Monitoring and Assessment of Biodiversity at the Cloudbridge Nature Reserve, Costa Rica

Interim Project Report
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Project Participants

Cloudbridge Nature Reserve, Costa Rica: funding, staffing, logistical support.
The Smithsonian Institution Monitoring and Assessment of Biodiversity Program: methodology, software.

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Project Location and Area Description

The biodiversity monitoring project takes place in the Cloudbridge Reserve, situated in South-Central Costa Rica, in a remote cloud forest area on the slopes of the Cordillera Talamanca range, Costa Rica's highest mountain chain. The reserve is a non-profit conservation project created to preserve and reforest an important gap in the cloud forest adjoining the Chirripó Pacifico River on the slopes of Mt. Chirripó. The reserve borders the Chirripó National Park, a UNESCO World Heritage Site, and thus serves as a significant buffer zone between the park and the surrounding areas of human settlements.
Cloudbridge Reserve lies at an altitude between 1,500 and 2,600m and covers about 600 acres. It is part of an important bioregion in that cloud forests in Costa Rica and around the world are known to be dwindling owing to the effects of climate change, and increasing temperatures, even at higher altitudes. In addition, it is home to several threatened animal species, such as the Resplendent Quetzal, Baird's Tapir, the peccary, and contains many organisms yet to be identified. With the assistance of local villagers, the forest is being restored through an ambitious program of

replanting native trees in some areas of the Reserve where previous human activities resulted in forest clearing.
The reserve has an international volunteer program that permits interested, qualified individuals to participate in conservation programs and research activities. Volunteer work is extremely important to support the different projects of the reserve. The volunteers conduct and/or support research activities in fields such as ornithology, entomology, habitat restoration, and environmental quality monitoring.

SI Monitoring & Assessment of Biodiversity Program

The Smithsonian Institution's Monitoring and Assessment of Biodiversity Program (hereafter SI/MAB; formerly the Man and the Biosphere Program) has been working to fulfill its mission of promoting the conservation of biodiversity since 1986.
MAB works internationally with governments, industries, academia, nongovernmental organizations, local communities, and others to assess and monitor the biodiversity in their regions. With an integrated approach of research and training, MAB provides scientific information and builds in-country capacity to foster the sustainable use of natural resources. The program focuses on the tropical and temperate forests of Latin America and the Caribbean, North America, Africa, and Asia.
MAB is involved in a variety of research and conservation activities:

- Research projects
- Biodiversity assessment and monitoring programs
- Education and training courses
- Publication series

Through the coordination of the International Network of Biodiversity Monitoring sites (IBMN), MAB is leading the way globally to standardize protocols for measuring and monitoring forest biodiversity.

Project Goals and Description

The project aims to establish a permanent one-hectare biodiversity monitoring plot in a primary tropical cloud forest stand in Cloudbridge Nature Reserve.
The project has three distinct goals:

1. To collect extensive biodiversity data in a primary cloud forest within a well-defined area, using standardized methodology and a set of sampling protocols, for two major benefits:
   i. comprehensive knowledge on the tree community in the studied area, for comparisons to similar sites
   ii. using the above baseline information to guide the habitat restoration efforts in other areas of Cloudbridge

2. To become a part of the Smithsonian International Network of Biodiversity Monitoring sites (IBMN) which assess and monitor dynamics of over 300 sites around the world. SI has implemented this long-term monitoring effort using standardized methodology to assess both regional and global long-term ecological changes, such as climate change. All sites are cooperative, interdisciplinary efforts and involve international, regional, and local researchers, decision-makers, and support personnel.

3. To establish a framework for future and long term biodiversity and ecological studies within the one-hectare study site. This includes engaging local residents and training them in field research methods, thereby creating a base of support for future projects.

The plot will be established using the SI/MAB methodology and will be included in the SI/MAB worldwide biomonitoring network. Currently, the SI/MAB network does not contain any tropical cloud forest study sites.

Methodology

There are two separate stages in the project.

- The initial stage includes site selection, plot survey and establishment, tree tagging, tree mapping, and tree species identification. The collected data will be processed using the BIOMON database system developed by the SI/MAB.
- In the second stage, biodiversity studies of various organisms will commence within the perimeters of the established plot.

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A one-hectare plot (100x100m) has been established in a primary cloud forest stand using the SI/MAB methodology. The plot is located in the Gavilan section of the Cloudbridge Reserve (see Fig.1), at altitudes between 1,850 and 1,915 metres. The topography of the plot ranges from nearly flat sections to steep areas with close to 80% slope (Figs. 2,3).

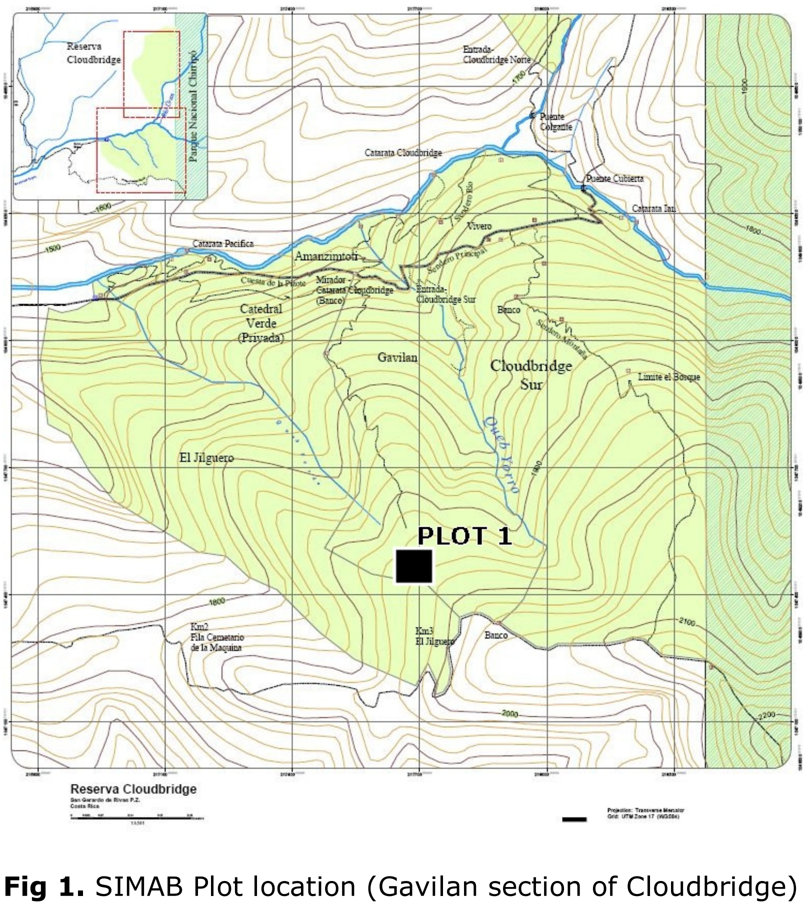

Fig 1. SIMAB Plot location (Gavilan section of Cloudbridge)

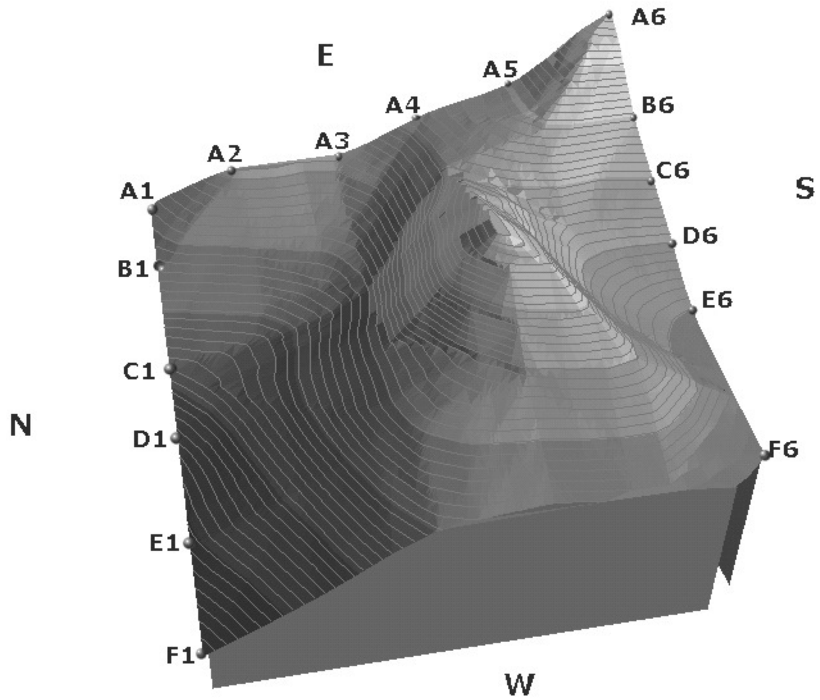

Fig. 2 Plot topography – 3D view with markers

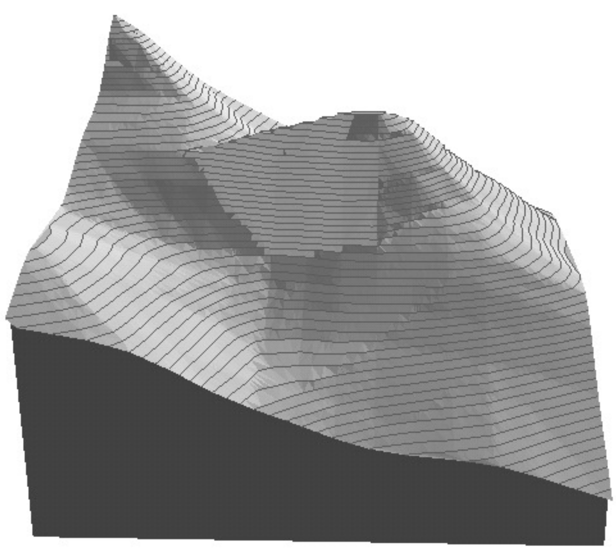

Fig. 3 Plot topography – 3D view north-south

A crew of 2-3 staff has been used to select the site, survey the plot, map and tag the trees, and identify, or collect samples from the plot's trees with a dbh >10cm, for later identification. All collected data are being entered into the BIOMON database. The plot selection and establishment process has been consistent with the 'Methodology for Establishing Biodiversity Plots' (Dallmeier 1992). Some adjustments to the methodology needed to be made due to the size limitation of the primary forest in Cloudbridge area, difficult terrain, and number of available staff.
The plot was surveyed using a measuring tape, range finder, and compass/GPS devices. To ensure that the initially selected area of primary forest was covered, the measurements started from the corner A6 (Fig. 4).

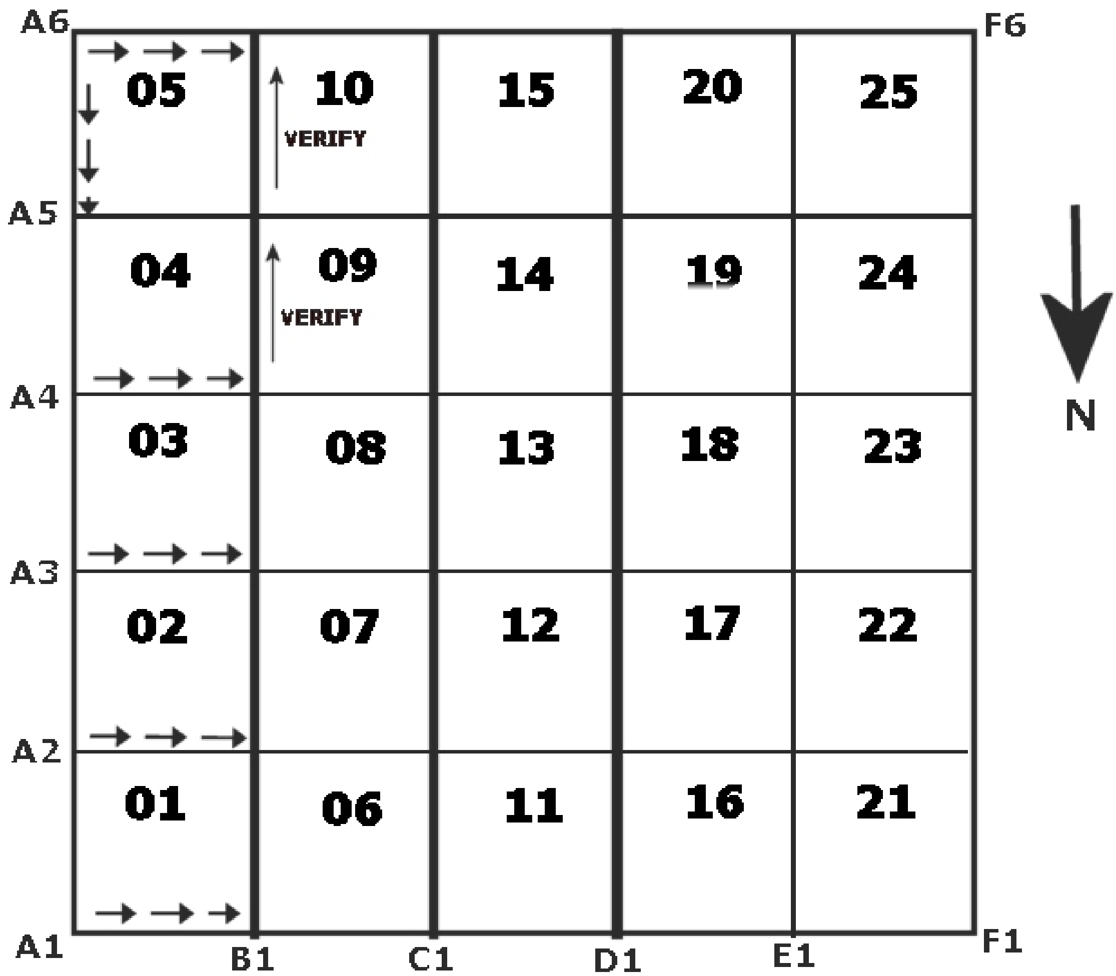

Fig. 4 Plot survey – directions and quadrat numbers

The general direction of the plot was set North-South, with the baseline of the plot oriented towards north (line 1). The corners of the plot were established in the East-West direction. Each established corner was verified to the adjacent corner south of it (Fig. 4). Corrections were applied if necessary.
Because of the significant amount of sloping within the plot, frequent slope corrections were performed using a clinometer (Dallmeier 1992). Each corner was marked by a metal rebar with a wooden top painted red, with marked coordinates (Fig. 5). A red ribbon was tied to vegetation above or next to each corner stake to provide a better visual marker from a distance.

Fig. 5 Rebar corner markers

After all corners had been established, a white string was used to delimit the quadrats for better orientation while collecting the tree data.
For each tree with a diameter of 10cm or higher, the coordinates within the quadrat were recorded, as well as its diameter and height. Photos, notes, and/or branch samples were collected that would be used in subsequent tree identification. All samples were recorded and placed in a plant press to be used as a reference in the future ID process. Each tree was labelled using an aluminum tag with the plot, tree, and quadrat numbers (eg. 01-10-14 - plot 1, quadrat 10, tree #14), consistent with Dallmeier 1992.
All tree data were entered in the BIOMON software. Tree maps for all quadrats were printed to help researchers locate individual trees during the identification process (for an example of the quadrat map, see Fig. 6).

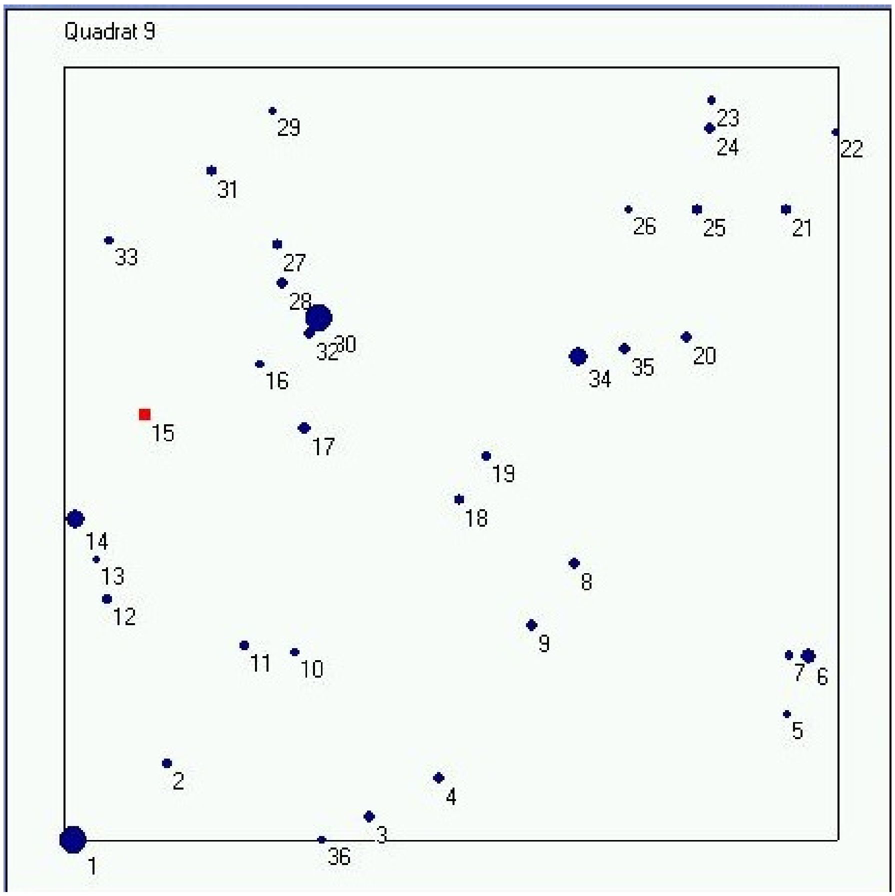

Fig. 6 Quadrat 9 tree map

Currently, about one quarter of the trees have been identified (Appendix 1). Some trees will require flowers and/or fruits for further identification. The ID process is ongoing and should be completed sometime during 2007.
The preliminary data show a high overall tree diversity index. Fifty-five tree species were identified in a sample of 129 surveyed trees (712 total trees; 583 remain to be identified). The same pattern holds for individual quadrats surveyed so far. For example, in Quadrat 9 (400m^2 area), out of 36 trees, 24 were found to be distinct species. In Quadrat 10, there are 23 species out of 38 trees, and in Quadrat 16, the number is 20 out of 29. However, the overall high tree diversity index for the plot is expected to change significantly once all 712 trees are identified.
Any further discussion of patterns in tree/species distribution will require a more complete set of data.

The following values will be calculated and discussed once all 712 trees in the plot are identified:

$$\text{Basal area (b.a.)} = \text{area occupied at breast height}$$

$$\text{Relative density} = \frac{\text{\# individuals of a species}}{\text{total \# individuals of all species.}} \times 100$$

$$\text{Relative dominance} = \frac{\text{combined b.a. of a single species}}{\text{total b.a. of all species}} \times 100$$

$$\text{Frequency} = \text{number of quadrats in which a species is found}$$

$$\text{Relative frequency} = \frac{\text{frequency of one species}}{\text{sum of all frequencies}} \times 100$$

$$\text{Relative diversity} = \frac{\text{\# of species in one family}}{\text{total \# of species}} \times 100$$

All tree data and maps have been stored in the BIOMON database. An extensive photo library has also been created for selected tree samples to help in identification and future reference. These are available upon request. Pressed herbarium specimens are retained at the Herbarium of Universidad Nacional de Costa Rica in Heredia.

Completing identification of all surveyed tree species will conclude the first stage of the project. Specific surveys of various organisms will follow to provide standardized biodiversity data of the plot.

Materials and Staff

<u>Materials used during plot survey:</u>

- 30m steel measuring tape
- Cans of spray paint
- Tagging ribbon
- Aluminum tags and nails
- Electronic range finder
- SUUNTO clinometer
- Pocket calculator
- Metal rebars with wooden tops
- Marking pen
- 6-foot yellow pole (for sightings)
- Plant press (used for collected specimens)
- DBH tape
- Measuring tape
- White string
- Cans of spray paint
- Slingshot, with heavy-weighted cord
- Plastic sample bags

Staff:

- 1 project leader/field investigator
- 2-3 volunteer field investigators
- 1 Costa Rican botanist

References

Dallmeier, F. (1992). "Long-term monitoring of biological diversity in tropical forest areas." *Methods for establishment and inventory of permanent plots.* MAB Digest Series, 11. UNESCO. Paris.

Dallmeier, F. and J. A. Comiskey. (1996). "From the forest to the user: a methodology update." *Manu: The biodiversity of southeastern Peru; la biodiversidad del sureste del Peru* (Wilson, D. and A. Sandoval, Eds.). Smithsonian Institution Press. Washington, DC. pp 41-56.

Appendix1. Further Notes on Cloudbridge

Goals of the Reserve

Preservation. Cloudbridge includes an important piece of existing natural cloud forest with an enormous diversity of tropical trees, birds, insects and other flora and fauna. The property includes a significant portion of riparian and high-altitude mountainside forest. Cattle grazing and its consequent denuding and erosive effects has been halted. In parts of the reserve, natural regrowth is taking place. Currently the directors are working to inscribe the project into the government preservation and forestation programs. Easements and other legal means will be employed to protect the forest in perpetuum.

Reforestation. With the assistance of experts in Costa Rica, the local community, and volunteers from abroad, a program of careful multispecies tree planting has begun. This is being done in such a way as to extend and preserve the diversity of the surrounding virgin forests. The efforts include:

- Planting saplings. This began with the planting of about 4,200 trees in 2002. Subsequent plantings have brought the number to over 10,000.
- Ongoing maintenance to help the trees survive.
- Parallel with the diversity project, a small portion of the reserve has been set aside for a demonstration project of sustainable forestry.
- To understand what we are doing and to help others, we label, measure and monitor the trees' progress.

The goal is restore the mix of trees and flora that is native to the surrounding area. With the assistance of specialists, the founders compiled a list of trees and other flora, of which selected species have been chosen for the reforestation project. These are described on the Cloudbridge web site.

Research. From its beginnings as a reforestation project, Cloudbridge has evolved into an ongoing series of studies of the cloud forest. Some work is repeated year after year, to gauge the progress of the forest's recovery -- examples include the biomonitoring, plantation and moss recovery studies. Others focus on a particular aspect of the flora or fauna -- one study, for example, sought to measure the diversity of bromeliad species in the primary forest and in open areas. Others have focused on vegetation mapping, avian life, arthropods, anurans, mammals, and epiphytes.

Research Volunteers form an integral part of the Cloudbridge Nature Reserve. Year after year, they have contributed to an ever-increasing body of knowledge about the flora and fauna and recovery of the cloud forest. Their contributions may be found at the Research Reports section of the Cloudbridge web site. Some have continued to be involved with Cloudbridge research long after their initial stay.

Education. A further objective is to allow school groups and other visitors to learn about cloud forests, and to see the progress of the plantation while hiking the Reserve's steep slopes and enjoying the views of the valleys and waterfalls. Trails have been laid out and, with volunteers and villagers’ assistance, are gradually being improved. In many places, interpretive signs explain some aspect of the flora or fauna.

The people of San Gerardo de Rivas are actively involved in Cloudbridge on a daily basis. They bring local knowledge, supply experienced planters, gather saplings from the neighboring forest, and encourage schoolchildren to participate in planting and learning activities.

Much more information on Cloudbridge and the cloud forest ecology can be found at the Cloudbridge web site, www.cloudbridge.org.

Appendix 2 Preliminary list of tree species

SpCode	Genus	Species
AIOCOS	Aioueae	costaricensis
ARDSPP	Ardisia	sp.
BILHIP	Billia	hippocastanum
BROCOS	Brosimum	costaricense
BROSPP	Brosimum	sp.
CEDTON	Cedrela	tonduzii
CHISYL	Chione	sylvicola
CHRSPP	Chrysoclamys	sp.
CINTRI	Cinnamomum	triplinerve
CITCOS	Citronella	costaricensis
CLUSPP	Clusia	sp.
CYASPP	Cyathea	sp.
DENARB	Dendropanax	arborens
ELAAUR	Elaeagia	auriculata
EUPSP1		
FERN		
FICTUE	Ficus	tuerckheimii
GUAGLA	Guarea	glabra
HELAME	Heliocarpus	americanus
HIEALC	Hyeronima	alchornioides
HYEPOA	Hyeronima	poasana
INGSPP	Inga	sp.
LAUSP1		
LAUSP2		
LAUSPP		
LICSPP	Licania	sp.
MACMAC	Macrohasseltia	macroterantha
MELVER	Meliosma	vernicosa
MICSPP	Miconia	sp.
MOLSPP	Mollinedia	sp.
MORANI	Mortoniodendrum	anisophylum
MYRFRA	Myristica	fragrans
NECSPP	Nectandra	sp.
OREXAL	Oreopanax	xalopansis
PANSUA	Panopsis	suaveolens
PERAME	Persea	americana
PERSCH	Persea	schiedeana
POSLAT	Posoqueria	latifolia
POSSPP	Posoqueria	sp.
POUSP2	Pouteria	sp.
POUSPP	Pouteria	sp.
PRUANN	Prunus	annularis
PSESPP	Pseudolmedia	sp.
QUESPP	Quercus	sp.
RANSPP	Randia	sp.
RONAMO	Rondeletia	amoena
RUBSP1		
RUBSP2		
SABMEL	Sabia	melliosma
SAPGLA	Sapium	glandulosum
SAPSPP	Sapium	sp.
SENCOP	Senecio	copeyensis

SLOAMP	Sloanea	ampla
SYMGLO	Symphonia	globulifera

SUMMARY:	**#species,**	**# identified trees,**	**#trees,**
	55	**129**	**712**

Summary:
Total Area of the Plot: 1 hectare
Number of Families: to be determined
Number of Species: to be determined
Total Number of Trees: 712

Other measures and interpretations to be determined:
Species Richness (#of species vs. total trees vs. area)
Where the individual species occur (correlate with topography or other factors?)
Comparative tree density (correlate with tree size or other factors?)