hemsl.	Symplocaceae
6523	*Thelypteris decussata* (L.) Proctor	Thelypteridaceae
6603	*Pilea microphylla* (L.) Liebm.	Urticaceae
6601	Urticaceae sp. 1	Urticaceae
6605	Urticaceae sp. 2	Urticaceae
6606	Urticaceae sp. 3	Urticaceae

NOTABLE PLANT SPECIES

***Quercus lancifolia* (Fagaceae):** Notable for its very large acorns, undoubtedly a significant source of food for wildlife, for its very restricted habitat type, and for its dominance in the area. (Shown are a leaf & germinating acorns of *Quercus lancifolia*.)

***Chamaedorea costaricana* (Arecaceae):** This clumped palm was unknown to Belize prior to a previous collection in the BNR in 2004 (Brewer coll. No. 1996). The southern Maya Mountains of Belize represent the northernmost extent of this species. The palm is very patchy in distribution with only a few small populations currently known from the Bladen Nature Reserve (and one possible population observed by Brewer in the CBWS in 2006).

***Hypolepis repens* (fern; Dennstaedtiaceae):** This fern has been collected only twice in Belize, both (apparently) on limestone in disturbed areas at low elevation (<500m). This species was found on acid soils in a high-elevation (900m+) marsh occupying a seep and slow-moving, first-order stream in a narrow valley.

Sphaeropteris horrida **(tree fern; Dicksoniaceae)**
This massive tree fern was collected previously in Belize only from Union Camp, Columbia River Forest Reserve. Elsewhere in Central America the trunks have been used as house posts.

Bolbitis hemiotis **(Lomariopsidaceae):** This fern has only been collected twice in Belize (Doyle's Delight and Ceibo Grande) and seems to be uncommon in the Maya Mountains.

***Pecluma atra* (Polypodiaceae):** This fern is apparently very rare in Belize with only a few collections. The type specimens of this epiphytic/hemi-epiphytic (in Belize) fern were collected from Mountain Pine Ridge in Cayo by Lundell in 1936; however, no specimens from Belize have been collected since.

***Thelypteris decussata* (Thelypteridaceae):** This large terrestrial fern was collected only once before in Belize, on Little Quartz Ridge. The species typically has just one frond open at a time.

Satyria meiantha **(Ericaceae):** Previously known in Belize only from two collections in the Columbia River Forest Reserve.


Styrax glabrescens **(Styracaceae):** One other collection in Belize, from Doyle's Delight. This tree was seen only twice in the Oak Ridge area


***Symplocos jurgensenii* (Symplocaceae):** This species was last collected in the Toledo district in 1934. The genus is taxonomically very difficult and is still being revised. The genus is apparently rare in the Maya Mountains (Brewer, pers. obs).

***Tassadia obovata* (Apocynaceae)**, a vine only collected once before, in the Bladen Nature Reserve along the Maya Mountain Divide, by Gerrit Davidse (MO).

***Lasiacis standleyi*: (No photos).** This grass appears to be rare in northern Central America and was collected only once before in Belize, in similar habitat near the Maya Mountain Divide, BNR. The species was common in the high-elevation marsh near camp. The genus is an occasional understory grass in rainforest in the Maya Mountains under small canopy openings.

***Notopleura guadalupensis* (Rubiaceae):** This epiphytic shrub in the coffee family was previously collected only twice, near Union Camp Columbia River Forest Reserve. It seems to be uncommon to rare in the Maya Mountains, but this may be an artifact of its epiphytic habit.


LAURACEAE
The Bladen Nature Reserve has an unusual assortment of species in the Lauraceae (avocado family). At least three species collected by Brewer appear to be new to science, and others have very limited and/or unusual distributions. In Oak Ridge, the following species are notable:

***Beilschmiedia mexicana*:** This species is limited to high elevations (≥ 900m) on acid substrata of southern Mexico and Bladen Nature Reserve, Belize (reports from El Salvador and Venezuela are erroneous). This represents only the second collection from Belize. *Beilschmiedia hondurensis,* an equally-rare sister species, was previously known only from the Columbia Forest Reserve before being collected by Brewer and Stott in one of the 1-ha permanent plots ("slope plot") established on limestone by Ya'axché.


Lauraceae (cf. *Licaria*): This species could not be conclusively identified to genus because it was sterile, though *Nectandra* can be excluded and overall morphology best resembles *Licaria*. The vestiture (hairs) is unusual and therefore it seems very likely that this is a new species for Belize, if not to science. Re-collection of this species is necessary for a final determination of identity.

***Cinnamomum* sp.:** This species unquestionably belongs to *Cinnamomum* and is possibly new to science. It was collected on a ridgetop on the route to/from Oak Ridge and has been collected by Brewer along volcanic ridges elsewhere in the Bladen Nature Reserve and near Doyle's Delight. Specimens from BNR do not match any species in the 1996 revision of this genus or specimens at the Missouri Botanical Garden.

SECTION 2: BATS

INTRODUCTION

Copperhead Environmental Consulting has been participating with the Belize Foundation for Research and Environmental Education (BFREE) and the Ya'axché Conservation Trust (Ya'axché) since 2009 to document the bat fauna of the Bladen Nature Reserve (BNR) and neighboring BFREE.

During the spring of 2012, an expedition team made up of naturalists from Ya'axché, BFREE, and Copperhead Consulting accompanied by Ya'axché rangers and porters from the village of Golden Stream, hiked from Golden Stream to the a site designated Oak Ridge at 1,000 m elevation, near the Mayan Mountain divide, 26 km due north of San Miguel in the Toledo District of Belize.

The objective of the expedition was document plants, snails, birds, herptiles and mammals present at this high elevation site (1,000 m) in the Mayan Mountains.

Project Area

The expedition team traveled from Golden Stream Village, up Indian Creek past Chicle Camp, to a campsite below Raspaculo Hill where camp was made on 28 February 2012. The following day, the team went up Raspaculo Hill, past Palmer Camp, down a tributary to the Bladen Branch, and then upstream to AC Camp where camp was made. On 2 March 2012 the expedition went up a tributary north of the Bladen River then up the mountain side to the ridge top. The team proceeded along the ridge to a spur off the divide (Oak Ridge) at an elevation of approximately 1,000 m where camp was made.

The egress route followed the ingress back to AC Camp where camp was made on the night of 9 March 2012. From there the bat team followed the Bladen Branch to Tea Kettle Camp where camp was made on 10 March 2012. The bat team followed the Bladen Branch down to BFREE at the edge of the BNR on 11 March 2012. The expedition access route is shown in Figure 3.

Methodology

BAT MIST NETTING

The bat survey team was comprised of members of Copperhead Consulting who were assisted by Dan Dourson (BFREE), Steven Brewer (BFREE), and Maarten Hoffman (Ya'axché), with logistical support from Ya'axché Rangers and Golden Stream Porters.

Surveys were conducted for 9 consecutive nights (2-10 March 2012) and were split between Oak Ridge (7 nights) and lower elevation sites along the route (2 nights).

Mist nets were set to maximize coverage of flight paths used by bats along suitable travel corridors, foraging areas, drinking areas, and in open forest. Placement of mist nets was based on the forest conditions near the site. Each mist net site consisted of at least two net locations monitored for a single night. Nets were deployed at sunset each night and were left open for five hours or until bat activity had ceased due to precipitation and wind. Nets were checked every 10 minutes, and disturbance near the nets was kept at a minimum.

Netting occurred in all weather, as the research team was there for a limited time. Notes about precipitation and wind were made on mist-net datasheets.

Bats were live-caught in mist nets and released unharmed near the point of capture. Biological and morphometric data (e.g., species, sex, age class, reproductive condition, mass, and lengths of forearm, tibia, dorsal hair, ear, and tragus) were recorded on data sheets for each individual captured. Time and GPS location of each net site was also recorded.

Bat identification was typically made using researchers' knowledge and prior experience with the bats of Belize, however the following resources were used to aid in identification: Annotated Key to the Known Bats of Belize by Bruce Miller (2012), Key to the Bats of Belize by M. Brock Fenton (2000), Murcielagos de Costa Rica by Richard K. LaVal and Bernal Rodriguez (2002), and A Field Guide to the Mammals of Central America and Southeast Mexico: Second Edition by Fiona A. Reid (2009). The key, as well as advice in years past, of Dr. Bruce Miller has been of particular help in differentiation of difficult species.

RADIO TELEMETRY

Focal bats were fitted with a radio transmitter and tracked over the course of the study. Transmitters were model LB-2N, with mass varying from 0.35 - 0.42 grams (Holohil Systems Ltd., Carp, Ontario). Transmitters were tested before attachment, a small patch of fur was trimmed between the scapula of the bat and the transmitter was attached with non-toxic surgical adhesive (Perma-Type Surgical Cement, Perma-Type Company, Inc., Plainville, CT) . The authors' experience using Perma-Type in the past has resulted in 5 to 15 days of tracking prior to the transmitter falling off the bat.

Model R1000 (Communications Specialists, Inc., Orange, CA) tracking receivers and 173 FB 3-element Yagi directional antennas (ATS Inc. Isanti, MN) were used to locate day roosts used by focal bats.

All roosts were marked with a numbered aluminum tag and were photographed. Location coordinates were obtained using a handheld Global Positioning System (GPS) unit. Tree roosts were identified to species by botanist Steven W. Brewer, PhD. The following roost characteristics were recorded: Habitat (interior, edge, open), Canopy cover at roost (open, intermediate, or closed), Roost location (cavity, bark or similar, crevice), Tree condition (snag, live, damaged), and Tree ranking (canopy, sub-canopy, understory). Each roost tree was sketched and photographed.

EMERGENCE COUNTS

Emergence counts were attempted at dusk as possible, but priority was given to mist netting activities. Emergence counts were conducted by visually watching roosts for emerging bats.

ACOUSTIC SURVEY

Although acoustic sampling was attempted via Anabat SD1 bat detector, precipitation and humidity damaged Anabat microphones on the first night of survey and no usable data was recorded.

Results and Discussion

MIST NET SURVEY

Nine mist net sites were surveyed for a total of 18 net nights at 8 sites (Figure 3). Seven sites were at Oak Ridge near the Mayan Mountain divide, the remaining two were along the Bladen Branch.

Table 4. Mist net site locations for March 2012 bat surveys in the Bladen Nature Reserve, Toledo District, Belize.

Site ID	Description	Elevation
VR1	Price and Josh's Camp	1029
VR2	Across creek from kitchen	991
VR3	Saddle above camp	979
VR4	Across stream downstream from Camp	961
VR5	Downstream from VR4	973
VR6	Ridge southwest of VR2	996
AC Camp	AC Camp along the Bladen Branch	360
Tea Kettle	Tea Kettle Camp along the Bladen Branch	195

Netting efforts resulted in 50 bat captures of twelve species, including 3 Jamaican fruit-eating bats *(Artibeus jamaicensis)*, 4 Toltec fruit-eating bats *(Artibeus toltecus)*, 8 Thomas' fruit-eating bat *(Artibeus watsoni)*, 1 Van Gelder's bat *(Bauerus dubiaquercus)*, 1 Seba's short-tailed bat *(Carollia perspicillata)*, 8 Sowell's short-tailed bats *(Carollia sowelli)*, 12 Brown long-tongued bats *(Glossophaga commissarisi)*, 1 Underwood's long-tongued bat *(Hylonycteris underwoodi)*, 1 Dark long-tongued bat *(Lichonycteris obscura)*, 6 Common mustached bats *(Pteronotus parnellii mesoamericanus)*, 3 Yucatan yellow bats *(Rhogeessa aneus)*, and 2 Fringe-lipped bats *(Trachops cirrhosis)*. Bats captured at Oak Ridge are summarized in Table 6. Bats captured along the Bladen Branch are summarized in Table 7. Total bats captured are summarized in Table 8.

Table 5. Naming convention for bat species encountered for the March 2012 bat surveys in the Bladen Nature Reserve, Toledo District, Belize.

Common Name	Scientific Name	Species Code
Jamaican fruit-eating bat	*Artibeus jamaicensis*	ARTJAM
Toltec fruit-eating bat	*Artibeus toltecus*	ARTTOL
Thomas' fruit-eating bat	*Artibeus watsoni*	ARTWAT
Van Gelder's bat	*Bauerus dubiaquercus*	BAUDUB
Seba's short-tailed bat	*Carollia perspicillata*	CARPER
Sowell's short-tailed bat	*Carollia sowelli*	CARSOW
Brown long-tongued bat	*Glossophaga commissarisi*	GLOCOM
Underwood's long-tongued bat	*Hylonycteris underwoodi*	HYLUND
Dark long-tongued bat	*Lichonycteris obscura*	LICOBS
Common mustached bat	*Pteronotus parnellii mesoamericanus*	RHOAEN
Yucatan yellow bat	*Rhogeessa aneus*	TRACIR
Fringe-lipped bat	*Trachops cirrhosis*	PTEPAR

One juvenile Dark long-tongued bat was captured at Oak Ridge. The Dark long-tongued bat has not previously been captured along the Bladen Branch despite numerous mist-net/harp trap surveys conducted in the BNR and neighboring BFREE, by the research team, BFREE staff, and BRI. Reed (2009) describes this species as being rare and usually reported in lowland evergreen forest and plantations. Given its rarity, little speculation can be made from one capture at Oak Ridge. Because a juvenile was captured, it is possible that a maternity colony for this species could be located close by.

Meaningful statistical comparison between the high elevation sites at Oak Ridge and the lower elevation sites along the Bladen Branch cannot be made due to low sample size. Likewise, fewer net nights were conducted at sites along the Bladen Branch. However, for the purpose of guiding future study, it is interesting to consider capture differences.

Four species of bats were captured at Oak Ridge that were not captured at lower elevations along the Bladen Branch (ARTTOL, BAUDUB, LICOBS, and RHOAEN). Of these two, BAUDUB and RHOAEN have been caught on multiple occasions at neighboring BFREE which lies along the Bladen Branch downstream of the BNR. While ARTTOL has also been captured at BFREE, it has been captured much less frequently than it was encountered near the Mayan Mountain Divide. It is interesting that LICOBS was captured at Oak Ridge and has not been documented at BFREE or lower elevation sites in the BNR despite much greater netting effort over several years.

Netting was conducted one night during a heavy downpour with sustained heavy winds and very heavy gusts. Researchers estimated that sustained winds were in excess of 32 km/hour with gusts exceeding 55 km/hour. While the heaviest rain came in waves, some precipitation was always present and winds were constant. We did not expect to capture bats at all on this evening, yet we captured one Toltec fruit-eating bat and one Thomas' fruit-eating bat. Their flight in these conditions was unexpected.

A fringe-lipped bat carrying a dead juvenile mouse was captured at AC Camp. The mouse had been killed by having the cap of its head bitten off. Reid (2009) reports this species as preying predominantly on frogs with insects and lizards also being taken. To the author's knowledge, this is the first recorded instance of this species preying on small mammals.

Table 6. Summary of bat captures during March 2012 mist net surveys of Oak Ridge in the Bladen Nature Reserve, Toledo District, Belize.

Species	Adult Male[1]		Adult Females[1]				Juvenile		Escaped	Total
	NR	SCR	PG	L	PL	NR	Male	Female		
ARTJAM	1				1					2
ARTTOL	1	1						1	1	4
ARTWAT					1		1	1		3
BAUDUB		1								1
CARSOW		2			1		3	1		7
GLOCOM	1	2	1	2			2			8
LICOBS								1		1
RHOAEN	1							2		3
TRACIR					1		1			2
PTEPAR					1	1				2

1 - NR=non reproductive; SCR=scrotal; L=lactating; PL=post lactating
Species not captured along Bladen Branch highlighted

Table 7. Summary of bats captured during March 2012 mist net surveys at two sites along the Bladen Branch in the Bladen Nature Reserve, Toledo District, Belize.

Species	Adult Male[1]		Adult Females[1]				Juvenile		Escaped	Total
	NR	SCR	PG	L	PL	NR	Male	Female		
ARTJAM	1									1
ARTWAT		1			3		1			5
CARPER								1		1
CARSOW						1				1
GLOCOM			1	1				1		3
HYLUND					1					1
TRACIR					1					1
PTEPAR	2						2			4

1 - NR=non reproductive; SCR=scrotal; L=lactating; PL=post lactating

Species not captured at Oak Ridge highlighted

Table 8. Summary of all bat captures during March 2012 mist net surveys in the Bladen Nature Reserve, Toledo District, Belize

Species	Adult Male[1]		Adult Females[1]				Juvenile		Escaped	Total
	NR	SCR	PG	L	PL	NR	Male	Female		
ARTJAM	1	1			1					3
ARTTOL	1	1						1	1	4
ARTWAT		1			4		2	1		8
BAUDUB		1								1
CARPER								1		1
CARSOW		2			1	1	3	1		8
GLOCOM	1	4	1	3			2	1		12
HYLUND					1					1
LICOBS								1		1
RHOAEN	1							2		3
TRACIR					1		1			2
PTEPAR	2				1	1	2			6

1 - NR=non reproductive; SCR=scrotal; L=lactating; PL=post lactating

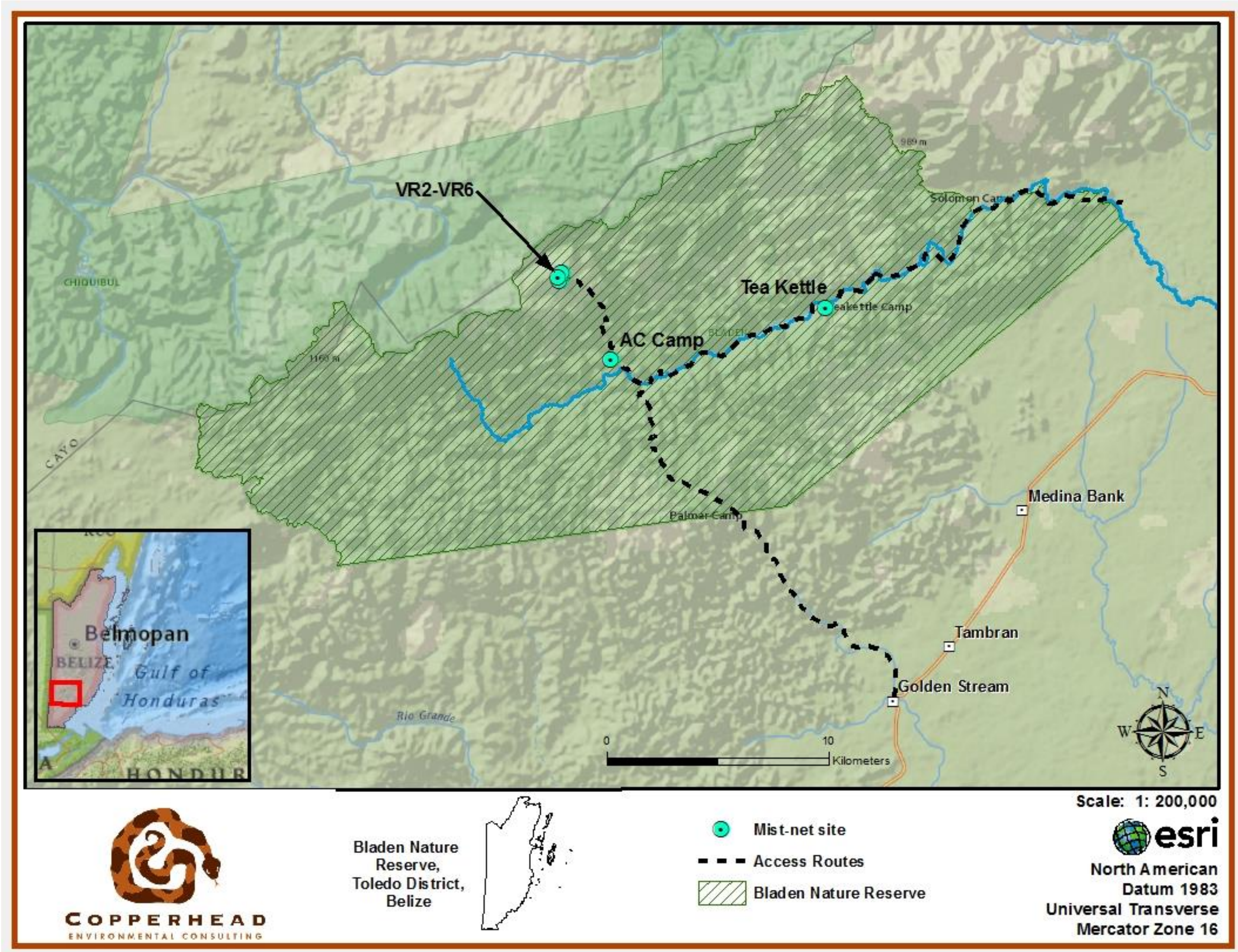

Figure 3. Mist net survey site locations for the March 2012 mist net survey of the Bladen Nature Reserve, Toledo District, Belize.

RADIO TELEMETRY

Radio tracking was conducted with two focal bats, a reproductive male Van Gelder's bat for 3 days and a reproductive male brown long-tongued bat for five days.

The Van Gelder's bat roosted singly in the same live hairy palm (*Colpothrinax cookii)* until the signal was lost after three days. The bat roosted on the bowl of the tree in a "bald" area below and at the base of folded dead leaf petioles that remained dry, despite daily heavy rainfall. This roost sites also appeared to provide shelter from the heavy winds that were frequent during the visit. Other hairy palms inspected had similar sheltered areas. Given the "hairy" nature of the trunks, this micro-habitat could potentially offer thermal insulation as well. The hairy palm may provide an important rooting niche for the CITES listed Van Gelder's bat during frequent inclement weather at the upper elevations of the Mayan Mountains, especially during the rainy season. A further investigation of Van Gelder's bat use of this palm may be warranted.

The brown long-tongued bat stayed in a cavity in a dead Santa Maria tree (*Calophyllum brasiliense*) for the duration of the study (5 days). Emergence counts conducted at this roost at dusk were negative for any bats. It is possible that bats emerged after dusk and emerging bats could not be seen by observers. It is also possible that bat emergence was delayed or that bats did not leave the roost due to weather. A third possibility is that the bat was able to groom the transmitter off inside the tree. Any combination of these theories is also possible.

Roost tree photographs are included in Appendix B.

Table 9. Roost tree locations for bat roosts located during 2012 mist net survey in the Bladen Nature Reserve, Toledo District, Belize.

Roost Number	Tree Species	Bat Species
534	Santa Maria	Brown long-tongued bat
556	Hairy palm	Van Gelder's bat

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Appendix A

Bat Photographs

Jamaican fruit-eating bat (*Artibeus jamaicensis*)

Toltec fruit-eating bat (*Artibeus toltecus*)

Thomas' fruit-eating bat (*Artibeus watsoni*)

Van Gelder's bat (*Bauerus dubiaquercus*)

Seba's short-tailed bat (*Carollia perspicillata*)

Sowell's short-tailed bat (*Carollia sowelli*)

Brown long-tongued bat (*Glossophaga commissarisi*)

Underwood's long-tongued bat (*Hylonycteris underwoodi*)

Dark long-tongued bat (*Lichonycteris obscura*)

Common mustached bat (*Pteronotus parnellii mesoamericanus*)

Yucatan yellow bat (*Rhogeessa aneus*)

Fringe-lipped bat (*Trachops cirrhosis*)

Appendix B

Roost Tree Photographs

Roost 556
Tree species: Hairy palm (*Colpothrinax cookii*)
Bat species: Van Gelder's bat
Bat sex: Male
Bat age: Adult
Bat reproductive condition: Scrotal
Roost 556 was used as diurnal roost 5-7 March 2012 (3 bat days).

Roost 534
Tree species: Santa Maria (*Calophyllum brasiliense*).
Bat species: Brown long-tongued bat
Bat sex: Male
Bat age: Adult
Bat reproductive condition: Scrotal
Roost 534 was used as diurnal roost 4-8 March 2012 (5 bat days).

SECTION 3: SNAILS & AN UNDETERMINED AMPHIBIAN

INTRODUCTION

The Maya Mountains Massif harbors one of the least known and studied land snail faunas in Central America due to a general lack of interest in land snail research and the inaccessibility of the mountains. As a result, gastropods of Belize have remained poorly understood and their significance to surrounding ecosystems clearly underestimated. Recent studies have shown, however, that where snails occur in numbers, they are valuable members of thriving eco-systems providing life supporting contributions to multiple species. For example, live snails or their vacant shells are reported to be a food or calcium carbonate source to a variety of small mammals (Reid 2006); numerous species of salamanders (Petranka 1998); several rather specialized snail-eating snakes from the genus *Sibon* (Lee 1994); a variety of passerine birds (Graveland et al. 1994; Graveland 1996); freshwater fish (Cochran 2008); bats (Bonato et al. 2004; Thabah et al. 2007), Morelet's crocodiles (Platt et. al. 2006) and several species of primates including squirrel monkeys in South America.

Land snails are also expected to play an important role in micronutrient cycling in terrestrial ecosystems (Dallinger et al. 2001), disperse plant seeds and fungal spores (Richter 1980; Gervais et al. 1998) and have been shown to predict vertebrate conservation priorities (Moritz et al. 2001). An advantage to using land snails as bio-indicators is that they can be harvested year round with little or no impact to the species, given that most shells collected (upwards to 90%) are without live animals. Furthermore, land snail inventories can be speedy and comprehensive (saving time and money). For example, research suggests that relatively small areas (under 5 hectares) can hold most (85-95%) of the locally occurring land snail fauna (Cameron et al. 2005; Dourson 2007).

Land snail declines can have ripple effects on surrounding ecosystems. Populations of the great tit *Parus major* in the Netherlands have declined precipitously with decreases in land snails as a result of acid rain (Graveland et al. 1994; Graveland 1996). A lack of snail shells in the bird's diet causes their egg shells to thin and break, thereby reducing reproductive success rates of the species. In North America, Hames et al. (2002) documented a correlation between a reduced number of wood thrushes (a common winter resident in the jungles of Belize) and acid rain. Their study also hypothesized a possible link to a decline in land snail populations.

Gastropods found living in forest environments, therefore, might be used as indicators of forest health, much in the same way that freshwater mussels are used to determine the quality of a stream or river. As snails feed on various foods, environmental contaminants are ingested and sequestered in their tissues (Dallinger and Wieser 1984), the mid-gut gland being the main accumulation site of these trace contaminants (Dallinger 1993). The use of land snails to monitor anthropogenic pollutants suspected to be accumulating in forest environments of the Maya Mountains is of special interest.

The geographic area of the Maya Mountains Massif is small, but belongs to a much larger region including Mexico and Central America that contains many biomes, different geological structures, complex physiographic features and a myriad of ecological settings (Thompson 2011). The number of recorded land snail species (an estimated 1239 taxa) from this enormous area is about 35% of the actual fauna. As much as 65% remain undiscovered. The high number of estimated undescribed species is based on the fact that most of Panama, much of Costa Rica, most of Nicaragua, nearly all of Honduras, most of Guatemala, nearly all of Belize, and 85% of Mexico have not been surveyed or sparsely explored for mollusks, especially small and minute species. Nearly all of the known species to date from this vast region are based on sound taxonomic studies and reviews dating back to Shuttle, Menke, and Pfeiffer (Thompson 2011). Most recently, studies throughout Mexico and Central America including Belize have been conducted by Fred Thompson who has described many new species.

OBJECTIVES

The primary objectives of the land snail survey of the Oak Ridge expedition were to 1) document species diversity in a previously unsampled and unique ecosystem 2) document the presence of new species (to science and/or Belize).

METHODS

A variety of substrates were surveyed for the presence of land snails within the study area labeled Oak Ridge including leaf litter, surface soils, around rock features and other structure like decaying logs, bromeliads, seeps, and under exfoliating bark of standing and downed dead trees for the presence of both macro snails (>5mm) and micro snails (<5 mm). Each substrate was first visually searched for macro snails. Samples of leaf litter or loose soils were examined with a hand lens (10X magnification) for the presence of micro snails. All macro snail shells encountered were collected and placed in Ziploc bags. If micro snails were encountered on the initial search, then at least one quart-sized cloth soil sample bag was collected. Any live snails encountered were documented and released.

All shells and leaf litter collected were brought back to the lab at BFREE to be identified. Leaf litter/soil sample bags were then dried for two weeks, and then sorted by use of series of sieves ranging in size from 4.76 mm to 500 micrometers. Shells were handpicked using tweezers and an Optivisor for magnification then placed in vials.

All shells were then examined under a dissecting scope and identified using the following reference materials: An Annotated Checklist of the Land and Freshwater Snails of Mexico and Central America (Thomson 2011), Von Martens (1895) Biologia; A Natural History of the Bladen Nature Reserve and Its Gastropods (Dourson 2009). Undetermined species were also confirmed by Dr. Fred Thompson of the Florida Museum of Natural History (leading expert on land snails for Mexico and Central America).

RESULTS AND DISCUSSION

Initial searches for macro snails in the survey area produced relatively few snail shells that are considered macro snails. Therefore, most of the survey efforts were focused on searches for the micro snails with a total of 25 leaf/soil sample bags collected and processed

The Oak Ridge snail survey (March 2012) results documented a total of 18 genera and 20 species (Table 10). Of the twenty species documented, twelve are undetermined and presumed new to science (60% of the total documented) with seven of the twelve not previously documented prior to this survey including: *Ceciloides* spp., *Hawaiia* spp., *Leptinaria* spp., *Myastyla* spp., *Radiodiscus* spp., two species in the genus *Volutaxis*. *Pallifera costaricensis*, a slug, *Striatura meridionalis*, and *Punctum vitreum* are new records for Belize. Five of the twelve undetermined species documented at Oak Ridge were previously documented in Belize and the BNR between 2006 and the present. The largest snail documented was *Varicoglandina monilifera* at 22 mm. The smallest snail recorded was *Punctum vitreum* at 1.5 mm.

Thompson (2011) estimates that as much as 65% of the total fauna encountered in Central America may be undetermined. The Oak Ridge snail survey confirms this estimate with 60% of the total fauna documented being undetermined. Based on the species richness of the Oak Ridge survey in montane oak forest, it would be expected to obtain comparable results in similar habitats along the Maya Mountain Divide. These results emphasize the need for future surveys like this one in targeted, previously unsampled areas of the BNR that could potentially yield similar results, especially in the higher elevations and therefore contribute to the overall knowledge of species diversity of land snails in the Bladen Nature Reserve.

Table 10. Taxa of snails documented from the Oak Ridge survey.

Genus	Species	Notes	Status in Belize
Beckianum	*beckianum*	Common	Previously doc. in BNR
Carychium	*species (undetermined)*	appears like other species of *Carychium* of lower elevation limestone forests	Previously doc. in BNR
Ceciloides	*species(undetermined)*	shell clear, live animal yellow, 3.5 whorls, fine spiral striae, lip simple, umbilicus appears as slightly open	NEW (Doc. in Oak Ridge Survey)
Habroconus	*species (undetermined)*	refers to same found at lower elevations in BNR	Previously doc. in BNR
Hawaiia	*species (undetermined)*	refers to H. minuscula but has smaller umbilicus	NEW (Doc. in Oak Ridge Survey)
Helicina	*oweniana*		Previously doc. in BNR
Leptinaria	*species (undetermined)*	refers to Obese Cone but w/o teeth	NEW (Doc. in Oak Ridge Survey)
Miradiscops	*species (undetermined) #3*	refers to the species of lower elevation limestone, body pink-orange	Previously doc. in BNR
Myxastyla	*species undetermined*	animal color white with yellow, differs from lower elevation species by being shorter and more obese	NEW (Doc. in Oak Ridge Survey)
Pallifera	*costaricensis*	Thompson (2012) confirmed ID	New for Belize
Punctum	*vitreum*	refers to *P. vitreum* found in eastern USA	New for Belize
Punctum	*minutissimum*	refers to *P. minutissimum*	Previously doc. in BNR
Radiodiscus	*species (undetermined)*	Shell brown, flat, 4.5 whorls, strongly ribbed, umbilicus 1/3 diameter of shell	NEW (Doc. in Oak Ridge Survey)
Rectaxis	*species (undetermined*	refers *to Rectaxis* species of low elevation forests	Previously doc. in BNR
Striatura	*meridionalis*	refers to *S. meridionalis* of eastern USA	New for Belize
Strobilops	*salvini*		Previously doc. in BNR
Varicoglandina	*monilifera*	a carnivorous snail, largest found in survey at 22 mm	Previously doc. in BNR
Volutaxis	*species (undetermined)*	refers to Bladen Barb but more obese in shape	NEW (Doc. in Oak Ridge Survey)
Volutaxis	*species (undetermined)*	thinner in shape than above species of Volutaxis	NEW (Doc. in Oak Ridge Survey)
Xenodiscula	*taintori*		Previously doc. in BNR

UNDETERMINED SALAMANDER

Salamanders are not well known in the Maya Mountains and new taxa await discovery, especially in the higher elevation forests. For example, a recent 2012 expedition into the Bladen Nature Reserve found an intriguing Bolitoglossa species (Figure 4), dubbed the painted salamander. Discovered in wet montane oak forests at around 1000 meters, the salamander is currently being studied and appears to represent an animal unknown to science; however classification to species is typically done using a combination of morphology and mtDNA sequences (Devitt and Wake 2007).

At this time, the salamander remains undetermined. A review of all available literature on amphibians of Belize failed to produce a positive identification of the salamander. Paul Walker of Wildtracks who has conducted past amphibian surveys in the high elevations of the Maya Mountains was contacted several times and asked to send images of salamanders documented on previous expeditions. No response was received. Dr. Julian Lee, author of Reptiles and Amphibians of Belize, was also contacted and sent images of the salamander in question. He was unable to assign the salamander to species and suggested another contact person in Mexico who was also contacted but was not responsive.

Bolitoglossa is the most diverse genus of salamander, currently containing 128 described species (AmphibiaWeb 2013). The genus is well known for lacking an aquatic larval stage, for being terrestrial rather than aquatic as adults, and for having many species that are arboreal. Only two specimens were recovered on Oak Ridge and both were found in curled up (dead) leaves on the forest floor. This may also be the site where eggs are deposited, but this remains to be investigated. The oak ridge specimens have webbed feet –previously believed to be an adaptation for an arboreal/semi-arboreal habit in Bolitoglossa (citations in AmphibiaWeb 2013); however, later analysis of webbing in bolitoglossines show that the trait is not adaptive (Jaekel and Wake 2007)

Figure 4. The salamander *Bolitoglossa* sp. found in leaf litter on the forest floor. The specimens of this species have yet to be determined to species.

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