2005

Ecology of disjunct cloud forest sugar maple populations (Acer saccharum subsp. skutchii) in North and Central America

Yalma Luisa Vargas-Rodriguez

Louisiana State University and Agricultural and Mechanical College

ECOLOGY OF DISJUNCT CLOUD FOREST SUGAR MAPLE POPULATIONS (*ACER SACCHARUM* SUBSP. *SKUTCHII*) IN NORTH AND CENTRAL AMERICA

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The Department of Biological Sciences

by
Yalma Luisa Vargas-Rodriguez
B.S., University of Guadalajara, 1998
August 2005

DEDICATION

I dedicate this work to those people interested in the conservation of relict montane cloud forests in western Mexico, mainly those from Talpa de Allende, Jalisco. Also, I dedicate my thesis to my parents, sister, brother, and fiancé.

ACKNOWLEDGMENTS

I appreciatively acknowledge financial support from the National Council for Science and Technology, Mexico (Consejo Nacional de Ciencia y Tecnología CONACYT-161695) and the University of Guadalajara through scholarships for my Master of Sciences studies at Louisiana State University. IDEAWILD Foundation, Raúl Vargas-Rodriguez, and the University of Guadalajara through the research program of Antonio Vazquez-García provided financial support for my research. I thank to the Department of Biological Sciences and LSU-Herbarium for assistantships granted.

I thank and appreciate the support from my advisor, William Platt. He significantly helped me throughout my graduate studies. He was a source of motivation every time we talked and during his lectures. I thank Kyle Harms and Richard Stevens their advice and their important suggestions for my research.

Many people and organizations provided support to my research and graduate studies. At El Cielo Biosphere Reserve, Gerardo Sánchez Ramos and Rene Celis allowed me to visit to the protected area and Eduardo Padrón and Antonio Vázquez-García helped in the field. At Talpa de Allende, Toribio Quintero Moro, Raquel Flores, Osvaldo Zuno, Francisco Vargas Aguilar, Angeles Vargas, and Antonio Vázquez-García helped me in the field. At Sierra de Manantlán Biosphere Reserve, Martín Gómez García, Luis Eugenio Rivera, Deidad Partida Lara, Leyla Winter, and Alfredo Aragón helped with technical support; Francisco Vargas Aguilar and Angeles Vargas helped in the field. At Chiapas, authorities at Tenejapa and Neptali Ramírez Marcial provided assistance; Alejandra González, Manuel Luna Méndez II, and Antonio Vázquez-García significantly helped in the field. At Guatemala, César Tot and Luisa Soler from Fundación Defensores de la Naturaleza and Sierra de Las Minas Biosphere Reserve facilitated my visit to the area. Isabel Nájera García, Julio César Lemus, and Antonio Vázquez-García helped me in the field. Oscar Medinilla and Mario Véliz from FAUSAC herbarium (Universidad de San Carlos, Guatemala) helped with data acquisition and species identification respectively. Species identifications were made possible with the assistance of Antonio Vázquez-García, Miguel Cházaro, Mario Souza, and Fernando Chiang. I also appreciate support from the MEXU herbarium, especially Gerardo Salazar and María del Rosario García. I thank the incredible help and friendship from Armando Rincón and Virginia Cervantes while I was visiting the MEXU herbarium. Farrell Jones and Gerardo Boquin from LSU Department of Geography helped with the polygon. The Poissot family (Lynn, James, Katie) always supported me in different ways throughout my graduate studies at LSU. I thank the valuable friendship, support and more from Veronica Bohorquez, Vesna Karaman, the Mexican students at LSU, Heather Passmore, Soraya Silva, Antonio Vázquez-García, and Fabian Vera during different stages of my studies. I appreciate the friendship from my lab mates, Becky Carmichael, Raelene Crandall, Ellen Leichty, Paul Gagnon, Heather Passmore, and Jean Huffman. Finally, I appreciate the support of Bruce Williamson, Meredith Blackwell, Gustavo Moya and Eduardo Sahagún at the beginning of my graduate studies.

TABLE OF CONTENTS

ABSTRACT

The cloud forest sugar maple, *Acer saccharum* subsp. *skutchii,* occurs as five disjunct populations, four in Mexico and one in Guatemala. I assessed the current status, distribution, and environmental relations of forests containing these populations, and I compared the species composition of these forests with other temperate and cloud forests in North and Central America. I gave special emphasis to a recently discovered population in Talpa de Allende, Jalisco, Mexico, by assessing its tree richness and generic composition in a continental context. In the five studied cloud forest sugar maple populations, basal area of all trees ≥1 cm DBH varied between 25.7-52.2 $m^2 ha^{-1}$, and density ranged from 990-2929 trees per ha. *A. saccharum* subsp. *skutchii* represented 7-43% of the total basal area and 1-16% of the tree stems. Bray & Curtis ordination of cloud forest sugar maple populations indicated that most of the variation in relative tree abundance could be explained by soil characteristics and presence of canopy gaps. More cloud forest sugar maples occurred in sites with higher soil moisture ($r=0.716$). In contrast, a NMS ordination indicated that the majority of the variance in community composition of all temperate and cloud forests analyzed was related to latitude, elevation, and precipitation. Tree species richness of Talpa de Allende and 14 other temperate and cloud forests around the world was significantly different ($F=27.53$, $p=<0.0001$). Species richness of forest in Asia and Talpa de Allende did not differ. In addition, generic composition was similar for forests in Asia and Talpa. Based on NMS ordination and Ward's classification, I hypothesize that six forest sites in Jalisco, Tamaulipas, Veracruz, and Hidalgo (Mexico) contain a unique and ancient flora, were connected and shared species before the Pleistocene, and currently function as tree refuges of that ancient flora. Based on the limited distribution of cloud forest sugar maple and its small number of extant populations I propose the inclusion of *A. saccharum*

subsp. *skutchii* in the IUCN Red List Catalog and as Endangered in the Guatemalan Species Red List. In addition, I propose the creation of a 56,394.9 ha Biosphere Reserve in Talpa de Allende.

CHAPTER 1

INTRODUCTION

The name *Acer* was assigned to the genus of maples by Linnaeus in 1753. *Acer* derivates from *ac*, a Proto-Indo-European word meaning "sharp", in association with pointed maple leaves (Gelderen et al. 1994). Three regions of China (Sichuan, Yunnan, and Hubei provinces) possibly are the center of origin of the genus. At the present, the genus contains 150 species (Brizicky 1963).

The genus *Acer* L. (Aceraceae *sensu lato*) is predominantly distributed in north-temperate areas, with a few elements in the tropics from Southeast Asia (Gelderen et al. 1994). *Acer* occurs in Indonesia, Philippines, Sumatra, Borneo, Malaysia, China, Japan, Europe, and northern Africa. In North America, *Acer* is distributed in temperate regions of Canada, the southernmost part of Alaska, the continental United States, Mexico, and Guatemala (Wolfe and Tanai 1987, Gelderen et al. 1994). Some of the native *Acer* species to North America are *A. grandidentatum, A. macrophyllum, A. negundo, A. nigrum, A. rubrum, A. saccharinum,* and *A. saccharum.* The genus occurs in Mexico with the species *A. glabrum* Torr. var. *neomexicanum* (Greene) Kearney & Peebles (Chihuahua), *A. grandidentatum* Nutt. (northern states of Chihuahua, Coahuila, Nuevo León, Sonora), *A. grandidentatum* Nutt. var. *sinuosum* (Rehd.) Little (Coahuila), *A. negundo* L. subsp. *mexicanum* (DC.) Wesm. (Coahuila, central and south Mexico), *A. nigrum* Michx. f. (Sonora), and *A. saccharum* Marsh subsp. *skutchii* (Rehder) Murray (Chiapas, Jalisco, Tamaulipas) (REMIB 2005). Only *A. negundo* subsp. *mexicanum* and *A. saccharum* subsp. *skutchii* occur in Guatemala.

The presence of sugar maple in Latin America was first recognized by Rehder (1936). Subsequently, two other populations were found in northern and southern Mexico (Hernandez-

Xolocotzi et al. 1951, Breedlove 1986) and two in western Mexico (Jardel et al. 1996, Vázquez-García et al. 2000). Rehder (1936) described the plant from Nebaj, Guatemala, as a new species, *Acer skutchii* Rehder (Rehder 1936, Murray 1970). The taxon was subsequently renamed a subspecies (*Acer saccharum* subsp. *skutchii* (Rehder) Murray) of the North American *Acer saccharum* Marsh (Marshall 1785, Murray 1975). The subspecies closely resembles *A. saccharum* morphologically, but can be distinguished by its nutlets, which are thicker, larger, and smoother than those of other sugar maples. The present study follows the taxonomy of Murray (1975, 1980) and considers Latin American sugar maple as *A. saccharum* subsp. *skutchii* (hereafter designated as cloud forest sugar maple).

In Mexico and Guatemala, *A. saccharum* subsp. *skutchii* is an element of montane cloud forest. The populations have been reported in the states of Coahuila, Tamaulipas, Jalisco, and Chiapas (Hernandez-Xolocotzi et al. 1951, Murray 1980, Breedlove 1986, Jardel et al. 1996, Vázquez-García et al. 2000). In Guatemala, populations occur in El Quiche (Sierra de los Cuchumatanes), Chiquimula, Zacapa and El Progreso Departments (Sierra de Minas) (Rehder 1936, Medinilla-Sánchez 1999). In all sites, the subspecies is confined to protected ravines in montane cloud forests. This vegetation shows transitional conditions between tropical and temperate forest, containing floristic elements from deciduous forest of North America, Asia, and South America, allowing high species richness (Miranda and Sharp 1950). This condition is traditionally explained by climatic fluctuations during the Tertiary and Quaternary, favoring migration of temperate elements towards the south and migration of tropical genera from south to north (Graham 1999a). Current distribution of montane cloud forest is discontinuous across Mexico and Guatemala, with an archipelago-like pattern, mainly confined to humid and protected ravines (Vázquez-García 1995a, Islebe and Véliz-Pérez 2001). These forests are now considered as relicts, distributed on humid temperate climates, with continuous presence of fog, and between 1200 and 2500 m above sea level (m a.s.l.) (Alcántara et al. 2002). Four Mexican floristic provinces include montane cloud forest: “Sierra Madre Oriental”, “Sierra Madre Occidental”, “Serranías Transísmicas”, and “Sierranías Meridionales”, which include suitable conditions for the development of the forest (Challenger 1998, Alcántara et al. 2002). In Guatemala, these forests occur in “Sierra de los Cuchumatanes”, “Sierra Madre”, and “Cadena Volcánica” (Islebe and Véliz-Pérez 2001).

A few protected areas designated to conserve montane cloud forest are distributed across those floristic provinces. Montane cloud forests cover less than 800,000 ha (0.4%) of Mexico and no more than 150,000 ha are included in natural protected areas (Challenger 1998, Luna-Vega et al. 2001b). In Guatemala, 60,000 ha of this vegetation type is protected in Sierra de las Minas Biosphere Reserve and no more than 2,000 ha in three other protected areas (Islebe and Véliz-Pérez 2001, Fundación Defensores de la Naturaleza 2002). The protection of this fragmented, relictual, and endangered ecosystem and the creations of reserve networks should be a priority. Suitable biotic and abiotic conditions for *A. saccharum* subsp. *skutchii* populations in disjunct montane cloud forest need to be explored to preserve this relict species.

Environmental variables have been related to persistence of *Acer saccharum* populations in the U.S. and Canada. Soil moisture and nutrient availability affect survival of *A. saccharum* and co-occurring hardwood species, determining species composition (Poulson and Platt 1996, Wilmot et al. 1996, Arii and Lechowicz 2002). *Acer saccharum* occupies the most fertile soils, particularly those that are well-drained with high calcium and magnesium availability (Godman et al. 1990, McClure and Lee 1993, Breemen et al. 1997). The consistency in environmental requirements close to southernmost limits of distribution needs to be addressed.

The objectives of this thesis were to assess the current status and distribution of *A. saccharum* subsp. *skutchii*. I surveyed known populations and described their ecological characteristics. I described the structure and composition of montane cloud forests where *A. saccharum* subsp. *skutchii* occurs in relationship to environmental variables. In addition, I compared generic composition and tree species diversity of these forests with those in North and Central America, Europe, and Asia. I assessed the relationship between environmental variables and generic composition of temperate and cloud forests in North and Central America. Finally, I propose specific conservation measures for *A. saccharum* subsp. *skutchii* in the recently discovered population in Talpa de Allende, Jalisco, Mexico.

CHAPTER 2

DISTRIBUTION AND ENVIRONMENTAL GRADIENTS CHARACTERIZING DISJUNCT POPULATIONS OF *ACER SACCHARUM* SUBSP. *SKUTCHII*

INTRODUCTION

Disjunct or distinctly separated congeneric plants are documented in temperate and tropical forests worldwide (Qian and Ricklefs 2000, Wen 2001, Thorne 2004). For instance, 57 woody temperate genera are known to have disjunct distributions in eastern Asia and eastern North America (*Carya, Illicium, Magnolia, Nyssa, Osmanthus*, among others) (Qian and Ricklefs 2004). In North America, the distributions of several of these temperate genera extend into Mexico and Central America, usually in montane cloud forests at higher elevations (Furlow 1987, Qian and Ricklefs 2000). Paleobotanical evidence suggests that the present disjunct distributions of temperate and montane cloud forest woody genera in Mexico and Central America have resulted from climate change during the late Tertiary and Pleistocene (Martin and Harrell 1957, Furlow 1987, Graham 1999a). Disjunct genera occurring in eastern North America and Mexico include *Acer, Alnus, Carpinus, Carya, Cercis, Cornus, Fagus, Fraxinus, Juglans, Liquidambar, Magnolia, Myrica, Nyssa, Ostrya, Platanus, Prunus, Rhus, Smilax, Tilia*, and *Ulmus* (Graham 1999a). The current distributions of several species in the previously listed genera are considered Tertiary relicts (Graham 1999a).

The current distribution of *Acer* species along valley slopes and ravines at the southern end of their distributions in North America may be considered relictual (Martin and Harrell 1957, Axelrod 1975, Graham 1993, Peters 1997, Graham 1999b). The genus was widely distributed throughout the boreal zone in the Neogene (Miocene and Pliocene) (Graham 1999a). Cooling of the climate during the Neogene produced major geofloristic changes, and some floristic elements shifted southward, producing changes in their ranges (Graham 1999b). In addition, drying of the environment during late Tertiary and Quaternary in continental North America resulted in many tree species becoming isolated along the slopes of valleys and ravines, which served as refugia.

The ancestor of *Acer saccharum* Marsh (sugar maple) probably arrived in North America via long-distance dispersal from western Eurasia during the early Miocene (Wolfe and Tanai 1987). Pollen records from Malpaso, Chiapas, indicate the presence of *Acer* in Mexico during the lower Miocene, but the Neogene flora of Mexico is poorly known (Rzedowski and Palacios-Chávez 1977, Wolfe *pers. comm.*). The neartic and neotropical distribution of *Acer sacchraum* is consistent with neotropical populations being relicts that may have been separated from those in temperate North America throughout the Pleistocene (Gelderen et al. 1994).

Acer saccharum subsp. *skutchii* has disjunct populations in Mexico and Guatemala. North and central Mexican populations are separated by 900 km, and central and south Mexican populations are separated by 1600 km. Detailed information about the current status of these populations is lacking. Except for the cloud forest sugar maple population from Tamaulipas, the species is inconspicuous. For instance, the population from Chiapas was first collected in 1953 by F. Miranda; no other collection or study has been attempted until the present study. The cloud forest sugar maple is onlyconsidered as endemic or with restricted distribution by the Guatemalan Species Red List and it is not currently protected by any international legislation.

Acer saccharum and other prominent components of hardwood forests in U.S. and Canada show relationships with environmental variables. Soil moisture and nutrient availability affect survival of trees, as well as species composition (Poulson and Platt 1996, Wilmot et al. 1996, Arii and Lechowicz 2002). *Acer saccharum* occupies the most fertile soils, particularly those that are well-drained and high in calcium and magnesium availability (Godman et al. 1990, McClure and Lee 1993, Breemen et al. 1997). High aluminum concentrations have shown negative effects on sugar maple survival, by reducing seedling survival due to the interaction of aluminum with other soil nutrients (Bertrand et al. 1995). In addition, the species exhibits little drought tolerance (Ellsworth and Reich 1992).

I had four objectives for this study. First, I assessed the distribution of cloud forest sugar maple. Second, I compared floristic relationships of forests containing cloud forest sugar maple with those of other temperate and montane cloud forests in North and Central America. Third, I surveyed the extant of cloud forest sugar maple populations and described their stand structure, composition and relationships with environmental variables. Fourth, I analyzed environmental variables related to generic composition in cloud forest sugar maple, temperate, and montane cloud forests in North and Central America. Using data collected that relate to each objective, I hypothesized which forests contain an ancient floristic composition and thus might be functioning as refuges for this flora. I also proposed the need for conservation reserves and protection status for cloud forest sugar maple populations.

MATERIALS AND METHODS

Field Sites. I collected information relating to the distribution of *A. saccharum* subsp. *skutchii* from scientific literature and herbaria data. I used maps (1:50,000) produced by INEGI (Instituto Nacional de Estadística, Geografía e Informática, Mexico) and Instituto Geográfico Nacional (Guatemala) to locate individual sites. The area of each stand was estimated from communication with the local community, from literature and reports, or from personal explorations.

Based on collected information, six sites were identified where cloud forest sugar maple had been recorded. Curators at the Harvard Herbarium pointed out that cloud forest maple reported from Cañon del Milagro in Coahuila state (Mexico) was erroneously determined as *Acer saccharum* subsp. *skutchii*. The specimen was annotated by E. Murray in 1977 as *Acer saccharum* Marsh. subsp. *brachypterum* (W. & S.) E. Murray. Thus, remaining populations of cloud forest sugar maple appear to be limited to five sites in three states in Mexico and one department in Guatemala (Table 1, Fig. 1). Recently, I recorded the presence of cloud forest sugar maple in three more departments in Guatemala (Chiquimula, El Quiche, and Zacapa). However, those sites were not possible to include in the present study.

Cloud forest sugar maple populations were located between 15º - 23ºN and 89ºW – 104ºW (Table 1), under different edaphic and geologic conditions. The population in Tamaulipas is distributed along La Colmena, Agua Escondida, and Agua del Indio localities, west of Alta Cima in Gómez Farías municipality, at El Cielo Biosphere Reserve (Puig and Bracho 1987) (Table 1). Cloud forest sugar maple in Talpa de Allende is located within the tributary watershed Talpa. The forest lies between the town of Talpa de Allende, El Refugio village, and La Cumbre de los Arrastrados, within *predio* "Ojo de Agua del Cuervo" in Talpa de Allende municipality (INEGI 1974a, 1974b) (Table 1). The population in Sierra de Manantlán is located along La Moza creek, within the Corralitos tributary watershed. The forest lies between Corralitos and the Scientific Station Las Joyas, within *ejido* Ahuacapán and Autlán de Navarro municipality, at Sierra de Manantlán Biosphere Reserve (CETENAL 1975, 1976) (Table 1). The cloud forest sugar maple population in Chiapas is located at Cañada Grande locality, northwest of Tenejapa town (INEGI 1993, 1999) (Table 1). In Guatemala, the cloud forest sugar maple population is located at northwest of Los Albores village, in the El Balsamal locality at Sierra de

Table 1. Site characteristics of *Acer saccharum* subsp. *skutchii* populations.

Country	State	Site	Coordinates	Elevation (m)	Aspect	Mean annual T(ºC)	Mean annual precipitation (mm)	Substrate
México	Tamaulipas	La Colmena	23º03”658’ N 99º12”274’ W	1357	NE	16.3	927.7	Sedimentary rocks. Lithosol, Rendzina
		Agua Escondida	23º04”325’ N 99º13”908’ W	1548	S	16.3	927.7	Sedimentary rocks. Lithosol, Rendzina
		Agua Escondida	23º04”325’ N 99º13”908’ W	1548	NE	16.3	927.7	Sedimentary rocks. Lithosol, Rendzina
		Agua Escondida	23º04”325’ N 99º13”908’ W	1548	N	16.3	927.7	Sedimentary rocks. Lithosol, Rendzina
		Agua del Indio	23º04”637’ N 99º12”983’ W	1481	E	16.3	927.7	Sedimentary rocks. Lithosol, Rendzina
		Camino a Agua del Indio	23º04”152’ N 99º13”032’ W	1392	S	16.3	927.7	Sedimentary rocks. Lithosol, Rendzina
	Jalisco	Talpa de Allende	20º12” N 104º45” W	1798	N, NE, NW, S, SW	18.3	1294.6	Cretaceous, Plio-Quaternary, acid extrusive rocks. Dystric Regosol, haplic Phaeozem, dystric Cambisol
		Sierra de Manantlán	19º36”280’ N 104º17”792’ W	1850	N, NW, W	18.5	1257.6	Intermediate extrusive rocks. Ferric Cambisol
	Chiapas	Tenejapa	16º49”273’ N 92º32”359’ W	2160, 2186, 2209, 2201	N, NE, E	13.4	1011.7	Cretaceous, Tertiary, and sedimentary rocks. Humic Acrisol, chromic Luvisol, and chromic Cambisol
Guatemala	El Progreso	Las Minas	15º03”004’ N 89º58”557’ W	1750, 1763	S, SE, SW	-	-	-

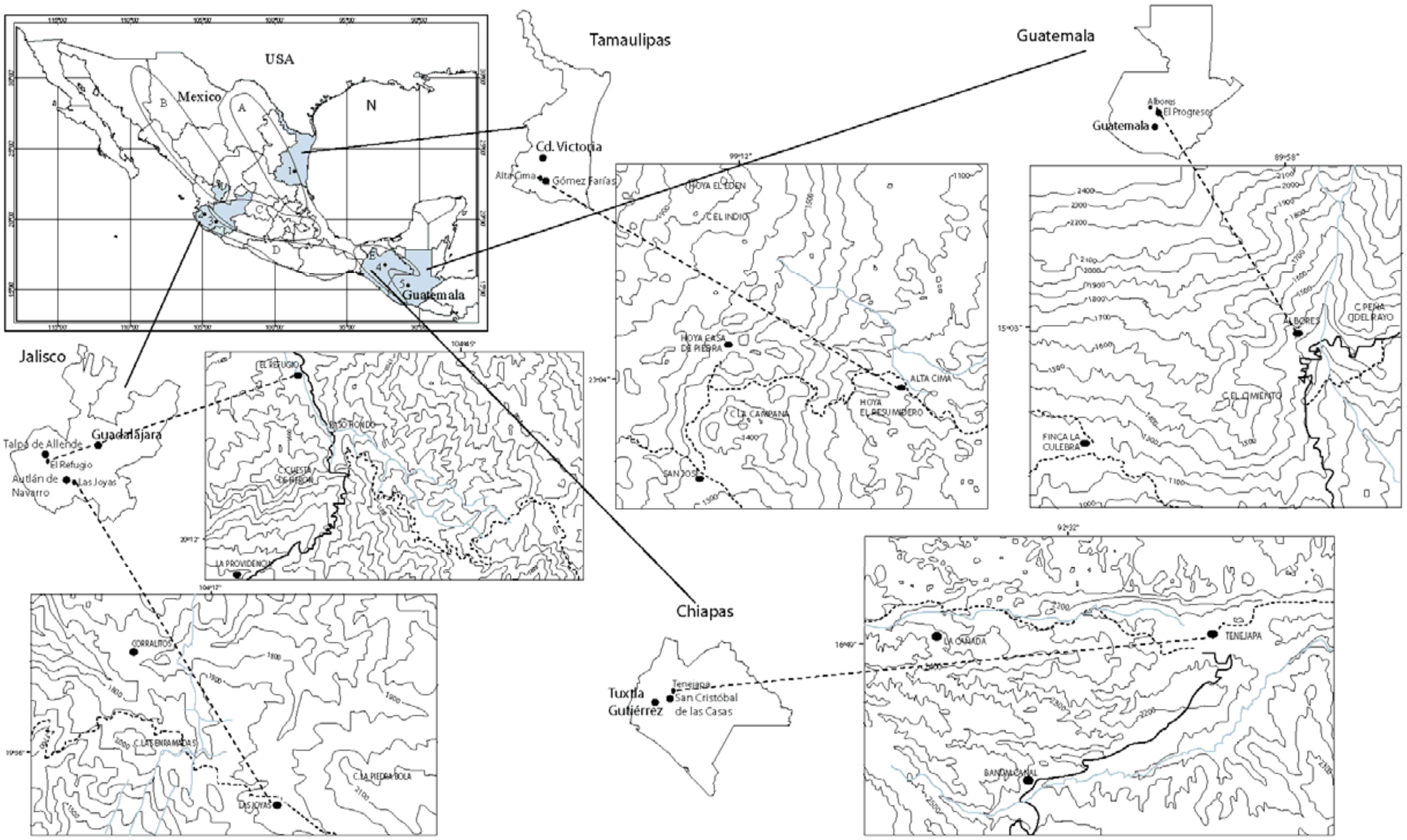


Figure 1. Distribution of the *Acer sacchraum* subsp. *skutchii* populations in Mexico and Guatemala. Some Mexican provinces are illustrated. 1 is Tamaulipas (Tamaulipas state), 2 is Talpa de Allende (Jalisco state), 3 is Sierra de Manantlán (Jalisco state), 4 is Tenejapa (Chiapas state), and 5 is Las Minas (El Progreso department, Guatemala). A is Sierra Madre Oriental, B is Sierra Madre Occidental, C is Eje Neovolcánico, D is Sierra Madre del Sur, and E is Serranías Transísmicas. C and D are considered Serranías Meridionales. More detailed location of sites studied are not provided to prevent wood extraction.

las Minas Biosphere Reserve. Climatic, geologic, and edaphologic data were not available for El Balsamal; however, in Sierra de las Minas Biosphere Reserve Paleozoic rocks, lime and clay soils are present (Fundación Defensores de la Naturaleza 2002).

Field Sampling Methods. I sampled cloud forest sugar maple populations in five sites. I sampled two populations in Jalisco state using the circular quadrat method (Curtis and McIntosh 1951) and a stratified random design (Matteuci and Colma 1982). The circular quadrats were stratified throughout gentle slopes in the entire site. The number and location of plots depended on the density of maples and the size of the area of the forest. I subdivided the Sierra de Manantlan (Jalisco) site into 20 equal squares. Ten squares were randomly selected, and their centers marked with stakes. A measuring tape was used to measure a radius of 5.64 m around the stakes. The combined sampled area of the 10 circular plots totaled 0.1 ha. I subdivided the Talpa de Allende (Jalisco) site into 60 equal squares. A total of 30 squares were randomly selected, their centers marked with stakes, and a radius of 5.64 m was measured around the stakes (Vázquez-García 1995b). The combined sample area of 30 circular plots totaled 0.3 ha. In both sites, adjacent circles were non-overlapping.

I sampled the cloud forest sugar maple populations in Tamaulipas and Chiapas states (Mexico), and El Progreso department (Guatemala) using a random design. I located six circle plots of 10 m radius distributed among three localities where maple was found (one circle plot in La Colmena, three in Agua Escondida, and two in Agua del Indio) at El Cielo Biosphere Reserve (Tamaulipas). The combined sampled area totaled 0.188 ha. I established four circle plots of 10 m radius, distributed in the Cañada Grande locality, in the Tenejapa (Chiapas) sampling site. The combined sampled area totaled 0.126 ha. At Las Minas (El Progreso) sampling site, I located three circle plots of 10 m radius in the Santa Martha-El Duraznal locality. The combined sample area totaled 0.094 ha. At all sites, the number, size, and location of circle plots depended on the density of maples and the size of the area in which it occurred.

I sampled all circular plots during the spring and summer of 2003. I recorded the species of trees and/or shrubs rooted in the plots. I measured diameters at 1.3 m at breast height (dbh) of woody plants ≥ 1cm dbh. Heights of cloud forest sugar maple juveniles (individuals <130 cm height) and saplings (dbh <1 cm and ≥130 cm height) were recorded in each circle plot at Sierra de Manantlan and Talpa de Allende (Jalisco) sampling sites. In the remaining sites, maple juveniles and saplings were measured in a 5.64 m radius subplot, concentric with the main plot. All trees and juveniles and saplings were tagged and mapped. No herbs or liana species were measured in the plots.

I collected at least one voucher specimen of each species of all trees and shrubs present within the plots. Species identifications were performed by specialists at the Universidad de Guadalajara, Universidad Nacional Autónoma de México and Universidad de San Carlos de Guatemala. Nomenclature follows the Gray Card Index International Plant Name Index Query (IPNI). Herbarium specimens were deposited at IBUG herbarium of the University of Guadalajara and at the Mexican national herbarium (MEXU) of the Universidad Nacional Autónoma de México (Holmgren et al. 1990; Holmgren and Holmgren 1993).

I recorded site conditions at each cloud forest maple population. I determined position and elevation using a global positioning device (GPS12 Garmin-Corporation) and aspect and slope using a compass and clinometer, respectively. The topography, physiographic unit, and rockiness were also recorded. I divided topography into two categories: regular (continuous relief, without undulations and/or trenches) and irregular (discontinuous relief, with undulations and/or trenches). Physiography was recorded as one of six categories: crest, plateau, upper slope, middle slope, lower slope, valley bottom. The amount of rock was recorded as one of six classes: nonrocky land (<2% surface occupied by rock), slightly rocky land (2-10%), moderately rocky land (10-25%), very rocky land (25-50%), exceedingly rocky land (50-90%), and excessively rocky land (>90%).

I recorded litter and soil characteristics. I took a soil sample (30 cm depth) at each circle plot. The pH, electrical conductivity, texture, organic matter, nutrients, cation exchange capacity, and moisture were analyzed (Appendix 1). Nutrients were measured following the extraction Mehlich III method, NO_4 with Kjendhal, NO_3 with Cadmium reduction, pH with potentiometer, soil moisture with gravimetric method, organic matter with Walkey-Black, and texture with Bouyoucos methods (AOAC 1990, APHA-AWWA-WPCF 1992, Agricultural Experiment Stations 1998).

I measured the extent of natural and anthropogenic disturbances at each site. Canopy cover was measured in the center of each circle plot using a spherical densiometer. I assessed the degree of disturbance by recording the number of standing dead trees, fallen trees, woody stems, and tree stumps. Insect damage was noted for juveniles and saplings. Grazing was categorized by using the following scale: 0 - no grazing, 1 – little grazing, dung hardly visible, grass and herbs inside the plot, 2 – moderate grazing, dung every 50 m inside and outside the plot, moderate grass, few visible livestock tracks, 3 – heavy grazing, dung every 50 m, livestock tracks very evident, small amount of grass, 4 – severe grazing, many livestock tracks, dung and no presence of grasses. A similar type of scale was used for fire: 0 - no evidence of fire, 1 - evidence of low intensity surface fires (some litter and small branches consumed, and regeneration and herb cover present), 2 - evidence of moderate intensity fires (trees show fire scars, partial fuel consumption and little regeneration), 3 - evidence of high intensity fires (tree trunks with fire scars above 1 m height and total fuel consumption, young trees dead and no regeneration present), 4 - evidence of severe intensity fires (total consumption of dead wood, soil denuded, many trees dead). Average disturbance values were calculated for each circle plot. Hurricane and tropical storm frequency for each site was compiled from U.S. National Oceanic and Atmospheric Administration (NOAA) records.

Data Analysis. I examined compositional similarities at the generic level of neotropical cloud forest and temperate US forest habitats in which *Acer saccharum* occurs. To examine those similarities, I analyzed data from 0.1 ha plots using Nonmetric Multidimensional Scaling ordination (NMS). A matrix with generic presence-absence (293 genera) for 90 montane cloud forests was constructed (Appendix 2, Table 2). In addition, I constructed a matrix with latitude, longitude, elevation, and precipitation data for each site. Data for each 0.1 ha plot was obtained following either Gentry's technique (Gentry 1982) or Curtis and McIntosh's method (1951). Gentry's data were available through The Missouri Botanical Garden (http://www.mobot.org/MOBOT/ Research/gentry/transect.shtml). Forests examined and sources are shown in table 2. Comparability among data obtained with different techniques is possible at the floristic composition level (Phillips and Miller 2002). Beal's smoothing transformation (sociological favorability index) was applied to the presence/absence matrix. The transformation replaces the binary data with quantitative values that represent the probability of the genus occurring in that particular sample unit, based on the joint occurrences in the whole data set (McCune and Grace 2002). Beals smoothing transformation relieved the "zero truncation problem" and reduced the noise in the data by enhancing the strongest patterns (Beals 1984, McCune 1994). NMS was performed following the method described by Kruskal (1964) and Mather (1976). NMS is an effective ordination method for ecological community data because it does not involve assumptions of linear relationships among variables (Minchin 1987). This technique searches for the best position on *n* entities on *k* axes seeking to minimize the

Table 2. Forests examined in the regional analysis of montane cloud forest. Method and source of data are included.

Country	Site	State	Method and source
Canada	Mt. St. Hilaire	Ontario	Gentry 1982 (Phillips and Miller 2002)
USA	Cedar Bluffs	Indiana	Gentry 1982 (Phillips and Miller 2002)
	Babler State Park, Cuivre River State Park, Tyson Reserve Woods, and Valley View Glades.	Missouri	Gentry 1982 (Phillips and Miller 2002)
	Cary Arboretum and Montgomery Place.	New York	Gentry 1982 (Phillips and Miller 2002)
	Bankamp State Park, Heuston Woods: Beech-Maple, and Heuston Woods: Mixed Forest.	Ohio	Gentry 1982 (Phillips and Miller 2002)
	Kane Allegheny Forest, Laurel Ridge, and Tridroute: Allegheny Forest.	Pennsylvania	Gentry 1982 (Phillips and Miller 2002)
	Wild Basin Preserve	Texas	Gentry 1982 (Phillips and Miller 2002)
	Potomac	Virginia	Gentry 1982 (Phillips and Miller 2002)
Mexico	Benito Juarez	Chiapas	Gentry 1982 (Phillips and Miller 2002)
	Tenejapa	Chiapas	Curtis and McIntosh 1951 (Present study)
	La Mojonera (Zacualtipan)	Hidalgo	Gentry 1982 (Williams-Linera et al. 2003)
	Cerro Grande: CG-1, CG-10, CG-11, CG-12, CG-13, CG-14, CG-15, CG-16, CG-17, CG-18, CG-19, CG-2, CG-20, CG-21, CG-22, CG-23, CG-24, CG-25, CG-26, CG-27, CG-28, CG-29, CG-3, CG-30, CG-4, CG-5, CG-6, CG-7, CG-8, and CG-9.	Jalisco	Curtis and McIntosh 1951 (Vázquez-García 1995b, 1998)
	La Bulera and Milpillas.	Jalisco	Curtis and McIntosh 1951 (Reynoso 2004)
	Las Joyas and Quince Ocotes.	Jalisco	Gentry 1982 (Phillips and Miller 2002)
		Jalisco	Gentry 1982 (Phillips and Miller 2002)
	Sierra de Manantlan	Jalisco	Curtis and McIntosh 1951 (Present study)
	Talpa de Allende 1, Talpa de Allende 2, and Talpa de Allende 3.	Jalisco	Curtis and McIntosh 1951 (Present study)
	Sierra de Coalcomán in Cerro La Mona: C1, C2, M1, M2, M3, S1, S2, S3, and S4.	Michoacán	Curtis and McIntosh 1951 (Sahagún 2004)
	Sierra de Juárez: BB-M4, BB-M5, BB-M6, BB-M7, BB-M8, BB-M9, BB-M10, and BB-M11.	Oaxaca	Gentry 1982 (Boyle 1996)
	Casa de Piedra (El Cielo Biosphere Reserve)	Tamaulipas	Gentry 1982 (Williams-Linera et al. 2003)

Table 2 cont.

Country	Site	State	Method and source
	Tamaulipas (El Cielo Biosphere Reserve)	Tamaulipas	Curtis and McIntosh 1951 (Present study)
	Bosque de Guadalupe	Veracruz	Gentry 1982 (Phillips and Miller 2002)
	Mesa de la Yerba, Acatlán Volcano crater, and Acatlán Volcano top.	Veracruz	Gentry 1982 (Williams-Linera et al. 2003)
Guatemala	Las Minas	El Progreso	Curtis and McIntosh 1951 (Present study)
Costa Rica	Braulio Carrillo National Park: BB-C1, BB-C2, BB-C3, BB-C4, BB-C5, BB-C6, BB-C7, BB-C8, and BB-C9.	San José	Gentry 1982 (Boyle 1996)

stress on the *k*-dimensional configuration (Minchin 1987, McCune and Grace 2002). A configuration with 1500 runs with real data was employed to evaluate stability. The dimensionality of the data set was assessed with a three axes ordination. The probability that a three dimensional ordination would achieve lower final stress than would be expected by chance was assessed with a Monte Carlo test with 1500 runs in real data and 900 runs in randomized data. Sørensen's distance measure was used. This measure is robust with ecological distance (Beals 1984, Faith et al. 1987). The relationship between generic composition and the four environmental variables was evaluated using Pearson correlation between the identified axes of the ordination and the environmental variables. *P*-values were not assigned because, strictly speaking, the ordination scores are not independent of each other (McCune and Grace 2002). PCORD v4.0 software was used for the analysis (McCune and Mefford 1999).

In contrast with previous studies of floristic relationships of Mexican montane cloud forests, the present work uses binary generic data of comparable plot size (0.1 ha). Prior studies considered floristic checklists (differing in surface sampled, collection intensity, and life forms considered), making it difficult to conclude whether or not relationships result from differences in botanical exploration intensity (Ramirez-Marcial 2001). In addition, this study uses Beals Smoothing function which enhances possible floristic relationships.

The relative ecological importance of each tree species at each site was expressed as an importance value index (IVI). I calculated the IVI by averaging the values for relative dominance, stem density and frequency following Curtis and McIntosh (1951). Because density and basal area were normally distributed (Shapiro-Wilks *W* test, P<0.0001), differences in stand structure among sites were examined using ANOVA. When significant differences were found, a Tukey-Kramer multiple comparison post-hoc procedure was used to identify significant differences between means. All tests were performed using SAS v8.02 statistical software (SAS Institute 1999-2001).

I used ordination to explore associations of maple populations and co-occurring vegetation with environmental variables. For each of the five sites, matrices were constructed for the density of trees and for values of environmental variables. Bray & Curtis variance-regression ordination was used in connection with the Sørensen coefficient of similarity distance (Beals 1984; McCune and Grace 2002). This type of ordination gives a complete community structure, regardless of its relationship to environmental variables and produces clear species patterns (Beals 1984, McCune and Grace 2002). Thus, Bray & Curtis, like most indirect (sociological) ordination techniques, can be more applicable than direct (environmental) ordination techniques. Endpoints for ordination were selected by variance-regression, which reduces shortcomings of the original technique. Pearson correlations between the identified axes of the ordination and the environmental variables were calculated. For these analyses, I used PCORD v4.0 (multivariate analyses for ecological data) (McCune and Mefford 1999).

RESULTS

Floristic Composition. Generic composition of cloud forest sugar maple sites indicated both temperate and tropical affinities. The number of genera in cloud forest sugar maple sites with tropical affinity was high (49). The majority of the tree genera occurring in cloud forest sugar maple sites had pantropical or neotropical affinity (70%). The number of temperate genera dencreased from northern Mexico (13) to Guatemala (6) (Appendix 3). Temperate genera with disjunct distributions in Mexico and Guatemala comprised 20% of the total generic composition in the five sites studied. Graham (1999a) recognizes 20 temperate genera from North America with disjunct distributions in Mexico. Of these genera, 16 were present in cloud forest sugar maple sites and four of them were disjunct from eastern Asia and eastern North America (*Carya, Illicium, Magnolia, Osmanthus*) (Qian and Ricklefs 2004). Not all disjunct temperate genera were present at each site, only *Cornus* co-occurred with cloud forest sugar maple at all sites. In addition, *Carpinus* and *Ostrya* were present in four of the five cloud forest sugar maple sites. *Cornus, Carpinus,* and *Liquidambar,* all extend to the southern most distribution of *Acer* in Guatemala.

A preliminary assessment of tropical disjunct genera pointed out 17 disjunct genera with Asia, Antilles, Africa, and Central-South America. Disjunct tropical genera with eastern Asia were *Cinnamomum, Cleyera, Dendropanax, Licaria, Litsea, Meliosma, Persea, Phoebe, Podocarpus, Styrax, Symplocos*, *Ternstroemia* and *Turpinia* (Rzedowski 1996, Luna-Vega et al. 1988, Luna-Vega and Contreras-Medina 2000). *Trophis* and *Lippia* out of 110 genera with range disjunctions between America and Africa were present in cloud forest sugar maple sites (Thorne 1973, Renner 2004). *Licaria, Parathesis,* and *Persea* had disjunct distribution in the Antilles, *Zinowiewia* is disjunct in Central and west South America, and *Podocarpus* in Central and South America, West Indies, Oceania, and Africa.

A total of 140 tree species representing 82 genera and 50 families were recorded in the five sites. Species richness varied from 19 in Sierra de Manantlán to 43 in Talpa de Allende, both in Jalisco state. The most speciose families were Fagaceae (12), Lauraceae (11), and Myrsinaceae (11). *Quercus, Dendropanax* and *Oreopanax* were present in more than 50% of the sites. *Acer saccharum* subsp. *skutchii* had the highest importance value in every site except in Tenejapa (Appendix 3).

Dominance of Fagaceae and Lauraceae families in cloud forest sugar maple sites were consistent with patterns found by Gentry (1995). Mexico and north Central America montane cloud forests were dominated by Lauraceae and Fagaceae at 1,500-2,500 m in elevation. Dominance varied from Mexico and north Central America with Fagaceae and other Laurasian elements as dominant families to south Central America with Lauraceae and Myrsinaceae.

Regional Variation of Cloud Forest Sugar Maple Sites and Temperate and Montane Cloud Forests. Ordination using non-metric, multidimensional scaling indicated a three dimensional model. The final stress was 0.0398. Axes accounted for a reduction in stress of 0.0001 and instability of 0.0835 with 200 iterations. Most of the stress was reduced after 38 iterations. The Monte Carlo test recommended a two dimensional solution, with 59 % of the variance being represented by the first axis, which was correlated with three environmental variables. The sites 10, 11, 12, and 13 at Braulio Carrillo National Park in Costa Rica resulted in outliers and thus were removed from the ordination.

Five major groups were distinguished in the NMS ordination (Fig. 2). Cloud forest sugar maple sites were placed in two clusters in the center of the ordination. Geographically distant montane cloud forests, such as those in eastern Mexico (Hidalgo, Tamaulipas, and Veracruz) were clustered with cloud forest sugar maple sites from western Mexico (Jalisco) (group III, Fig. 2). All forest in this group included relict and isolated populations of *Fagus grandifolia* var. *mexicana*. Cloud forest sugar maple sites from Chiapas and Guatemala, however, were grouped with the geographically close montane cloud forests in western and southwestern Mexico (Groups IV, VI, VII, Fig. 2). Other clusters included: I. Temperate U.S. and Canadian forests; II. Cerro Grande in eastern Sierra de Manantlán, Jalisco, Mexico; VIII. Sierra de Juárez in Oaxaca; and X. Braulio Carrillo Nacional Park in Costa Rica (Fig. 2).

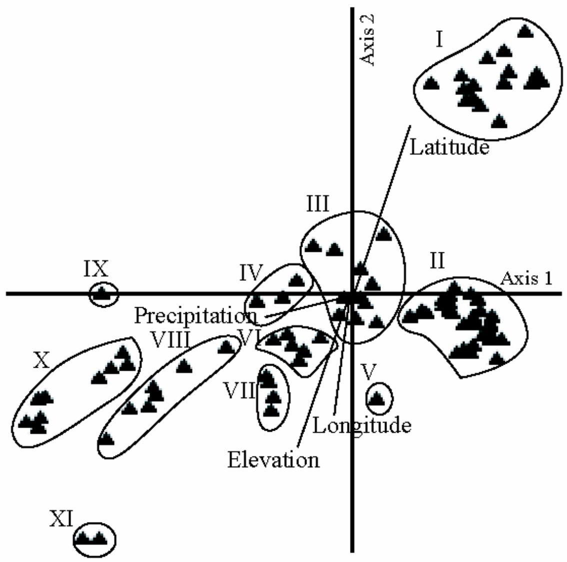


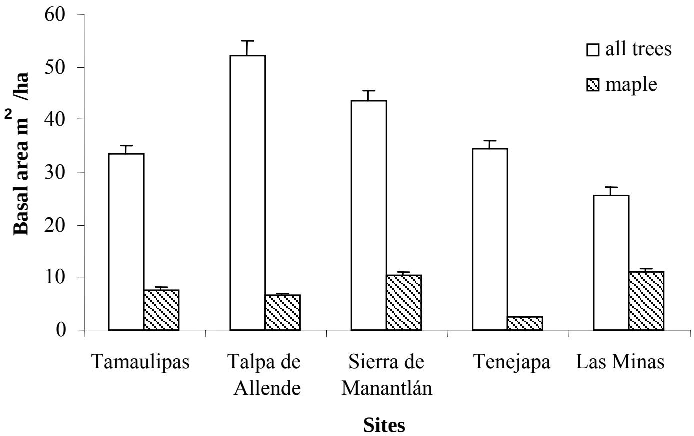
Figure 2. Ordination diagram for axes 1 and 2 derived from NMS ordination using sites (▲), presence-absence data of tree genus and environmental variables (vectors). Groups include sites as follow: I are U.S. and Canada; II is Cerro Grande (Jalisco); III are Casa de Piedra (Tamaulipas), Tamaulipas-maple, La Mojonera (Hidalgo), Manantlán-maple (Jalisco), Acatlán Volcano crater (Veracruz), Acatlán Volcano top (Veracruz), Talpa de Allende1, Talpa de Allende2, Talpa de Allende3 (Jalisco), S1, S3, S4 (Sierra de Coalcomán in Cerro La Mona, Michoacán); IV are Tenejapa (Chiapas), Mesa de la Yerba (Veracruz), Benito Juárez (Chiapas); V is Milpillas (Jalisco); VI are Las Joyas (Jalisco), Bosque de Veracruz, S2 (Sierra de Coalcomán in Cerro La Mona, Michoacán), Las Minas (Guatemala), Quince Ocotes (Jalisco), M1 (Sierra de Coalcomán in Cerro La Mona, Michoacán); VII are M3, M2, C1, C2 (Sierra de Coalcomán in Cerro La Mona, Michoacán); VIII are Sierra de Juarez, except BB0M10 and BBM011; IX is Bulera (Jalisco); X is Braulio Carrillo Nacional Park (Costa Rica); XI are BB0M10 and BB0M11 (Sierra de Juárez, Oaxaca).

In the NMS, variance in the first axis was correlated with three of the environmental variables: latitude (r=0.451), precipitation (r=-0.510), and elevation (r=-0.413). Axis 2 was explained by latitude (r=0.809), elevation (r=-0.742), and longitude (r=-0.676). Axes 1 and 2 represented a latitudinal gradient along which temperate U.S. forests were separated from sites containing cloud forest sugar maple in Mexico and Guatemala and also were separated from Mexican and Central America montane cloud forests. In addition, these axes were related to an elevation gradient that is negatively related to generic composition, with fewer genera in forests at lower elevations in temperate U.S. forests and greater at higher elevations in east Sierra de Manantlán and Costa Rica (Fig. 2).

Removing U.S. sites from the ordination, precipitation became important. This provincial analysis of the forests in Mexico and Central America showed that variance in NMS axes was explained by precipitation. Variance in Axis 1 was not explained by any environmental variable, whereas variance in Axis 2 was explained by precipitation (r=-0.468).

Basal Area and Density of Trees. The forests containing cloud forest sugar maple had similar basal areas and densities of trees (Fig. 3). Basal area of all trees varied between 25.7 and 52.2 m^2 ha^{-1}, but did not differ significantly among sites (one-way ANOVA, F=0.75, P=0.562). Maples constituted 7.2 to 42.9% of the total basal area at each sites, but basal area was not significantly different among sites (one-way ANOVA, $F=1.36$, $P=0.271$). Density of all trees varied from 990 to 2929 individuals ha^{-1} and was marginally significantly different among sites (one-way ANOVA, F=2.21, P<0.0819). Lowest and highest densities of trees occurred at Tenejapa and Talpa de Allende, respectively. Maples constituted 1 - 16 % of the total tree density at each site, but density did not differ significantly among sites (one-way ANOVA, $F=1.63$, $P=0.1928$). Cloud forest sugar maple densities were higher in sites with high

A



B

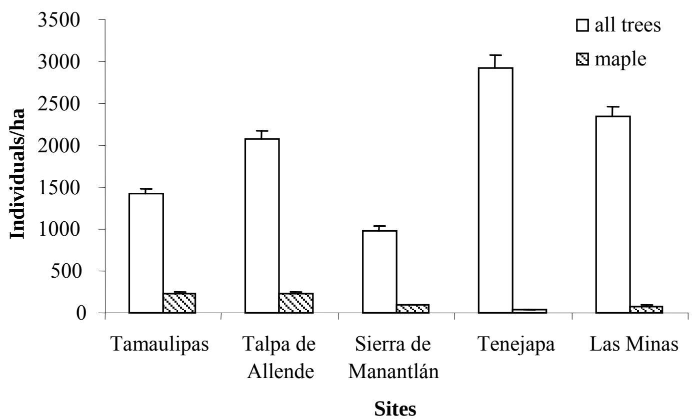


Figure 3. Basal area (A) and density (B) of all trees and maple individuals in the five maple populations. Error bars represent 1 SE.

hurricane frequency, such as Tamaulipas and Talpa de Allende. However, the Sierra de Manantlán site, with a similar hurricane frequency as Talpa de Allende, had fewer tree densities, mainly because of the small size of the area of forest containing maples.

Tree size-class distributions differed among sites (Fig. 4a, 4b). Size-class distributions of trees resembled an inverted-J distribution in Tamaulipas and Talpa de Allende. According to diametric distributions, the largest trees were present in Talpa de Allende. *Abies guatemalensis* var. *jaliscana*, *Carpinus caroliniana*, and *Ostrya virginiana* reached 1 m dbh in this locality. Some trees, such as *Quercus germana* and *Carpinus caroliniana,* reached 90 cm dbh, respectively in Tamaulipas and Sierra de Manantlán sites. In contrast, in Las Minas the largest trees were no larger than 65 cm dbh. Talpa de Allende had the largest number of trees in the 1-5 cm dbh category, whereas Sierra de Manantlán had the lowest in the same category (Fig. 4a, 4b).

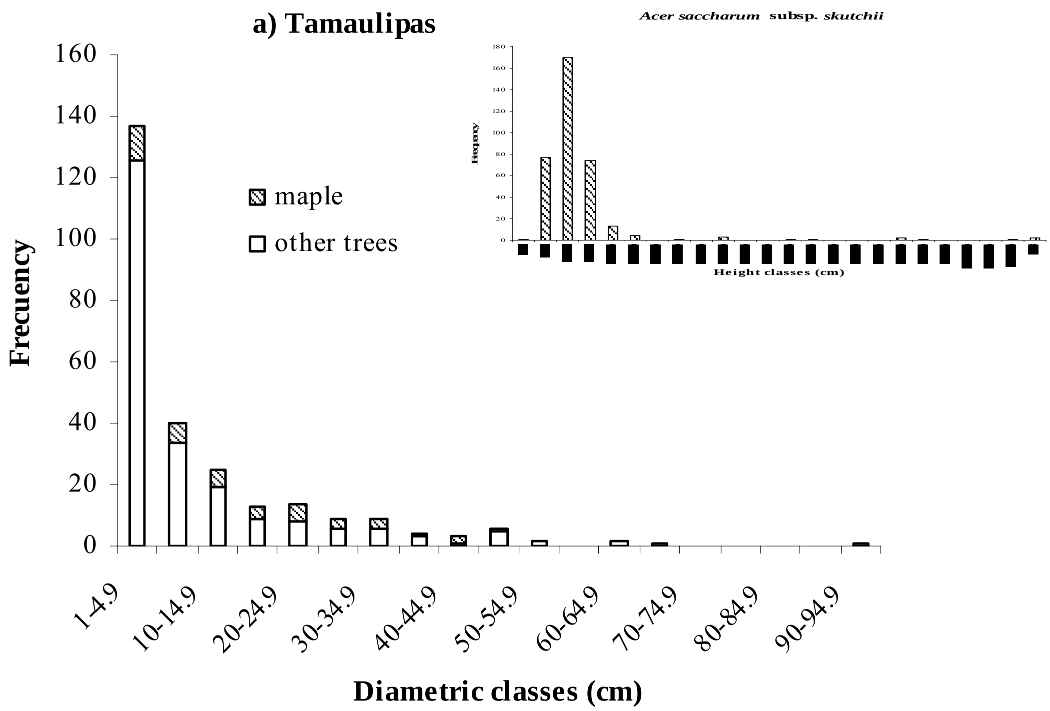
Cloud forest sugar maple populations contained trees, saplings and juveniles in inverted-J distributions in only two sites (Fig. 4a, 4b). In Tamaulipas and Talpa de Allende, the species was uniformly distributed in all diameter classes. Talpa de Allende had the largest number of small maple individuals; the opposite was found in Tenejapa, with only four individuals (Fig. 4a, 4b). Cloud forest sugar maple was the largest tree in Las Minas and Talpa de Allende (Fig. 4a, 4b). Although Sierra de Manantlán and Tamaulipas sites had the highest densities of juveniles and saplings, only in the Talpa de Allende maple individuals were uniformly distributed in all height categories. Tenejapa and Las Minas had the fewest juveniles and saplings (Fig. 4b). Therefore, inferred from diametric and height distributions of cloud forest sugar maple, the species displayed successful establishment and growth in Tamaulipas and Talpa de Allende.

Cloud forest sugar maple is a dominant or co-dominant tree species. The species is dominant in Guatemalan forest and co-dominant in the Mexican forest, together with *Alnus acuminata* subsp. *arguta*, *Carpinus caroliniana*, *Cornus excelsa*, *Liquidambar styraciflua*, *Podocarpus reichei*, and *Zinowiewia concinna* (Appendix 3). This is consistent with the dominance or co-dominance of *Acer saccharum* in U.S. and Canada (Curtis 1959, Maycock 1963, Lambert and Maycock 1968, Roman 1980, Morrison 1990, Poulson and Platt 1996, Dodge 1997, Beaudet et al. 1999, Arii and Lechowicz 2002). However, stem densities (trees/ha) of cloud forest sugar maple were different along its geographic distribution. The values and the proportion of trees represented by cloud forest sugar maple individuals in Tenejapa and Las Minas sites was smaller than the values of densities and basal areas reported for several sugar maple forests in U.S. and Canada (Ontario, Norberg Creek, 28.6 m^2 ha^{-1}, 682 trees ha^{-1}, Morrison 1990; Ontario, Wishort Lake 24.7 m^2 ha^{-1}, 787 trees ha^{-1}, Morrison 1990; Quebec, Mont St. Hilaire, 24.5 m^2 ha^{-1}, 248 trees ha^{-1}, Arii and Lechowicz 2002; Nova Scotia, Cape Breton Island, 20.4 m^2 ha^{-1}, 145 trees ha^{-1}, Greenidge 1961; U. S. Lake States ranges from 27.6 to 36.8 m^2 ha^{-1}, a few older stands exceed 45.9 m^2 ha^{-1}, Burns and Honkala 1990).

Cloud Forest Sugar Maple Sites Ordination. Bray & Curtis ordination recovered three axes for community tree data at all Mexican sites. There were too few plots at Las Minas in the Sierra de Minas Biosphere Reserve, Guatemala, to analyze using ordination.

Cumulative variance of the three axes was 76.8% at Tamaulipas. Axes 1, 2, and 3 extracted 38.2, 22.7, and 15.9% of the original distance matrix, respectively. Variation in axis 1 was associated with slope ($r=-0.848$, $df=4$, $p<0.05$), ion exchange capacity ($r=0.902$, $df=4$, $p<0.05$), and Mn ($r=0.873$, $df=4$, $p<0.05$). Variation in axis 2 was associated with gaps ($r=-0.864$, $df=4$, $p<0.05$). None of the studied variables was associated with variation in axis three. Relative densities of *Podocarpus reichei* and *Ternstroemia sylvatica* decreased with decreasing slope and increasing Mn and ion exchange capacity. Five species increased in density with decreasing canopy gaps (Table 3).

Cumulative variance of the three axes was 66.9% at Talpa de Allende. Axes 1, 2, and 3



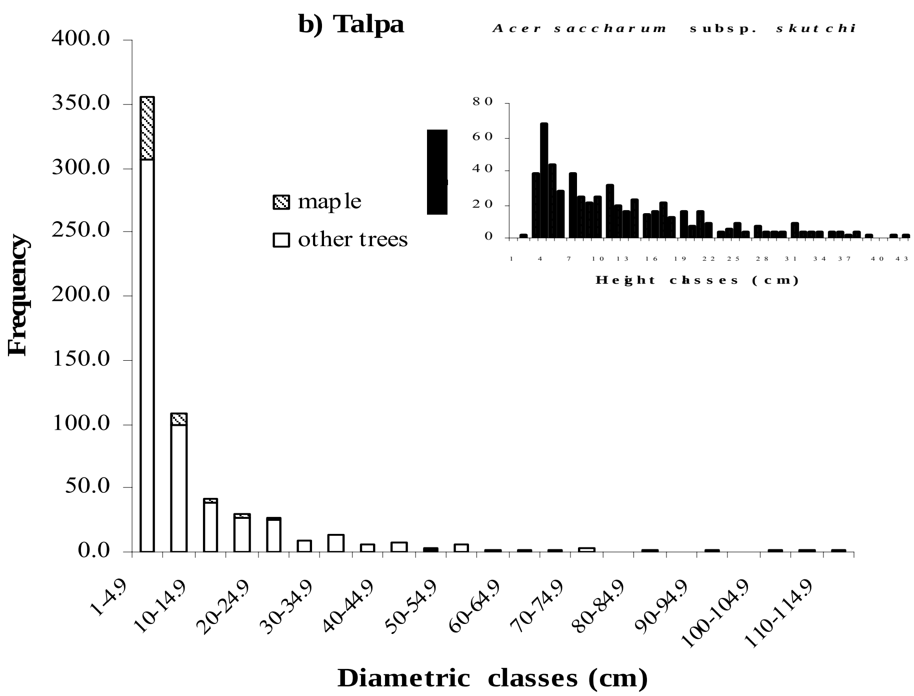


Figure 4a. Frequency of trees by dbh size categories for each of the five forests studied, and frequency of juvenile and sapling cloud forest sugar maples by height distribution in each population.

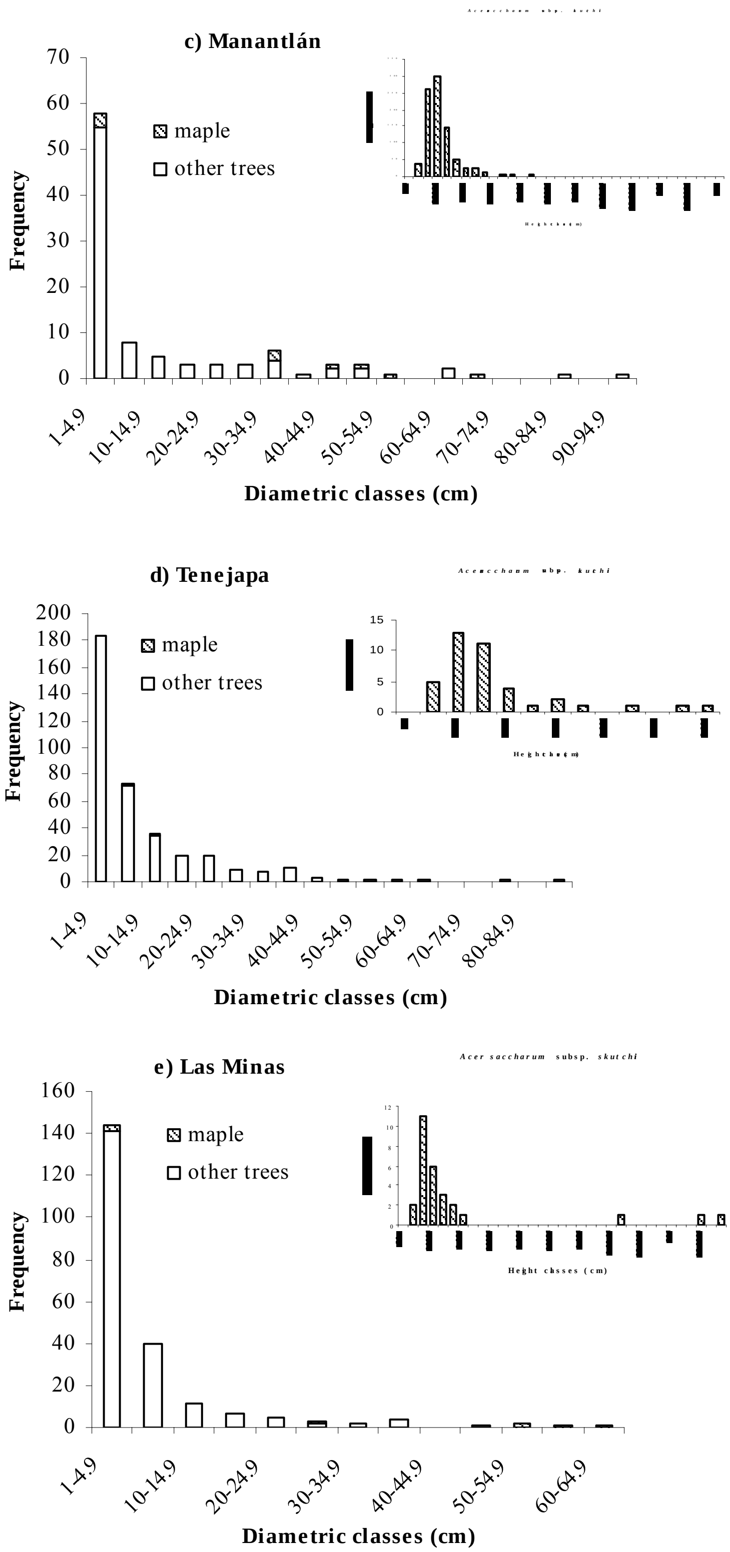


Figure 4b. Frequency of trees by dbh size categories for each of the five forests studied, and frequency of juvenile and sapling cloud forest sugar maples by height distribution in each population.

extracted 30.2, 20.8%, and 15.9% of the original distance matrix, respectively. Variation in axis 1 was associated with soil variables, axis 2 and 3 were associated with soil and canopy gaps variables (Table 4). Only three species decreased in density with decreases in soil nutrients, and two species increased (Table 3). *Abies guatemalensis* var. *jaliscana* decreased with decreasing canopy gaps. *Acer saccharum* subsp. *skutchii* density increased with increasing soil moisture (Table 3).

Table 3. Pearson correlation (r) of tree density and Bray & Curtis ordination axes per site.

Species	Tamaulipas			Talpa de Allende			Sierra de Manantlán			Tenejapa
	Axis 1	Axis 2	Axis 3	Axis 1	Axis 2	Axis 3	Axis 1	Axis 2	Axis 3	Axis 1
Abies guatemalensis var. *jaliscana*					-0.659					
Acer saccharum subsp. *skutchii*						0.716				
Carpinus caroliniana							-0.815			
Cinnamomum areolatum						0.669				
Cinnamomum effusum					0.632					
Clethra nicaraguensis										-0.916
Clethra vicentina								0.869		
Cornus disciflora				0.655			-0.689			-0.93
Eugenia capuli		0.901								
Fagus mexicana			0.899							
Ilex brandegeana				-0.772						
Ilex discolor		0.901								
Juglans mollis		0.901								
Myrcianthes fragrans				-0.791						
Ostrya virginiana		0.901								
Persea hintonii				0.619	-0.632					
Podocarpus reichei	-0.841			-0.893						
Prunus serotina		0.901								
Quercus candicans									0.707	
Quercus salicifolia					-0.615				-0.659	
Saurauia serrata					0.763					
Symplococarpon purpusii								0.869		
Ternstroemia sylvatica	-0.853									
Zanthoxylun melanostictum					0.728					
Zinowiewia concinna						-0.688				

Table 4. Pearson correlation coefficients (r) of environmental variables and ordination axes using density data of trees at Talpa de Allende site. Significant correlations are in bold.

Variable	Density data		
	Axis 1	Axis 2	Axis 3
Canopy gaps	0.438	**-0.704**	-0.075
Ca	**-0.730**	-0.222	0.291
Cu	**-0.866**	-0.113	0.118
Fe	**-0.696**	0.437	0.131
Mg	**-0.777**	-0.224	0.459
Mn	**-0.769**	-0.187	0.506
Na	**-0.757**	-0.291	0.292
Zn	-0.308	**0.653**	-0.144
S	**-0.765**	-0.100	0.497
B	**-0.845**	0.073	0.264
P	**-0.788**	-0.102	0.470
K	-0.100	-0.501	-0.340
Organic matter	**-0.648**	-0.285	0.487
Soil moisture	-0.030	-0.389	**0.620**
Slope	0.478	0.455	0.166
pH	0.004	-0.052	-0.443
Ion exchange capacity	-0.601	0.087	0.404
NO_3	0.478	0.552	-0.179
NO_4	0.246	0.193	0.227
Sand	-0.282	-0.547	0.040
Lime	0.389	0.402	0.155
Silt	-0.015	0.491	-0.309

Cumulative variance of the three axes was 76.9% at Sierra de Manantlán. Axes 1, 2, and 3 extracted 44.2, 17.1%, and 15.6% of the original distance matrix, respectively. Variation in axis 1 was associated with slope ($r=-0.636$, $df=8$, $p<0.05$). Variation in axis 2 was associated with Mn ($r=0.822$, $df=8$, $p<0.05$). Variation in axis 3 was associated with canopy gaps ($r=0.807$, $df=8$, $p<0.05$), K ($r=-0.663$, $df=8$, $p<0.05$), and Mg ($r=-0.661$, $df=8$, $p<0.05$). Relative densities of two species were negatively related to slope and positive related with Mn. Only *Quercus candicans* was positively related with canopy gaps, and increased in density with increasing gaps (Table 3).

Cumulative variance of the three axes was 100% at Tenejapa. Axes 1, 2, and 3 extracted 43.9, 35.7%, and 20.4% of the original distance matrix, respectively. Variation in axis 1 was associated with sand ($r=0.990$, $df=2$, $p<0.05$) and lime ($r=-0.957$, $df=2$, $p<0.05$). None of the studied variables was associated with variation in axis two or three. Relative densities of *Clethra nicaraguensis* and *Cornus disciflora* decreased with decreasing lime (Table 3).

Conservation Status and Disturbance of the Sites. I found evidence of disturbance in all sites. Common anthropogenic disturbances were cattle grazing, fire wood collection, and timber harvesting. Signs of past fires were also common in Talpa de Allende, Sierra de Manantlán and Las Minas (Table 5). Tenejapa site was clearly endangered. Intensive timber harvesting and firewood collection were common in the area and only eight maple trees were observed.

Table 5. Disturbance recorded as number of fallen trees, cut trees, and dead trees in each site. Total juveniles and sapling density per site. Density of maple trees per ha/site.

	Fallen trees	Cut trees	Dead trees	Livestock presence	Fire	Cloud forest sugar maple juveniles and saplings	Stand area/ha	Density (No./ha)	Hurricane frequency (period/years)
Tamaulipas	12	13	29	Cattle/Moderate dung	No fire	355	3	233.6	13 (146)
Talpa de Allende	26	2	12	No livestock	Fire scars	558	2	236.7	5 (139)
Sierra de Manantlán	13	4	16	Cattle/Moderate dung	Fire scars	916	1	90	5 (139)
Tenejapa	4	33	36	Cattle/Moderate dung	No fire	40	--	31.9	2 (139)
Las Minas	21	29	4	Cattle/Moderate dung	Fire scars above 1 m height	28	0.1	85	2 (139)

DISCUSSION

Asiatic and North American disjunct genera are important floristic elements in cloud forest sugar maple sites. A high proportion of temperate genera are disjunct with North America, while tropical genera are disjunct with Asia. The presence of disjunct genera from Asia in America may have a vicariant origin; these elements may have arrived in the Late Cretaceous, before the link Australasia-South America was broken and subsequently dispersed to Mexico through the Antilles (Thorne 2004). Arrival of other tropical genera might have occurred through the Antilles during the Tertiary (Iturralde-Vinent 2003) or from South America after the Plio-Pleistocene (2.5-1 Ma -Millions of years ago-) when the Panama isthmus connected North and South America (Graham 1993, Iturralde-Vinent 2003).

Patterns of temperate and tropical floristic affinities of tree genera in montane cloud forests analyzed are consistent with those in other Mexican and Central American forests (Luna-Vega et al. 2001a, 2001b). Montane cloud forests in Mexico contain a large proportion of tropical elements. However, temperate tree genera are the dominant elements in the canopy, varying in number with latitude.

Montane cloud forest stands in North America exhibit an increase in tree species diversity from north to south (Phillips and Miller 2002). The increase might be attributed to the presence of species with tropical affinity growing in both understory and overstory, replacing many temperate tree species. In this sense, temperate elements are mostly restricted as dominant or co-dominant trees, decreasing in numbers as latitude and elevation decrease (Luna-Vega et al. 1999, Luna-Vega et al. 2001b, Ramirez-Marcial 2001). Increases in species number from 40º to 20º N are also found in a comprehensive analysis of seasonal forests in the Americas (Quigley and Platt 2003). Shrubs and subcanopy trees in tropical families tend to increase at 30º, 20º and 10º N, while temperate elements decrease (Quigley and Platt 2003).

Persistent remnants of a formerly widespread flora in Mexico were grouped in the NMS ordination. These sites located in geographically extreme positions area clustered in the center of the ordination and contain species such as *Fagus grandifolia* var. *mexicana*, *Liquidambar* *styraciflua, Acer saccharum* subsp. *skutchii,* or *Matudaea trinervia,* for instance. Applying a parsimony analysis of endemicity to patches of Mexican montane cloud forest, Luna-Vega et al. (1999) found that the Mexican floristics provinces (Sierra Madre Oriental, Sierra Madre del Sur, and Serranías Meridionales) do not represent natural units. Both Sierra Madre Oriental and Serranías Meridionales split in different clades, showing relationships with the Sierra Madre Occidental and Sierra Madre del Sur. Accordingly, sites from Veracruz and Jalisco states were grouped in this study, suggesting a relationship between Serranías Meridionales and the south of Sierra Madre Oriental. In addition, sites from Tamaulipas and Hidalgo in Sierra Madre Oriental were clearly separated from those in Veracruz, at the south portion of the Sierra and related to forests in Chiapas. Furthermore, Sierra Madre Oriental and Sierra Madre Occidental contain a large number of shared species, suggesting that an ancient fragmentation separated the biotas in the two Sierras (Liebherr 1991). In this sense, tree forest composition in sites included in group III can be considered as those with an ancient floristic composition, or ancestral biotas that closely resemble forest composition before Pleistocene aridity, 11,000 years ago.

The ordination as a whole shows a latitudinal gradient. Temperate forests from U.S. are separated from the rest, despite sharing various genera. Along this gradient, east Sierra de Manantlán at central Mexico together with Sierra Madre Oriental and Occidental sites are at middle latitude. Oaxaca and Costa Rica sites are in the extreme of the gradient, demonstrating a more tropical composition. This close relationship between sites on the Pacific side of south Mexico and Central America has been found in previous studies (Vázquez-García 1995a, Luna-Vega et al. 2001a, Ramírez-Marcial 2001). In addition, a precipitation gradient distinguishes the ordination groups from seasonal forests in North America to sites without a marked seasonality in south Mexico and Central America in agreement with Gentry (2001). Provincial ordination is also consistent with a precipitation gradient related to generic composition in montane cloud forest of Mexico and Central America.

Canopy gaps have an effect on the density of montane cloud forest tree species. Tree fall regimes that create canopy gaps allow responses in tree abundance that differ depending on the gap size (McClure and Lee 1993). Tree fall regimes in Tamaulipas and Talpa de Allende might be strongly influenced by hurricane frequency (Arriaga 1988). Thus, the differences in tree density of the five studied sites might be related to some forests being in areas where hurricanes are more frequent (Quigley and Platt 2003). Increased density in forests with high hurricane frequency and large canopy gaps might result from resprouting of damaged trees and seedling recruitment (Foster et al. 1997, Arriaga 2000).

Soil variables explain most of the variation in tree density along cloud forest sugar maple sites. A larger number of soil macro and micronutrient variables were correlated with tree density in Talpa de Allende than in the rest of the sites. In temperate forests, Ca and Mg show also a relationship with trees, affecting their distribution and dominance (Breemen et al. 1997, Arii and Lechowicz 2002, Bigelow and Canham 2002, Dijkstra and Smits 2002, Horsley et al. 2002). Constant soil leaching may be causing the observed acidity in plots, which in turn has a pronounced effect on Ca and Mg availability (Schier and McQueattie 2000). Although pH does not show any relationship with tree density in the study sites, low values (pH 4.23-4.28) in Tenejapa might be having an effect in tree density (Wilmot et al. 1996, Duchesne et al. 2002, Horsley et al. 2002). Soil acidification has also been observed in declining sugar maple stands (Drohan et al. 2002). A detailed study in Tenejapa will be needed to determine the effect of low pH in vegetation structure.

Interaction between soil texture, topography, and slope might influence soil fertility and therefore tree density (Swanson et al. 1988). Larger soil particles such as those present in sand, affect the movement of air and water as well as in root penetration, giving a competitive advantage to the plant (Sollins 1998, McCarthy et al. 2001). K, Ca, and Mg concentrations change on a relatively small scale across a topographic gradient. This topographic gradient in soil fertility might result in differences in tree density in the higher slopes compared to the lower slopes and valleys as observed in Tamaulipas and Sierra de Manantlán sites (Breemen et al. 1997, Ortiz-Arrona 1999, Bailey et al. 2004).

Soil moisture might be the major determinant for cloud forest sugar maple density. Soil moisture deficiency or excess is one of the abiotic variables that cause sugar maple declines by reducing root respiration and affecting woody biomass and dominance (Ellsworth and Reich 1992, Walters and Reich 1997, Burton et al. 1998, Drohan et al. 2002, Horsley et al. 2002, Minorsky 2003). Soil drainage conditions can also alter nutrient uptake causing stress to sugar maples (Sauvesty et al. 1993, Roy et al. 2002). Overall, sugar maple's probability of mortality at sapling and adult stages increases with decreasing soil water availability (Bartlett et al. 1991, Walters and Reich 1997, Caspersen and Kobe 2001). Although several studies suggest that poor nutrient soils predispose a decline in tree density, in the present study, cloud forest sugar maple densities only appear correlated with soil moisture in Talpa de Allende (Horsley et al. 2000, Drohan et al. 2002, Bailey et al. 2004, Modry et al. 2004). Moisture conditions can be favoring a successful cloud forest sugar maple establishment, while the above soil factors, together with a suitable gap dynamics might contribute to differences in tree mortality and persistence of tree species.

Anthropogenic disturbance and fragmentation were evident in all sites. Cattle grazing are a major threat in all sites, especially in Las Minas, despite its protected status. The land owner of the Talpa de Allende cloud forest sugar maple population has recently allowed cattle grazing in the area. In Tamaulipas, habitat protective measures such as preventing cattle grazing and timber harvesting have been implemented recently. Similar protective measures have been implemented in Sierra de Manantlán site, where the maple forest was fenced in 1993. However, sporadic cattle grazing still occur in both sites (personal observation). Timber harvesting and fuelwood collection are the major threats in Tenejapa and Las Minas populations. Conversion of surrounding forests to farm lands is also common; this is decreasing the size of cloud forest sugar maple patches and increasing the edge effect (Lovejoy et al. 1986, Laurance et al. 1997). Tenejapa and Las Minas population might experience a reduction in genetic variation. Low juveniles, saplings and adult tree densities and their geographically isolation from each other population raises concern about their viability and suggest a possible inbreeding depression process (Young et al. 1993, Allendorf and Ryman 2002). Therefore, main threats to cloud forest sugar maple result from human activities (Allendorf and Ryman 2002).

Three cloud forest sugar maple sites are located within biosphere reserves. The reserves are El Cielo Biosphere Reserve, Tamaulipas, Sierra de Manantlán Biosphere Reserve, Jalisco, both in Mexico and Sierra de las Minas Biosphere Reserve, Guatemala. In addition, *Acer saccharum* subsp. *skutchii* is considered endangered by Mexican Endangered Species Act (MESA) (Diario Oficial 2002) and it is only considered as endemic in the Guatemalan Species Red List (CONAP 2001).

I propose three legal statuses for cloud forest sugar maple's conservation purpose. On the basis of available data and according to the IUCN Red List Criteria, *Acer saccharum* subsp.

skutchii merits Endangered status, given that the extent of the distribution is less than 5000 km^2, and contains fragmented populations in no more than five locations (IUCN 2001). Furthermore, the species must be included as Endangered in the Guatemalan Species Red List. In addition, Talpa de Allende cloud forest sugar maple population must have a protected status (chapter 3). Restoration practices need to be applied to the southern populations in Tenejapa and Las Minas. All localities are included in the Mesoamerican Biodiversity Hotspot, deserving priority for conservation purposes (Myers et al. 2000).

Concluding Remarks. At a regional level, the latitudinal gradient in floristic composition distinguishes U.S. and Canadian forests from cloud forest sugar maple sites. At a provincial level, the precipitation gradient groups montane cloud forests. Floristic similarities in generic composition exist among cloud forest sugar maple sites and forests in Michoacán and Veracruz. However, forests in Oaxaca with high precipitation are separated and grouped with those in Costa Rica. I hypothesize that montane cloud forests in Talpa de Allende, Sierra de Manantlán, El Cielo in Tamaulipas, Acatlán Volcano in Veracruz, La Mojonera in Hidalgo, and Cerro La Mona in Michoacán are those with an ancient floristic composition and were connected before fragmentation during the Pleistocene epoch. Currently, those sites might function as refugia for that primitive flora. Variation in tree density among disjunct cloud forest sugar maple forests is consistent with the disturbance regime and composition with latitude. High hurricane frequency in Tamaulipas and Talpa de Allende sites might promote variation in tree density; however, in southern sites, such as Tenejapa and Las Minas, tree densities appear more influenced by human disturbance. Low densities of cloud forest sugar maple and its requirement of appropriate soil moisture and nutrients conditions raise concerns about how to protect sugar maple forests. I propose three legal statuses for cloud forest sugar maple's conservation purpose, its inclusion in IUCN Red Book of endangered species, inclusion as Endangered in the Guatemalan Species Red List, and the creation of a protected area in Talpa de Allende, Jalisco, Mexico. Habitat restoration in the southern populations in Tenejapa and Las Minas will also be needed.

CHAPTER 3

A TERTIARY REFUGE OF MONTANE CLOUD FOREST OF WESTERN MEXICO: PROTECTED STATUS NEEDED

INTRODUCTION

Floristic relationships exist among North American flora and other continents (Qian 1999). The Old World, Central and South America share 67.3% of their vascular plant genera with North America (Qian 1999). Land past connections, air and sea currents, and bird dispersal are used to explain these floristic relationships. For instance, the Bering and North Atlantic land bridges during the Late Cretaceous and Early Tertiary are hypothesized to allow the migration of floras between Eurasia and North America (Qian 1999).

Disjunct genera from eastern Asia are more species rich than the same disjunct genera in eastern North American (Qian and Ricklefs 2000). Although the genera share a common history of ecological relationships before disjunction, genera in eastern Asia on average have twice as many species as those in eastern North America. Differences in diversity between continents have been hypothesized to result from the extreme physiographical heterogeneity of temperate eastern Asia. In addition, differences in climate might contribute to allopatric speciation (Qian and Ricklefs 2000). Tree species richness of relict Mexican montane cloud forests in relation to other temperate and cloud forests has not been previously assessed.

Conservation of species in relict genera has not been successful in Mexico. Of the 150 protected areas in the country, only 20 contain montane cloud forests, and six of these are Biosphere Reserves. Approximately 150 000 ha from an estimated total cover of 800 000 ha of montane cloud forest are included in the protected areas system. Montane cloud forests included in National Parks (14 out of 20 protected areas) underwent significant loss of species. The lack of management plans, fragmentation and illegal forest resource extractions are important threats to these small and disjunct forest remnants (Challenger 1998, INE 2000, Luna-Vega et al. 2001b).

A previously unknown montane cloud forest was discovered and described in Talpa de Allende Municipality, Jalisco State, Mexico in 2000 (Vázquez-García et al. 2000). The area, locally known as "Ojo de Agua del Cuervo" ("Crow spring"), is located at 20º11" N, 105º16" W and 1800 m a.s.l. The newly discovered montane cloud forest at "Ojo de Agua del Cuervo" contains the fifth known disjunct population of *Acer saccharum* Marsh. subsp. *skutchii* (Rehder) Murray (cloud forest sugar maple). This temperate disjunct tree species was first discovered in Nebaj, Guatemala (Rehder 1936). The subspecies is included in the Mexican Endangered Species Act (MESA) (Diario Oficial 2002), but it is not currently protected by any international legislation.

Other disjunct tree species from eastern North America are also present in "Ojo de Agua del Cuervo". The forest canopy in the montane cloud forests of "Ojo de Agua del Cuervo" is composed of genera such as *Carpinus*, *Cornus*, *Magnolia*, *Prunus*, *Ostrya*, and *Tilia*. The presence of these species suggests that the area might have been a Tertiary refuge (Graham 1999, Wen 1999, Qian and Ricklefs 2004). Climatic changes during Tertiary and Quaternary produced species extinctions and migrations, resulting in current disjunct species patterns and in a fragmentary distribution of montane cloud forest, now considered "montane islands" refuges (Toledo 1982, Kappelle and Brown 2001).

I placed tree species richness and floristic composition of the "Ojo de Agua del Cuervo" montane cloud forest in a world context of temperate and montane cloud forests. Then, I described "Ojo de Agua del Cuervo's" relevance for conservation purposes. I began by comparing tree species richness from 31 temperate and montane cloud forests sites (0.1 ha each) from North and Central America, Europe, and Asia. Then, I described floristic relationships at the generic level among 110 temperate and cloud forest communities from North and Central America, Europe and Asia. Specific structural characteristics and major threats were also addressed for "Ojo de Agua del Cuervo" forest. Finally, I proposed *in situ* conservation strategies for this forest site and described measures needed for "Ojo de Agua del Cuervo" protection.

MATERIALS AND METHODS

Species Richness and Floristic Relevance. Thirty one forest sites were used to compare tree species richness among temperate and montane cloud forests around the world (Table 6). Tree species richness was based on individuals ≥2.5 cm dbh x 0.1 ha site. I used data sets available from Alwyn H. Gentry's forest transects (Phillips and Miller 2002), and data from measurements in five disjunct cloud forests containing cloud forest sugar maple populations in Mexico and Guatemala (chapter 2) (Table 6). I selected sites with the occurrence of *Acer, Fagus*, and those with a canopy composition containing the most common genera for temperate and montane cloud forest. The forests share genera such as *Quercus, Fagus, Acer, Cornus, Fraxinus*, and *Prunus* among others. All sites were similar in area (0.1 ha) and sampling method (Gentry's transect) (Phillips and Miller 2002). I used ANOVA followed by Tukey-Kramer multiple comparison post-hoc procedure when there were significant differences. Software used was SAS v. 8.02 (SAS Institute 1999-2001).

I analyzed similarities in generic composition in 110 forests containing 354 genera from North and Central America, Europe, and Asia. Data sources were Vazquez-Garcia (1995b), Boyle (1996), Peters (1997), Phillips and Miller (2002), Williams-Linera et al. (2003), Sahagún

Table 6. Temperate and montane cloud forests sites selected for tree species richness comparison.

Continent	State/Country	Locality	Number or letter on map (Fig. 5)	Tree species richness
America	Ontario, Canada	Mt. St. Hilaire	10	12
	Ohio, US	Bankamp State Park	2	21
	Indiana, US	Cedar Bluffs	3	24
	Ohio, US	Hueston Woods, beech-maple	4	20
	Ohio, US	Hueston Woods, mixed forest	H	21
	Pennsylvania, US	Kane, Allegheny Forest	5	13
	Pennsylvania, US	Laurel Ridge	6	14
	New York, US	Montgomery Place	9	18
	New York, US	Cary Arboretum	C	19
	Pennsylvania, US	Tridoute, Allegheny Forest	14	19
	Missouri, US	Tyson Reserve, Woods	15	20
	Missouri, US	Cuivre River State Park	F	24
	Missouri, US	Babler State Park	1	18
	Missouri, US	Valley View Glades	O	22
	Virginia, US	Potomac	J	22
	Florida, US	San Felasco Hammock	L	17
	Florida, US	Univ. of Florida, Horticultural Woods	N	24
	Tamaulipas, Mexico	El Cielo Biosphere Reserve	13	28
	Jalisco, Mexico	Las Joyas, Sierra de Manantlán	I	26
	Jalisco, Mexico	Cañada La Moza, Sierra de Manantlán	8	20
	Jalisco, Mexico	Quince Ocotes, Sierra de Manantlán	K	36
	Jalisco, Mexico	Ojo de Agua del Cuervo	M	31
	Veracruz, Mexico	Bosque de Guadalupe	B	34
	Chiapas, Mexico	Benito Juárez	a	23
	Chiapas, Mexico	Tenejapa	d	36
	Guatemala	Las Minas	g	41
Europe	Finland	Liesjarvi National Park	7	5
	Finland	Ruissalo	11	10
	Germany	Suderhackstedt	12	15
	Germany	Allacher Lohe	p	20
Asia	Japan	Chiba	e	37

(2004), and Vargas-Rodriguez (chapter 2) (Fig. 6). Plots sizes and shapes varied from 300 to 2400 m^2 and were 2 x 50 m transects or circular plots (Gentry 1982, Curtis and McIntosh 1951). I used the Ward's linkage method in connection with Euclidean distance measure (McCune and Grace 2002). Hierarchical methods, such as the Ward's method, find groups nested within groups, and this is represented in a dendogram. This method is based on minimizing increases in the error sum of squares. Ward's method is considered an effective tool, space-conserving, and has less propensity to chain (McCune and Grace 2002).

"Ojo de Agua del Cuervo's" Structure Characteristics. I surveyed the structural characterisitics of trees in "Ojo de Agua de Cuervo" using the circular plots previously described. In addition, I measured densities of seedlings and saplings of cloud forest sugar maple and *Podocarpus reichei* in relation to soil and canopy cover variables. I sampled seedlings and saplings of cloud forest sugar maple and *P. reichei* using the circular quadrat method and a stratified random design (Curtis and McIntosh 1951, Matteuci and Colma 1982). I sampled 10 circular plots that totaled 0.1 ha. Heights of seedlings (individuals <130 cm height) and saplings (dbh <1 cm and ≥130 cm height) were recorded. I collected a soil sample at each plot, as well as measured canopy cover using a spherical densiometer. Soil variables studied and analytic methods used are described in chapter 2. I analyzed seedling and sampling densities of cloud forest sugar maple and *P. reichei* in relation to soil variables and canopy cover using ordination (Bray & Curtis variance-regression) (Beals 1984) and regression analyses respectively. Software used was PCORD v4.0 (multivariate analyses for ecological data) (McCune and Mefford 1999).

Species Protection Status and Temperate and Montane Cloud Forest Protection Worldwide. I determined tree species protection status at "Ojo de Agua del Cuervo" using the MESA, Mexican Endangered Species Act (Diario Oficial 2002), CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2005), and RLTS, the IUCN Red List of Threatened Species (Walter and Gillett 1998). MESA considers four species categories: endangered, threatened, under special protection, and probably extinct. The species covered by CITES are listed in three appendices according to the degree of protection:

species threatened with extinction, not necessarily threatened, and protected in at least one country. Species categories included in RLTS are extinct, extinct in the wild, critically endangered, endangered, vulnerable, and lower risk. In addition, I determined which of the 110 worldwide sites used in this analysis were in some protection category, and how many of those with floristic similarities with “Ojo de Agua del Cuervo” were so protected. Through personal exploration of “Ojo de Agua del Cuervo”, its surroundings areas, and interviews with the local inhabitants I determined main current threats to the forest.

Biosphere Reserve Proposal. I created a polygon for “Ojo de Agua del Cuervo” and its surroundings to propose them as a protected area (biosphere reserve). I used cartographic maps (1:50 000) together with a 2003 LANDSAT Thematic Mapper satellite imagery (14.25 m pixel) to determinate and create vertices of buffer and core area. I used 1:50 000 thematic maps for soil types, geology, potential vegetation, and land use to determinate abiotic characteristics of the area (INEGI 1974c, 1976, 2001). The software used to georeference cartographic maps was GeoMedia v. 5.2 (Intergraph 2005).

I considered biotic and abiotic criteria to determine the polygon boundaries. Biotic criteria included vascular plant species richness, disjunct tree species, vegetation type, endangered species and ecosystems. Abiotic criteria consisted of physical features such as soil type, elevational ranges and geomorphological heterogeneity, land use, and hydrological regions (Maddock and Benn 2000, Myers et al. 2000, Cantú et al. 2004, Boon and Gaston 2005, Breceda et al. 2005). I avoided the inclusion of human population centers because human pressure tends to prevent creation of new reserves in Mexico (Cantú et al. 2004). Size and shape criteria were also taken into account. I considered a minimum surface of 10,000 ha and a minimum distance of 8 km from core area boundaries to buffer area boundaries and a circular-like shape to prevent border effect (Diario Oficial 1988, Alverson et al. 1994, Primack 2002). In addition, I followed the minimum area suggestion of 30,000 ha for some Biosphere Reserves to fulfill the requirements of the United Nations Educational, Sicentific and Cultural Organization (UNESCO) (Deutsches Nationalkommitee 1996). I organized the polygon as interrelated core and buffer zones. The core area is proposed to exclude human activity, excepting research and monitoring, thus offering long-term protection to landscapes, ecosystems and species within that core. The buffer area, which surrounds the core area, will be designated for the sustainable use of forest resources, rehabilitation of degraded areas, education, training, tourism and recreation activities (Diario Oficial 1988, UNESCO-MAB www.unesco.org/mab).

RESULTS

Species Richness and Floristic Relevance. Tree species richness differed significantly among "Ojo de Agua del Cuervo" and 14 other temperate and montane cloud forest around the world (one-way ANOVA, F=27.53, P=<0.0001) (Table 7, Fig. 5). "Ojo de Agua del Cuervo" had higher tree species richness than 12 temperate forests from North America and Europe. These forests were distributed in Ohio, Indiana, Pennsylvania, New York, and Missouri in the United States, Ontario in Canada, Finland, and Germany (Fig. 5). In Mexico, "Ojo de Agua del Cuervo" had higher species richness than montane cloud forests in Tamaulipas and Sierra de Manantlán. These last two sites also included populations of *Acer saccharum* subsp. *skutchii* (cloud forest sugar maple). A total of 43 tree species $\geq$1 cm diameter at breast height (dbh) have been documented in only 0.3 ha (31 species/0.1 ha) of "Ojo de Agua del Cuervo". In contrast, the forests containing cloud forest sugar maple in Tamaulipas and Sierra de Manantlán exhibited lower species richness, with the lowest value of 20 / 0.1 ha occurring in the forest at Sierra de Manantlán (chapter 2). However, no differences occurred in species richness among Mexican forest that include tropical elements such as those in Chiapas and Veracruz. In addition, the Japanese forest, Chiba, was not different in species richness from “Ojo de Agua del Cuervo” (Fig. 5).

Ward’s dendogram recognized seven groups with 65% of retained information. The first group was composed of sites distributed in the U.S., exclusively. This North American forests cluster pointed out differences in precipitation and latitude, and the dominance of temperate genera (Qian 1999). A second cluster consisted of a heterogeneous group with sites from the U.S., Europe, and Asia. The third group consisted of sites from the Pacific, with the exception of one that is located along the Gulf of Mexico. A fourth group was composed by the “Ojo de Agua del Cuervo” site, sites containing *Acer* and *Fagus*, and sites from Asia. This Mexican group of 11 forest sites was the only one that showed floristic similarities with forest in Japan (Chiba forest) and two forests in China (Fanjing Shan and Miao’er Shan forest) (Fig. 6). None of 63 Mexican temperate and montane cloud forest sites analyzed clustered with other Asian temperate forests (Fig. 6). The fifth group contained only sites from Cerro Grande, Sierra de Manantlán, Mexico. This group was probably separated due to its karstic soils despite the geographically short distances with other cloud forests. The sixth group consisted in sites with montane cloud forest from Oaxaca, Mexico. The last group consisted in sites from Central America (Fig. 6). More humid sites in Oaxaca, Mexico and Costa Rica containing more genera with tropical affinities were grouped.

“Ojo de Agua del Cuervo” contained most of the genera known for western montane cloud forests of Mexico, and most of them represented disjunctions between eastern Asia and North America (Vázquez-García et al. 1995, Quian and Ricklefs 2004). Such genera were represented with the species *Abies guatemalensis* subsp. *jaliscana*, *Podocarpus reichei*, *Cyathea* *costaricencis, Magnolia pacifica, Matudaea trinervia, Tilia mexicana*, *Ostrya virginiana*, and *Carpinus caroliniana*, among others.

Table 7. *P*-values for 14 sites. The sites significantly differed in tree species richness from "Ojo de Agua de Cuervo".

Country	Site	*P* value
Canada	Mt. St. Hilaire, Ontario	$P<0.0001$
USA	Bankamp State Park, Ohio	$P=0.0051$
	Cedar Bluffs, Indiana	$P=0.0277$
	Hueston Woods, beech-maple, Ohio	$P=0.0277$
	Kane, Allegheny Forest, Pennsylvania	$P=0.0277$
	Laurel Ridge, Pennsylvania	$P=0.0005$
	Tridoute, Allegheny Forest, Pennsylvania	$P<0.0001$
	Tyson Reserve, Woods, Missouri	$P=0.0123$
	Montgomery Place, New York	$P=0.0033$
Mexico	El Cielo Biosphere Reserve, Tamaulipas	$P=0.002$
	La Moza, Sierra de Manantlán	$P<0.0001$
Finland	Liesjarvi National Park	$P<0.0001$
	Ruissalo	$P=0.0002$
Germany	Suderhackstedt	$P<0.0001$

"Ojo de Agua del Cuervo's" Structure Characteristics. Tree sizes distinguished forest in "Ojo de Agua del Cuervo". *Acer saccharum* subsp. *skutchii*, *Podocarpus reichei*, *Symplocos citrea*, *Zinowiewia concinna*, *Clusia salvinii, Ostrya virginiana*, and *Quercus salicifolia* had the highest relative importance values within "Ojo de Agua del Cuervo" (chapter 2, Vázquez-García et al. 2000). Trees reached 1 m dbh in some species, such as *Acer saccharum* subsp. *skutchii*, *Tilia mexicana, Abies guatemalensis* var. *jaliscana,* and *Podocarpus reichei* (chapter 2).

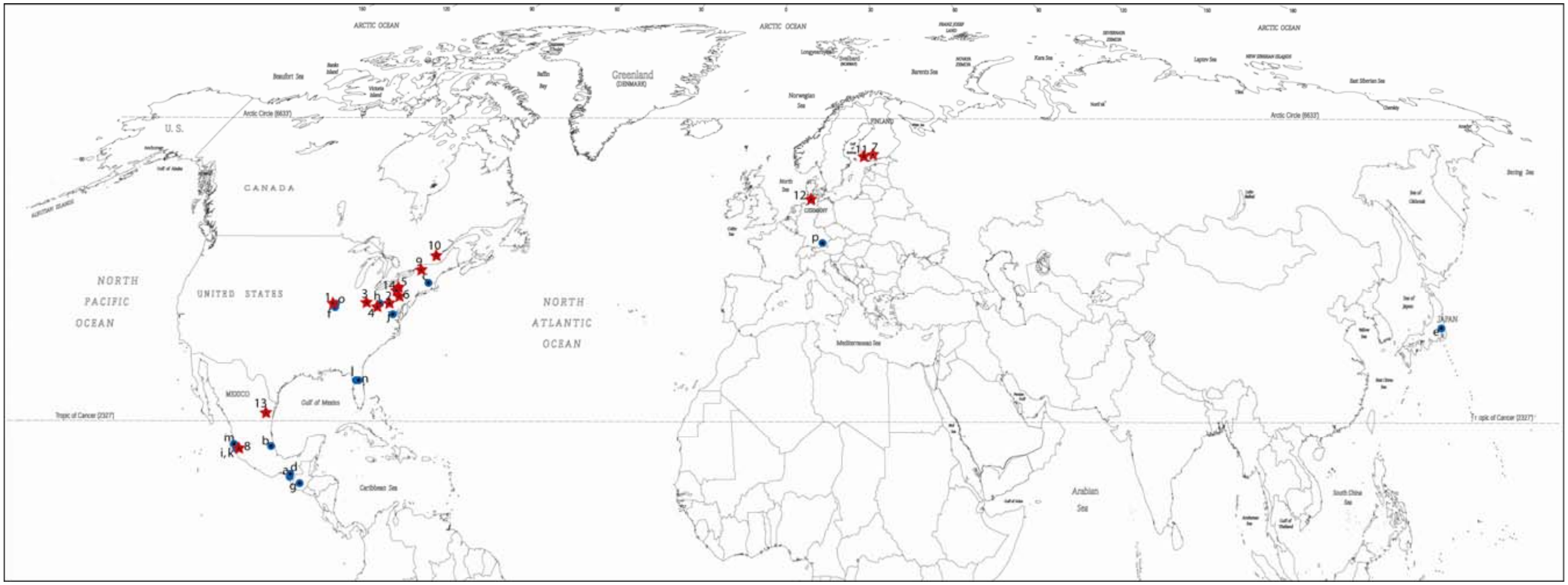


Figure 5. Sites with significant differences (★) and no significant differences (●) in species richness with "Ojo de Agua del Cuervo". 2. Bankamp State Park, Ohio. 3. Cedar Bluffs, Indiana. 4. Hueston Woods, beech-maple, Ohio. 5. Kane, Allegheny Forest, Pennsylvania. 6. Laurel Ridge, Pennsylvania. 7. Liesjarvi National Park, Finland. 8. La Moza, Sierra de Manantlán, Mexico. 9. Montgomery Place, New York. 10. Mt. St. Hilaire, Ontario, Canada. 11. Ruissalo, Finland. 12. Suderhackstedt, Germany. 13. El Cielo Biosphere Reserve, Tamaulipas, Mexico. 14. Tridoute, Allegheny Forest, Pennsylvania. 15. Tyson Reserve, Woods, Missouri. See table 1 for number and letters

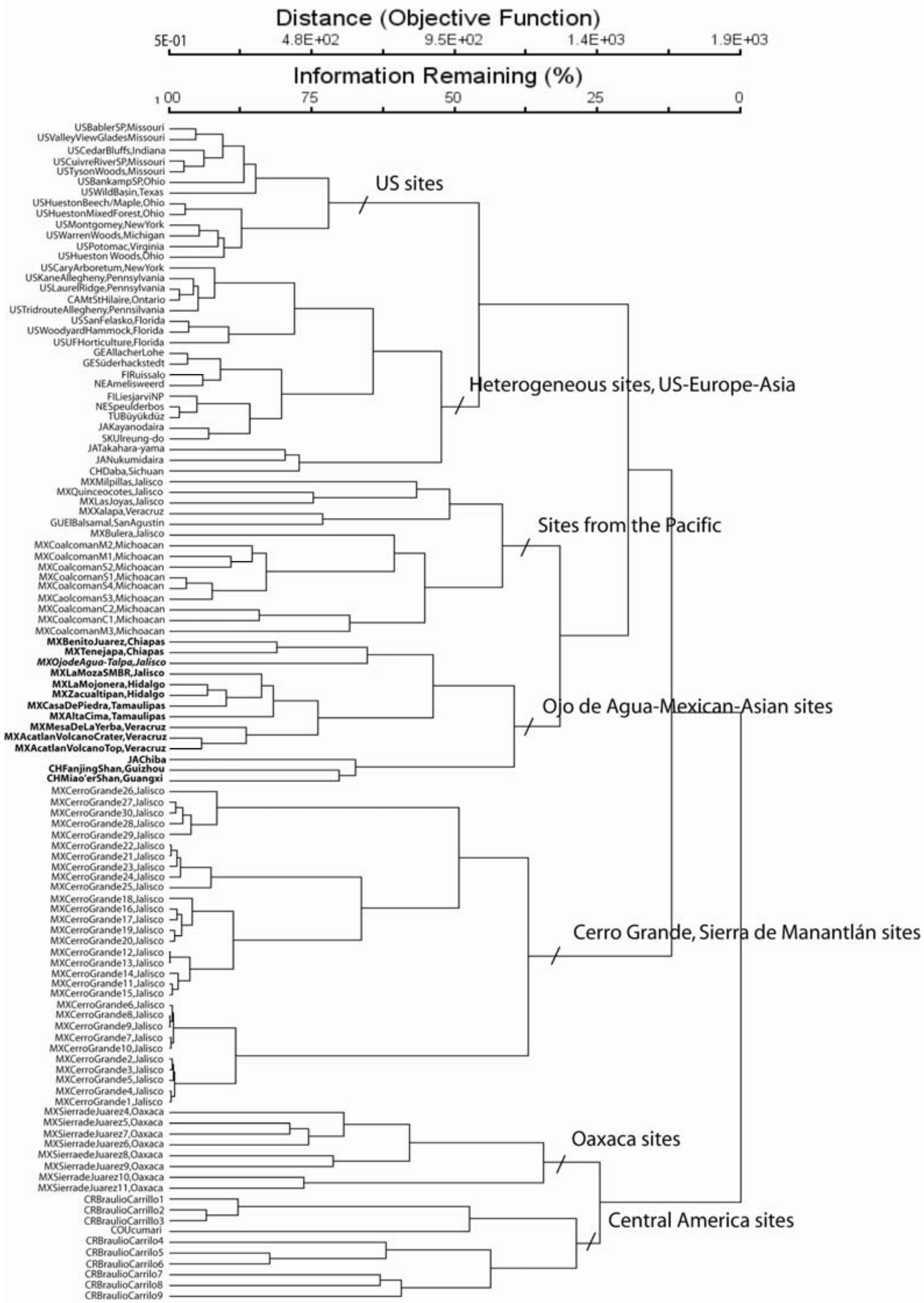


Figure 6. Classification of temperate and montane cloud forests communities based on generic composition. Cluster including "Ojo de Agua del Cuervo" is in bold, the forest is distinguished with bold italics. First initials indicate the country, followed by the locality name and in some cases the state name at the end in shown. CH is China, CO is Colombia, CR is Costa Rica, FI is Finland, GE is Germany, GU is Guatemala, JA is Japan, MX is Mexico, NE is Netherlands, SK is South Korea, TU is Turkey, and US is United States.

Densities of seedlings and saplings of cloud forest sugar maple and *Podocarpus reichei* are high in “Ojo de Agua del cuervo”. Size-class distributions of seedlings and saplings for both resemble an inverted-J distribution, suggesting successful establishment and growth throughout the different size classes to the largest trees (chapter 2, Vargas-Rodriguez and Vázquez-García 2001). Observations indicate that other species, such as *Magnolia pacifica*, *Tilia mexicana*, and *Juglans major,* also appear to be regenerating.

Bray & Curtis ordination recovered three axes for seedling and sapling densities of cloud forest sugar maple and *Podocarpus reichei*. Cumulative variance of three axes was 92%. Variation in axis 1 was associated with Ca+Mg ($r=0.816$, $df=8$, $p<0.01$), Ca ($r=0.842$, $df=8$, $p<0.01$). Variation in axis 2 was associated with K ($r=-0.866$, $df=8$, $p<0.01$) and ion exchange capacity ($r=0.832$, $df=8$, $p<0.01$). Regression analysis showed a significant negative relationship between seedling density of *P. reichei* and canopy cover ($r=-0.6280$, $df=8$, $p<0.1$).

Species Protection Status and Temperate and Montane Cloud Forest Protection Worldwide. Thirteen tree species from “Ojo de Agua del Cuervo” were included in MESA, CITES, or RLTS. Eleven species (26% from total tree richness) were included in MESA, 14% with endangered, 7% threatened, and 5% under special protection. *Acer saccharum* subsp. *skutchii*, *Zinowiewia concinna, Cyathea costaricensis, Litsea glaucescens, Abies guatemalensis* var. *jaliscana* and *Tilia mexicana* were considered endangered according to MESA. *Carpinus caroliniana* and *Matudaea trinervia* were threatened, and *Saurauia serrata* and *Ostrya virginiana* were under the special protection category. Appendix I of CITES included *Abies guatemalensis* var. *jaliscana* as threatened with extinction. Hence, trade of specimens of this species is permitted only in exceptional circumstances. In addition, the RLTS included *Abies guatemalensis* var. *jaliscana* under the vulnerable category; the species is facing a high risk of extinction in the wild in the medium-term future. RLTS also classified *Cornus disciflora* and *Quercus uxoris* as vulnerable and *Saurauia serrata* as an endangered species.

Of the 110 temperate and cloud forest sites analyzed worldwide for similarities in generic composition, 89% had some protection status. The majority of protected sites were included in the State Park category, but there were four biosphere reserves. Two of these biospheres reserves were located in Mexico, one in Guatemala and the fourth in Canada. The El Cielo Biosphere Reserve protects an important population of cloud forest sugar maple and *Fagus grandifolia* var. *mexicana*, however, it is not recognized at the Mexican Federal level (Cantú et al. 2001). In this sense, montane cloud forests are not suitably protected in Mexico.

Biosphere Reserve Proposal. I created a polygon for "Ojo de Agua del Cuervo" and its surroundings to propose the zone that would be protected under the biosphere reserve category. The total area, 56,394.9 ha, consisted of one core area of 6,759.7 ha (12 %) and a buffer area of 49,635.2 ha (88 %) (Fig. 7). "Ojo de Agua del Cuervo" was included in the core area. The core area would preserve disjunct and endangered species as well as pine, fir, oak, tropical, and montane cloud forests. In addition, the important hydrologic watersheds for Talpa de Allende will be protected within the biosphere reserve. Vertices for the buffer area were 11 and seven for core area (Table 8).

The proposed biosphere reserve occupies the steep foothills of Sierra de Cacoma, in the Sierra Madre del Sur, western Jalisco. The area included four *municipios*, Talpa de Allende, Tomatlán, Mascota, and Cuautla. Approximately 70% of the polygon was located in Talpa de Allende *municipio*. Main rivers were rio Talpa, rio Mascota, rio San Nicolás, and rio La Quebrada. Arroyo Los Tepehuajes and Paso Hondo were tributaries of rio Talpa. At the north of the polygon were arroyo El Zacatón, arroyo La Huerta, and arroyo Mirandilla, the last two were tributaries of rio Mascota. Arroyo Tescalama, arroyo La Quebrada, rio San Nicolás, and rio La Quebrada were located at the south–south west of the polygon. Elevation ranged from 500 to

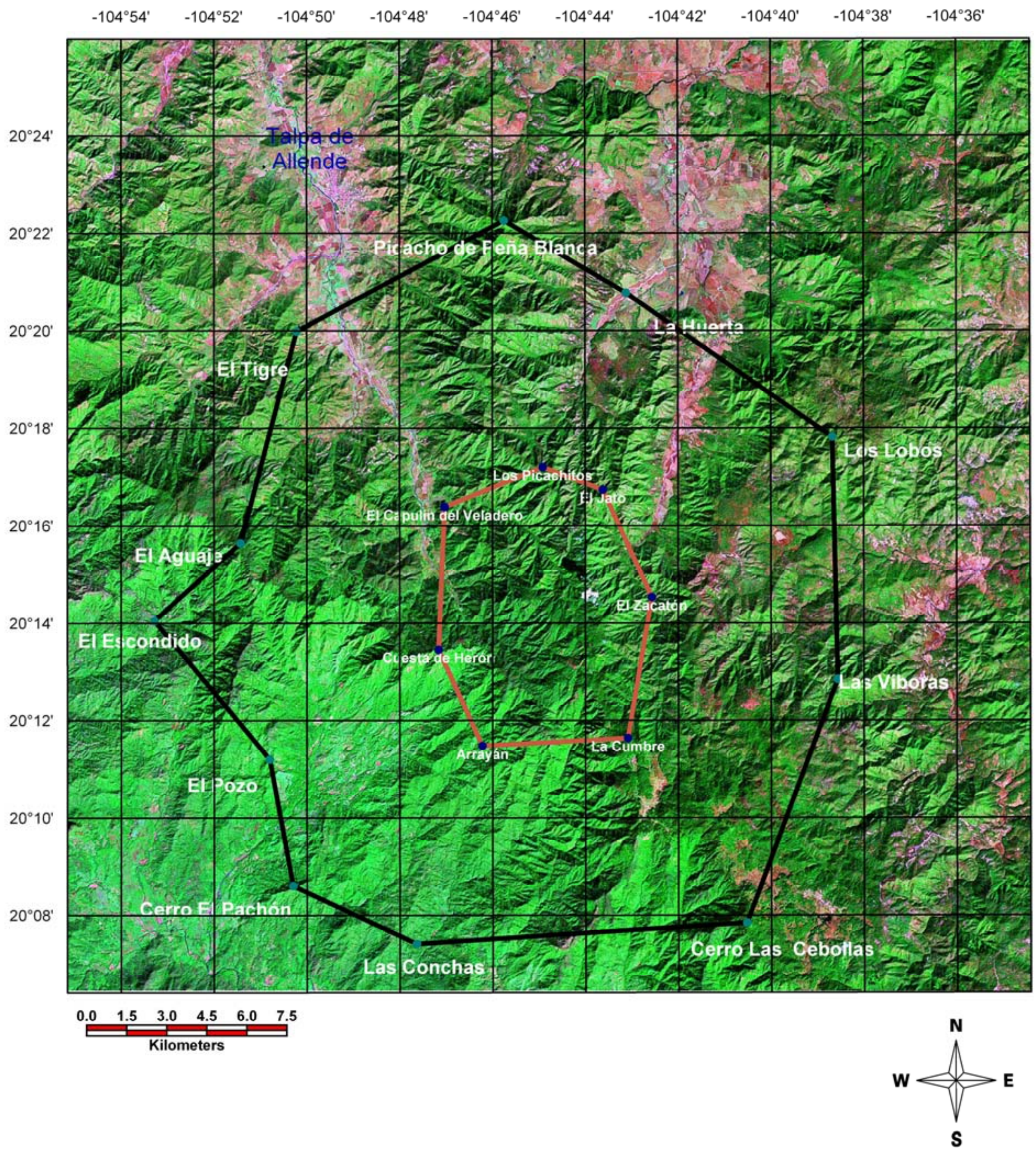


Fig. 7. Proposed biosphere reserve polygon in “Ojo de Agua del Cuervo”, Talpa de Allende, Jalisco, Mexico. Red line represents the core area boundary and black line represent the buffer area boundary.

Table 8. Vertices and their geographic coordinates for the proposed biosphere reserve in “Ojo de Agua del Cuervo”, Talpa de Allende, Mexico.

Zone	Vertex name	Latitude	Longitude
Buffer area	Cerro Las Cebollas	104º40”30.854’	20º7”51.887’
	Las Conchas	104º47”37.311’	20º7”26.107’
	Cerro El Pachón	104º50”16.694’	20º8”37.423’
	El Pozo	104º50”47’03’	20º11”12.469’
	El Escondido	104º53”15.926’	20º14”2.515’
	El Aguaje	104º51”24.586’	20º15”37.656’
	El Tigre	104º50”12.159’	20º19”57.067’
	Picacho de Peña Blanca	104º45”44.125’	20º22”13.0’
	La Huerta	104º43”6.316’	20º20”44.426’
	Los Lobos	104º38”40.069’	20º17”47.706’
	Las Víboras	104º38”33.076’	20º12”50.406’
Core area	Los Picachitos	104º44”54.107’	20º17”10.556’
	El Jato	104º43”36.575’	20º16”42.763’
	El Zacatón	104º42”33.474’	20º14”31.155’
	La Cumbre	104º43”4.323’	20º11”38.427’
	Arrayán	104º46”12.364’	20º11”29.039’
	Cuesta de Herón	104º47”9.095’	20º13”26.862’
	El Capulín del Veladero	104º47”1.046’	20º16”22.086’

2400 m a.s.l. in the polygon. Acidic extrusive rocks from mid Cenozoic and acidic intrusive rocks from Tertiary were prevalent in the area. Common soils included shallow, well drained lime soils (dystrict Regosol, eutric Regosol), as well as some lime secondary soils such as haplic Phaeozem. In addition, some sandy soils (Fluvisol), Lithosols and dystric, humic, and eutric Cambisols occurred (INEGI 1974c, 1975, 1976, 2001).

DISCUSSION

“Ojo de Agua del Cuervo’s” species richness is comparable to some Asian forests. Although temperate forests from eastern Asia are richer in tree species than similar forests in eastern North America (Latham and Ricklefs 1993, Qian 1999), they do not exhibit higher richness than “Ojo de Agua del Cuervo” forest. “Ojo de Agua del Cuervo” forest contains tropical elements in addition to temperate, which produces increased species richness. Therefore, “Ojo de Agua del Cuervo” forest is as species rich as those in Asia, which are considered to have an ancient floristic composition and extreme physiographical heterogeneity (Qian and Ricklefs 2000).

The classification of temperate and montane cloud forest tree communities based on their generic composition shows that “Ojo de Agua del Cuervo” is floristically related with those forests in Mexico and Asia that contain disjunct genera (Fig. 6). Similarities with other Mexican forest might be based on tropical genera shared with the forest in Chiapas (Benito Juárez), a locality close to El Triunfo Biosphere Reserve, established for protection of a highly diverse montane cloud forest. Temperate genera are also present in Tenejapa forest, sharing with “Ojo de Agua del Cuervo” genera such as *Acer*. In addition, “Ojo de Agua del Cuervo” clusters with forests in east Mexico, which contain disjunct species such as *Fagus grandifolia* var. *mexicana*. This cluster appears to contain forests with an ancient composition. The cluster was consistent with those found in an ordination analysis (chapter 2). Therefore, the unique forest in “Ojo de Agua del Cuervo” needs a protected status.

The tree community in “Ojo de Agua del Cuervo”includes an array of endangered species. Cloud forest sugar maple is considered by MESA because its fragmented distribution across Mexico and low stem densities occuring at most known sites. However, the species must also be included in the RLTS (chapter 2). Currently, only *Abies guatemalensis* var. *jaliscana* is listed in the Mexican Species Act, CITES, and RLTS as endangered. Based on the criteria used to assign protection categories, species such as *Mangnolia pacifica* var. *pacifica* and *Osmanthus americana* should be considered as vulnerable (RLTS) or threatened (MESA).

Soil variables are more important than canopy cover for cloud forest sugar maple establishment in “Ojo de Agua del Cuervo”. Availability of Ca, Mg, and K might affect seedling and sapling survival since these variables are related to photosynthesis and apical dominance. Mn has been demonstrated to affect sugar maple density (Schier & McQueattie 2000). In addition to soil variables, light is related to *P. reichei* density. Shade condition in the understory is important for establishment and persistant of this species. Thus, fragmentation and its border effect might have an important influence on cloud forest sugar maple and *P. reichei* regeneration.

The montane cloud forest community in “Ojo de Agua del Cuervo” is susceptible to disturbance and fragmentation effects. Cloud forest sugar maple and *P. reichei* seedlings establish in the low light environment present in the understory, and their numbers decrease with increased light levels along forest edges (Vargas-Rodriguez and Vázquez-García 2001). In addition, soil and environmental moisture conditions change along forest edges, reducing survival of seedlings of several other tree species restricted to montane cloud forest (Gascon et al. 2000). Therefore, deforestation, which is taking place in surrounding areas, and associated edge effects may well change environmental conditions in montane cloud forests, diminishing tree germination and establishment (Williams-Linera 2002).

Deforestation, illegal logging and the attempt to create new roads are the major threats at “Ojo de Agua del Cuervo”. Logging of *Abies guatemalensis* var. *jaliscana* occurs frequently in the area, although the species is included in the MESA, CITES, RLTS and has an endemic status. Deforestation in an extensive area surrounding “Ojo de Agua del Cuervo” is also occurring. In addition, species such as the arborescent fern, *Cyathea costarricencis* has been extracted illegally for commercial purposes. Finally, a new road has been proposed to connect Talpa de Allende and Llano Grande towns cutting through the adjacent montane cloud forest. This road might decrease species conectivity by preventing larger and cohesive protected zones. An increase in isolation among the forest and other adjacent areas and subsequent reduction in the reserve network might prevent the preservation of wide-ranging species movements (Crist et al. 2005).

The creation of a new biosphere reserve in western Mexico will allow a flora and fauna corridor between two others protected areas. Connection with Chamela-Cuixmla and Sierra de Manantlán Biosphere Reserves in western Mexico might be possible, creating a network of protected areas for the region. Tropical dry forest at Chamela-Cuixmala can be connected to tropical forest at the southern portion of the proposed polygon, while temperate and montane cloud forest could be able to connect with Sierra de Manantlán through Sierra de Cacoma.

The majority of the studied sites in Mexico do not have any protection status. These include the highly diverse montane cloud forest in Oaxaca, the relict populations of *Fagus grandiflora* var. *mexicana* from Veracruz and Hidalgo states and “Ojo de Agua del Cuervo”. The proposed biosphere reserve increases the protected surface of an endangered ecosystem. Mexico has 150 federally administrated Natural Protected Areas, representing 9.1% (17’904,000 ha) of the country (CONANP 2002). The proposed biosphere represents 0.7 % and 0.03 % of Jalisco state and Mexico territories respectively. The biosphere reserve polygon increases the montane cloud forest, pine and oak forest surfaces that are currently underrepresented by the Mexican natural protected system (Cantú et al. 2001, 2004). Intermediate elevations (<3,000 m) with montane cloud forest and high productive soils are the primary gaps in the current Mexican protected areas system (Cantú et al. 2004). The opposite is true for areas located in elevations from 0-500 m (Cantú et al. 2004). At the state level, Sierra de Manantlán Biosphere Reserve is the only biosphere reserve preserving montane cloud forest (2,066 ha, 0.025% Jalisco surface) (INE 2000). I estimate that a similar area of montane cloud forest will be protected in "Ojo de Agua del Cuervo".

The hydrologic region of Talpa de Allende can also be protected. Montane cloud forests have an important role stabilizing water quality and maintaining natural flow patterns of the streams and rivers originating from them (Bubb et al. 2004). The montane cloud forest has the unique additional value of capturing water from the condensation from clouds and fog. The amount of water intercepted by the vegetation in montane cloud forests can be 15 – 20 % of the amount of direct rainfall (Bubb et al. 2004). This is relevant to the Mexican Pacific slopes where rainfall and water availability throughout the year are lower than on the Atlantic slopes.

"Ojo de Agua del Cuervo" is eligible for long term protection. In an unprecedented initiative, 3,000 inhabitants of Talpa de Allende signed a protection proposal for cloud forest sugar maple in 2002. Through Jalisco State legislators, the proposal was sent to the Federal Mexican authorities in October 2002 and reviewed by Federal legislators in November 2004, but no response has been received yet. I urge Federal Mexican authorities to protect the zone under the Biosphere Reserve category, to ensure the protection and conservation of species-rich montane cloud forest in "Ojo de Agua del Cuervo" in Talpa de Allende.

The support of conservation agencies and organizations is needed to encourage Mexican authorities to provide a protected status to the area. In addition, botanists, zoologists, ecologists, geographers, and sociologists should study and describe the area to generate a management plan together with local communities. It is necessary to develop tools, such as geographic information systems (GIS) to help reach the reserve objectives. GIS will support management, monitoring and communication among the actors of the reserve. In addition, GIS, through gap analysis, can be used to identify gaps in the reserves networks of Jalisco state, predicting potential biodiversity at landscape level (Prendergast et al. 1999). Environmental diversity data has to be incorporated to identify rare species, vegetation types or endemic species with special environmental characteristics of their habitats (Bonn and Gaston 2005). Specific research and conservation priorities for montane cloud forest are biodiversity inventories, quantification of hydrological properties of montane cloud forest at watershed scale, research on the effects of fragmentation and means of ecological restoration (Bubb 2004). In addition, the creation of a Scientific Station inside the reserve would provide support for research, environmental monitoring, education and training, fulfilling with this, one of the MAB-UNESCO biosphere reserve objectives.

Unique and relictual biodiversity elements of “Ojo de Agua del Cuervo” forest, together with its regional hydrologic importance, the presence of charismatic species such as the cloud forest sugar maple, and a characteristic foggy-landscape in the area make the forest deserve a Biosphere Reserve status.

Concluding Remarks. “Ojo de Agua del Cuervo” has an important relict population of cloud forest sugar maple in Mexico and Guatemala. The montane cloud forest is unique in having high plant tree species richness and a number of endangered plants, compared only with those containing ancient species from Asia. “Ojo de Agua del Cuervo” is floristically related at the generic level to forests in Asia and with those in Mexico containing Tertiary tree species relicts. Tree structural characteristics from “Ojo de Agua del Cuervo” suggest that it is an old growth forest. High tree, seedlings, and saplings densities of cloud forest sugar maple occur in a wide range of height categories. Specific soil nutrient requirements and shade conditions for seedling establishment of cloud forest sugar maple and *P. reichei* respectively, raises concern of border effect and human disturbance taking place in the surroundings. I propose a 56,394.9 ha Biosphere Reserve that includes “Ojo de Agua del Cuervo” and its surroundings. The forest is part of the Mesoamerica hotspot (Myers et al. 2000). The proposal, is based, in part, on the diversity and relict tree values of “Ojo de Agua del Cuervo” in a continental context, an approach that has not been used before in the establishment of Biosphere Reserves in western Mexico. Therefore, “Ojo de Agua del Cuervo” deserves protection status.

CHAPTER 4

CONCLUSIONS

There are five disjunct populations of cloud forest sugar maple (*Acer saccharum* subsp. *skutchii*) in Mexico and Guatemala. The populations are widely separated along north, central, and south Mexico and north Guatemala. Botanical explorations have yet to be conducted in Sierra Madre del Sur, Mexico, as well as Sierra de las Minas, Guatemala, where other populations possibly exist.

The five cloud forest sugar maple populations co-occur with 73% of the disjunct temperate tree genera from North America. The proportion decreased toward southern sites, where tropical elements become dominants. Generic composition along North and Central America of temperate and cloud forest sites follows a gradient in latitude and precipitation. The NMS ordination and Ward's classification distinguished a group mainly distributed in central Mexico. The group includes the cloud forest sugar maple populations together with forest from Tamaulipas, Hidalgo, and Veracruz. These sites include species of *Fagus*, *Liquidambar*, *Magnolia*, and *Matudea*, for instance, suggesting that the sites are remnants with an ancient floristic composition. These forests might resemble the forest composition before major climatic changes in the Pleistocene. Furthermore, cloud forest sugar maple populations from western Mexico ("Ojo de Agua del Cuervo", Talpa de Allende) are related to those with an ancient floristic composition from Asia, and have no significant differences in tree species richness.

Acer saccharum subsp. *skutchii* is an important element in the forest canopy. In Mexico, it is a co-dominant element, while in Guatemala it is a dominant element in the canopy. Montane cloud forest trees from the genera *Alnus, Carpinus, Cornus, Liquidambar, Podocarpus*, and *Zinowiewia* are dominant or co-dominant along the five sites studies.

Three densities in the five cloud forest sugar maple populations might be related to soil and light variables. Calcium, magnesium, pH, and soil texture and moisture were related to tree densities, while establishment of species such as *Podocarpus reichei* is related to shade conditions in the understory. Canopy gaps could be the result of differences in tree fall regimes created by differences in hurricane frequency, allowing different light conditions in the understory. Maintenance of montane cloud forest tree species might be determinated by soil variables and canopy gaps resulting from different hurricane regimes along the sites.

Three of the five populations are included in biosphere reserves. Species protection in Sierra de Manantlán and El Cielo Biosphere Reserve is assured. However, in Sierra de las Minas Biosphere Reserve, Guatemala, the species occurs at low densities, suggesting possible inbreeding depression. In addition, cattle grazing and wood extraction are major threats for this population. I found similar conditions in the Tenejapa population. Therefore, the southernmost cloud forest sugar maple populations are endangered and need conservation and restoration measures.

Different conservation measures can be applied to cloud forest sugar maple. The species has yet to be included to the IUCN Red List and as Endangered in the Guatemalan Species Red List. A new biosphere reserve in “Ojo de Agua del Cuervo” cloud forest sugar maple population, Jalisco, Mexico needs to be established. I propose 56,394.9 ha as protected area, with a core area of 6,759.7 ha and a buffer area of 49,635.2 ha. The proposal is based on biotic and abiotic values of the zone. Biotic values are evaluated in a worldwide context.

REFERENCES

Agricultural Experiment Stations. 1998. Recommended Chemical Soil Test Procedures. North Central Regional Research Publications 221. USA.

Alcántara O., Luna-Vega I., and Velásquez A. 2002. Altitudinal distribution patterns of Mexican cloud forest based upon preferential characteristic genera. Plant Ecology 161: 167-174.

Allendorf F.W. and Ryman N. 2002. The role of genetics in population viability analysis. In: Beissinger S.R., McCullough D.R. (eds.). Population Viability Analysis. University of Chicago Press, Chicago and London. 50-85 pp.

Alverson W.S., Kuhlmann W., and Waller D.M. 1994. Wild forest. Conservation biology and public policy. Island Press, Covelo, California.

AOAC International. 1990. Official methods of analysis. Volume I. Association of official analytical chemists. 15th Ed. Maryland, USA.

APHA-AWWA-WPCF. 1992. Standard methods for the examination of water and wastewater. 18th Ed. American Public Health Association, Washington, USA.

Arii K. and Lechowicz M. J. 2002. The influence of overstory trees and abiotic factors on the sapling community in an old-growth *Fagus-Acer* forest. Ecoscience 9:386-396.

Arriaga L. 1988. Gap dynamics of a Tropical Cloud Forest in Northeastern Mexico. Biotropica 20: 178-184.

Arriaga L. 2000. Types and causes of tree mortality in a tropical montane cloud forest of Tamaulipas, Mexico. Journal of Tropical Ecology 16: 623-636.

Axelrod D.I. 1975. Evolution and biogeography of Madrean-Tethyan sclerophyll vegetation. Annals of the Missouri Botanic Garden 62: 280-334.

Bailey S.W., Horsley S.B, Long R.P., and Hallett R.A. 2004. Influence of edaphic factors on sugar maple nutrition and health on the Allegheny Plateau. Soil Science Society of America Journal 68: 243-252.

Bartlett R.M., Matthes-Sears U., and Larson D.W. 1991. Microsite- and are-specific processes controlling natural populations of *Acer saccharum* at cliff edges. Canadian Journal of Botany 69: 552-559.

Beals E.W. 1984. Bray-Curtis ordination: an effective strategy for analysis of multivariate ecological data. Advances in Ecological Research 14: 1-55.

Beaudet M., Messier C., Paré D., Brisson J., and Bergeron Y. 1999. Possible mechanisms of sugar maple regeneration failure and replacement by beech in the Boisé-des-Muir old growth forest, Québec. Ecoscience 6:264-271.

Bertrand A., Robitaille G., Boutin R., and Nadeau P. 1995. Growth and ABA responses of sugar maple seedlings to aluminum. Tree Physiology 15: 775-782.

Bigelow S.W. and Canham C.D. 2002. Community organization of tree species along soil gradients in a north-eastern USA forest. Journal of Ecology 90: 188-200.

Bonn A. and Gaston K. 2005. Capturing biodiversity: selecting priority areas for conservation using different criteria. Biodiversity and Conservation 14: 1083-1100.

Boyle B.L. 1996. Changes on altitudinal and latitudinal gradients in neotropical montane forest. Ph. D. dissertation, Washington University, St. Louis, Missouri, USA. 275 pp.

Breceda A., Arriaga L., Bojórquez L., and Rodríguez M. 2005. Defining critical areas for conservation and restoration in a Mexican biosphere reserve: a case study. Natural Areas Journal 25: 123-129.

Breedlove D.E. 1986. Listados florísticos de México. IV Flora de Chiapas. California Academy of Sciences, San Francisco, California, USA.

Breemen N.van, Finzi A.C., and Canham C.D. 1997. Canopy tree-soil interactions within temperate forests: effects of soil elemental composition and texture on species distributions. Canadian Journal of Forest Research 27: 1110-1116.

Brizicky G.K. 1963. The genera of Sapindales in the southeastern United States. Journal of the Arnold Arboretum 44: 462-501.

Bubb P., May I., Miles L., and Sayer J. 2004. Cloud forest agenda. UNEP-WCMC, Cambridge, UK. 34 pp.

Burns R.M. and Honkala B.H. 1990. Silvics of North America: 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. 877 pp.

Burton A.J., Pregitzer K.S., Zogg G.P., and Zak D.R. 1998. Drought reduces root respiration in sugar maple forests. 1998. Ecological Applications 8: 771-778.

Cantú C., Scott J.M., and Wright R.G. 2001. The gap analysis program on the assessment of nature reserves of Mexico. GAP analysis bulletin 10: 8-10.

Cantú C., Wright R.G., Scott J.M., and Strand E. 2004. Assessment of current and proposed nature reserves on Mexico based on their capacity to protect geophysical features and biodiversity. Biological Conservation 115: 411-417.

Caspersen J.P. and Kobe R.K. 2001. Interspecific variation in sapling mortality in relation to growth and soil moisture. Oikos 92: 160-168.

CETENAL. 1975. Carta geológica, escala 1:50 000. Instituto Nacional de Estadística, Geografía e Informática, México.

CETENAL. 1976. Carta edafológica, escala 1:50 000. Instituto Nacional de Estadística, Geografía e Informática, México.

Challenger A. 1998. Utilización y conservación de los ecosistemas terrestres de México. Pasado, presente y futuro. CONABIO, UNAM, Sierra Madre. México, D.F. 813 pp.

CITES. 2005. Convention on International Trade in Endangered Species of Wild Fauna and Flora, Appendices I, II and III. Geneva, Switzerland. 48 pp.

CONAP. 2001. Consejo Nacional de Áreas Protegidas. Lista Roja de Flora de Guatemala. Guatemala, Guatemala. 39 pp.

CONANP. 2002. Comisión Nacional de Áreas Naturales Protegidas. Perspectivas y logros. Informe técnico en el 11º Aniversario. Secretaría de Medio Ambiente y Recursos Naturales, México.

Crist M., Wilmer B., and Aplet G.H. 2005. Assessing the value of roadless areas in a conservation reserve strategy: biodiversity and landscape connectivity in the northern Rockies. Journal of Applied Ecology 42: 181-191.

Curtis J.T. 1959. The vegetation of Wisconsin. University of Wisconsin Press, Madison.

Curtis J.T. and McIntosh R.P. 1951. An upland forest continuum in the prairie forest border region of Wisconsin. Ecology 32: 476-496.

Deutsches Nationalkomitee für das UNESCO-Programm MAB. 1996. Kriterien für Anerkennung und Überprüfung von Biosphärenreservaten der UNESCO in Deutschland. Hrsg.: Deutsches Nationalkomitee für das UNESCO-Programm, Der Mensch und die Biosphäre (MAB, Bundesamt für Naturschutz. Red.: Stefan Weidenhammer).

Diario Oficial. 1988. Ley general del equilibrio ecológico y la protección al ambiente. Secretaria de Medio Ambiente y Recursos Naturales. México, D. F.

Diario Oficial. 2002. Norma Oficial Mexicana NOM-059-ECOL-2001. Protección ambiental-especies nativas de México de flora y fauna silvestres-categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-lista de especies en riesgo. Secretaria de Medio Ambiente y Recursos Naturales. México, D. F.

Dijkstra F.A. and Smits M.M. 2002. Tree species effects on calcium cycling: The role of calcium uptake in deep soils. Ecosystems 5: 385-398.

Dodge S.L. 1997. Successional trends in a mixed oak forest on High Mountain, New Jersey. Journal of the Torrey Botanical Society 124: 312-317.

Drohan P.J., Stout S.L., and Petersen G.W. 2002. Sugar maple (*Acer saccharum* Marsh.) decline during 1979-1989 in northern Pennsylvania. Forest Ecology and Management 170: 1-17.

Duchesne L., Ouimet R., and Houle D. 2002. Basal area growth of sugar maple in relation to acid deposition, stand health, and soil nutrients. Journal of Environmental Quality 31: 1676-1683.

Ellsworth D.S. and Reich P.B. 1992. Water relations and gas-exchange of *Acer saccharum* seedlings in contrasting natural light and water regimes. Tree physiology 10: 1-20.

Faith D.P., Minchin P.R., and Belbin L. 1987. Compositional dissimilarity as a robust measure of ecological distance. Vegetatio 69: 57-68.

Foster D.R., Aber J.D., Melillo J.M., Bowen R.D., and Bazzaz F.A. 1997. Forest response to disturbance and anthropogenic stress. BioScience 47: 437-445.

Fundación Defensores de la Naturaleza. 2002. Plan maestro 1997-2002, Reserva de la Biósfera Sierra de Minas. Guatemala. 80 pp.

Furlow J.J. 1987. The *Carpinus caroliniana* complex in North America. II. Systematics. Systematic Botany 12: 416-434.

Gascon C., Williamson G.B., and da Fonseca G.A.B. 2000. Receding forest edges and vanishing reserves. Science 5470:1356-1358.

Gelderen D.M.van, de Jong P.C., and Oterdoom H.J. 1994. Maples of the World. Timber Press, USA.

Gentry A.H. 1982. Patterns of neotropical plant species diversity. Evolutionary Biology 15: 1-84.

Gentry A.H. 2001. Patrones de diversidad y composición florística en los bosques de las montañas neotropicales. In: Kappelle M., Brown A. (eds.). Bosques nublados del neotrópico. Instituto Nacional de Biodiversidad, INBIO, Costa Rica. 125-154 pp.

Godman R.M., Yawney H.W., and Tubbs C.H. 1990. *Acer sacchraum* Marsh sugar maple. In: Burns R.M., Honkala B.H. (technical coordinators). Silvics of North America. Vol. 2. Hardwoods Agric. Handb. 654. Washington, DC. U.S. Department of Agriculture, Forest Service. 78-91 pp.

Graham A. 1993. Historical factors and biological diversity in Mexico. In: Ramamoorthy T.P., Bye R., Lot A., Fa J. (eds.). Biological diversity of Mexico, origins and distribution. Oxford University Press, Oxford. 109-127 pp.

Graham A. 1999a. Late Cretaceous and Cenozoic history of North American Vegetation. Oxford University Press, New York.

Graham A. 1999b. The Tertiary history of the northern temperate element in the northern Latin America biota. American Journal of Botany 86: 32-38.

Greenidge K.N.H. 1961. Patterns of distribution of sugar maple, *Acer saccharum* Marsh., in Northern Cape Breton Island. American Midland Naturalist 66: 138-151.

Hernandez-Xolocotzi E., Crum H., Fox W.B., and Sharp A.J. 1951. A unique vegetational area in Tamaulipas. Bulletin Torrey Botanic Club 78: 458-463.

Holmgren P.K., Holmgren N.H., and Barnett L.C. 1990. Index herbariorum. Part I. Regnum Vegetation 120: 1-693.

Holmgren P.K., and Holmgren N.H. 1993. Additions to the Index Herbariorum (herbaria). Taxon 42: 496-497.

Horsley S.B., Long R.P., Bailey S.W., Hallett R.A., and Hall T.J. 2000. Factors associated with the decline disease of sugar maple on the Allegheny Plateau. Canadian Journal of Forest Research 30: 1365-1378.

Horsley S.B., Long R.P., Bailey S.W., Hallett R.A., and Wargo P.M. 2002. Health of eastern North America sugar maple forests and factors affecting decline. Northern Journal of Applied Forestry 19: 34-44.

INE. 2000. Programa de manejo de la Reserva de la Biosfera Sierra de Manantlán, México. Instituto Nacional de Ecología, México, DF. 203 pp.

INEGI. 1974a. Carta edafológica E13-D81, escala 1:50 000. SPP-INEGI, México.

INEGI. 1974b. Carta geológica E13-D81, escala 1:50 000, SPP-INEGI, México.

INEGI. 1974c. Carta geológica F-13-D-81, escala 1:50,000, SPP-INEGI, México.

INEGI. 1976. Carta de uso potencial Carta F-13-D-71, escala 1:50,000, SPP-INEGI, México.

INEGI. 1993. Carta edafológica E15-11, escala 1:250 000, SPP-INEGI, México.

INEGI. 1999. Carta geológica E15-11, escala 1:250 000, SPP-INEGI, México.

INEGI. 2001. Carta topográfica F-13-D-71, escala 1:50,000, SPP-INEGI, México.

Intergraph. 2005. GeoMedia v. 5.2 Software. Huntsville, Al, US.

Islebe G.A. and Véliz-Pérez M.E. 2001. Guatemala. In: Kappelle M., Brown A. (eds.). Bosques nublados del neotrópico. Instituto Nacional de Biodiversidad, INBIO, Costa Rica. 231-242 pp.

Iturralde-Vinent M. 2003. A brief account of the evolution of the Caribbean seaway: Jurassic to Present. In: Prothero D., Ivany L., Nesbitt E. (eds.). From Greenhouse to Icehouse: The Marine Eocene-Oligocene Transition. Colombus University Press, New York. 386-396 pp.

IUCN 2001. The IUCN Red List Categories and Criteria: Version 3.1. International Union for Conservation of Nature and Natural Resources, Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. 30 pp.

Jardel E., Cuevas R., Santiago A., Muñoz E., and Aragon J. 1996. Nueva localidad y características de la población de *Acer skutchii* Rehder en la sierra de Manantlan, Jalisco, México. Acta Botánica Mexicana 35: 13-24.

Kappelle M. and Brown A.D. 2001. Bosques Nublados del Neotrópico. Costa Rica: Instituto Nacional de Biodiversidad.

Kruskal J.B. 1964. Nonmetric multidimensional scaling: a numerical method. Psychometrika 29: 115-129.

Lambert J.D.H. and Maycock P.F. 1968. The ecology of terricolous lichens of the Northern Conifer-Hardwood forests of eastern Canada. Canadian Journal of Botany 46: 1043-1078.

Latham R.E. and Ricklefs R.E. 1993. Continental comparisons of temperate-zone tree species diversity. In: Ricklefs RE.. Schulter D. (eds). Species diversity in ecological communities. University of Chicago, Chicago. 294-314 pp.

Laurence W.F., Bierregaard R.O. Jr., Gascon C., Dirham R.K., Smith A.P., Lynam A.J., Viana V.M., Lovejoy T.E., Sieving K.E., Sites J.W. Jr., Andersen M., Tocher M.D., Kramer E.A., Restrepo C., and Moritz C. 1997. Tropical forest fragmentation: Synthesis of a diverse and dynamic discipline. In: Laurence W.F., Bierregaard R.O. Jr. (eds.). Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities. University of Chicago Press, Chicago. 502-514 pp.

Liebherr J.K. 1991. A general area cladogram for montane Mexico based in distributions in the Platynine genera Elliptoleus and Calathus (Coleoptera: Carabidae). Proceedings of the Entomological Society of Washington 93: 390-406.

Lovejoy T.E., Bierregaard R.O. Jr., Rylands J., Malcolm J., Quintela C., Harper L., Brown K., Powell A., Powell G., Schubart H., and Hays M. 1986. Edge and other effects of isolation on Amazon forest fragments. In: Soulé M. (ed.). Conservation Biology: The Science of Scarcity and Diversity. Sinauer, Sunderland, MA. 257-285 pp.

Luna-Vega I., Almeida L., Villers L., and Lorenzo L. 1988. Reconocimiento florístico y consideraciones fitogeográficas del bosque mesófilo de montaña de Teocelo, Veracruz. Boletín de la Sociedad Botánica de México 48: 35-63.

Luna-Vega I., Alcantara O., Espinosa D., and Morrone J. 1999. Historical relationships of the Mexican cloud forests: a preliminary vicariance model applying Parsimony Analysis of Endemicity to vascular plant taxa. Journal of Biogeography 26: 1299-1305.

Luna-Vega I. and Contreras-Medina R. 2000. Distribution of the genera Theaceae (Angiospermae: Theales): a panbiogeographic análisis. Biogeographica 76: 79-88.

Luna-Vega I., Morrone J., Alcantara O, and Organista D.E. 2001a. Biogeographical affinities among Neotropical cloud forest. Plant Systematic and Evolution 228: 229-239.

Luna-Vega I., Velásquez A., and Velásquez E. 2001b. México. In: Kappelle M., Brown A. (eds.). Bosques nublados del neotrópico. Instituto Nacional de Biodiversidad, INBIO, Costa Rica. 183-230 pp.

Maddock A. and Benn G. 2000. Identification of Conservation-worthy areas is northern Zululand, South Africa. Conservation Biology 14: 155-166.

Marshall H. 1785. *Acer saccharum* Marsh. Arbustrum Americanum 1-4.

Martin P.S. and Harrell B.E. 1957. The Pleistocene history of temperate biotas in Mexico and eastern United States. Ecology 38: 468-480.

Mather P.M. 1976. Computational methods of multivariate analysis in physical geography. J. Wiley & Sons, London. 532 pp.

Matteuci S.D. and Colma A. 1982. Metodología para el estudio de la vegetación. Secretaría General de la Organización de los Estados Americanos. Washington, D. C., USA.

Maycock P.F. 1963. The phytosociology of the deciduous forest of extreme southern Ontario. Canadian Journal of Botany 41: 379-438.

McCarthy B.C., Small C.J., and Rubino D.L. 2001. Composition, structure and dynamics of Dysart Woods, an old-growth mixed mesophytic forest of southeastern Ohio. Forest Ecology and Management 140: 193-213.

McClure J.W. and Lee T.D. 1993. Small-scale disturbance in a northern hardwoods forest: effects on tree species abundance and distribution. Canadian Journal of Forest Research 23: 1347-1360.

McCune B. 1994. Improving community analysis with the Beals smoothing function. Ecoscience 1:82-86.

McCune B. and Grace J.B. 2002. Analysis of ecological communities. MjM Software Design, USA, 300 pp.

McCune B. and Mefford M.J. 1999. PC-ORD. Multivariate Analysis of Ecological Data. Version 4.0. MjM Software, Gleneden Beach, Oregon, USA.

Medinilla-Sánchez O.E. 1999. Estudio florístico de los bosques con dominancia de especies del género Pinus en la microcuenca del río Colorado, Río Hondo, Zacapa. Tesis de licenciatura, Universidad San Carlos de Guatemala, Guatemala. 136 pp.

Minchin P.R. 1987. An evaluation of the relative robustness of techniques for ecological ordination. Vegetatio 69: 89-107.

Minorsky P.V. 2003. The decline of sugar maples (*Acer saccharum*). Plant Physiology 133: 441-442.

Miranda F. and Sharp A.J. 1950. Characteristics of the vegetation in certain temperate regions of eastern Mexico. Ecology 31: 313-333.

Modry M., Hubeny D., and Rejsek K. 2004. Differential response of naturally regenerated European shade tolerant tree species to soil type and light availability. Forest Ecology and Management 188: 185-195.

Morrison I.K. 1990. Organic matter and mineral distribution in an old-growth Acer saccharum forest near the northern limit of its range. Canadian Journal of Forest Research 20: 1332-1342.

Murray A.E. Jr. 1970. A monograph of the Aceraceae. Ph. D. thesis, Pennsylvania State University, Pennsylvania, USA. 333 pp.

Murray A.E. Jr. 1975. North American maples. Kalmia 7: 1-19.

Murray A.E. Jr. 1980. Mexican maples (arces mexicanos). Kalmia 10: 5-8.

Myers N., Mittermeir R.A., Mittermeir C.G., da Fonseca G.A.B., and Kent J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Ortiz-Arrona C. 1999. Environmental effects on cloud forest tree seedling establishment under a *Pinus* canopy in Mexico. Thesis of Master of Philosophy, University of Aberdeen, UK. 113 pp.

Peters R. 1997. Beech forests. Geobotany 24, Kluwer Academic Publishers, The Netherlands.

Phillips O. and Miller J.S. 2002. Global patterns of plant diversity: Alwyn H. Gentry´s forest transect data set. Missouri Botanical Garden Press. 319 pp.

Poulson T.L. and Platt W.J. 1996. Replacement patterns of beech and sugar maple in Warren Woods, Michigan. Ecology 77: 1234-1253.

Prendergast J.R., Quinn, R.M., and Lawton J.H. 1999. The gaps between theory and practice in selecting nature reserves. Conservation Biology 13: 484-492.

Primack R. 2002. Essentials of Conservation Biology. Sinauer Associates, Sunderland, MA. 660 pp.

Puig H. and Bracho R. 1987. El bosque mesófilo de montaña de Tamaulipas. Instituto de Ecología, México D.F.

Qian H. 1999. Floristic analysis of vascular plant genera of North America north of Mexico: characteristics of phytogeography. Journal of Biogeography 26: 1307-1321.

Qian H. and Ricklefs R.E. 2000. Large-scale processes and the Asian bias in species diversity of temperate plants. Nature 407: 180-182.

Qian H. and Ricklefs R.E. 2004. Geographical distribution and ecological conservatism of disjunct genera of vascular plants in eastern Asia and eastern North America. Journal of Ecology 92: 253-265.

Quigley M.F. and Platt W.J. 2003. Composition and structure of seasonally deciduous forest in the Americas. Ecological Monographs 73: 87-106.

Ramirez-Marcial N. 2001. Diversidad florística del bosque mesófilo en el norte de Chiapas y su relación con México y Centroamérica. Boletín de la Sociedad Botánica de México 69: 63-76.

Rehder A. 1936. A new species of *Acer* from Guatemala. Journal of the Arnold Arboretum 17:350-351.

REMIB. 2005. Red Mundial de Información sobre Biodiversidad. Comisión Nacional para el conocimiento y uso de la Información, México, DF.

Renner S. 2004. Plant dispersal across the tropical Atlantic by wind and sea currents. International Journal of Plant Sciences 165: S23-S33.

Reynoso J. 2004. Florística y fitogeografía de la flora arbórea del bosque mesófilo de montaña en San Sebastián del Oeste, Jalisco, México. M. S. thesis, University of Guadalajara, Jalisco, México. 96 pp.

Roman J.R. 1980. Vegetation-environment relations in virgin, middle elevation forests in the Adirondack Mountains, New York. Ph.D. thesis. State University of New York, College of Environmental Sciences and Forestry, Syracuse, New York.

Roy G., Sauvesty A., Page F., van Hulst R., and Ansseau C. 2002. A comparison of soil fertility and leaf nutrient status of sugar maples (*Acer saccharum*) in relation to microrelief in two maple forests in Quebec. Canadian Journal of Soil Science 82: 23-31.

Rzedowski J. and Palacios-Chávez R. 1977. El bosque de *Engelhardtia* (*Oreomunnea*) *mexicana* en la región de la Chinantla (Oaxaca, México) una reliquia del Cenozoico. Boletín de la Sociedad Botánica de México 36: 93-123.

Rzedowski J. 1991. Diversidad y orígenes de la flora fanerogámica de México. Acta Botánica Mexicana 13:3-21.

Rzedowski J. 1996. Análisis preliminar de la flora vascular de los bosques mesófilos de montaña de México. Acta Botánica Mexicana 35: 25-44.

Sahagún E. 2004. Ordenación del bosque mesófilo de montaña en el Cerro La Mona, Sierra de Coalcomán, México, en el contexto del cambio climático. Ph. D. dissertation, University of Guadalajara, Jalisco, México. 115 pp.

SAS Institute. 1999-2001. SAS Statistical Software. SAS Institute, Inc., Cary, N.C., USA.

Sauvesty A., Page F., and Giroux M. 1993. Impact of hollow and bumpy soil on phenolic-compounds and mineral elements in leaves of the sugar maple (*Acer saccharum*) during decline in Quebec. Canadian Journal of Forest Research 23: 190-198.

Schier G.A. and McQuattie C.J. 2000. Effect of manganese on endomycorrhizal sugar maple seedlings. Journal of Plant Nutrition 23: 1533-1545.

Sollins P. 1998. Factors influencing species composition in tropical lowland rain forest: Does soil matter?. Ecology 79: 23-30.

Swanson F.J., Kratz T.K., Caine N., and Woodmansee R.G. 1988. Landform effects on ecosystem patterns and processes. BioScience 38: 92-98.

Thorne R. 1973. Floristic relationships between tropical Africa and tropical America. In: Menges B.J., Ayensu E.S., Duckworth W.D., (eds.). Tropical forest ecosystems in Africa and South America: a comparative review. Smithsonian Institution, Washington, DC. 27-47 pp.

Thorne R. 2004. Tropical plant disjunctions: a personal reflection. International Journal of Plant Sciences 165: S137-S138.

Toledo V.M. 1982. Pleistocene changes of vegetation in Tropical Mexico. In: Prance G.T. (ed.). Biological Diversification in the Tropics. New York: Columbia University Press. 93-111 pp.

Vargas-Rodríguez Y.L. and Vázquez-García J.A. 2001. Environmental gradients in the establishment of relict *Acer saccharum* subsp. *skutchii* (Rehder) E. Murray-*Podocarpus reichei* Buchh et N Gray communities in southwestern Mexico. ESA [The Ecological Society of America], Proceedings of the 86th Annual Meeting, August 5-10. Madison, Wisconsin, USA.

Vázquez-García J.A. 1995a. Cloud forest archipelagos: Preservation of fragmented montane ecosystems in tropical America. In: Hamilton L.S., Juvick J.O., Scatena F.N. (eds.) Tropical montane cloud forest. Ecological Studies, No. 110. Springer Verlag, New York, 315-332 pp.

Vázquez-García J.A. 1995b. Gradient analyses of neotropical montane forest. Ph. D. dissertation, University of Wisconsin, Madison, Wisconsin, USA. 180 pp.

Vázquez-García J.A., Cuevas R., Cochrane T., Iltis H., Santana F., and Guzmán L. 1995. Flora de Manantlán. Texas: Sida Botanical Miscellany 13 and Botanical research Institute.

Vázquez-García J.A. and. Givnish T.J. 1998. Altitudinal gradients in tropical forest composition, structure, and diversity in the Sierra de Manantlán. Journal of Ecology 86: 999-1020.

Vázquez-García A., Vargas-Rodriguez Y.L., and Aragon F. 2000. Descubrimiento de un bosque de *Acer-Podocarpus-Abies* en el municipio de Talpa de Allende, Jalisco, México. Boletín del Instituto de Botánica, Universidad de Guadalajara 7: 159-183.

Walter K.S. and Gillett H.J. [eds] (1998). *1997 IUCN Red List of Threatened Plants*. Compiled by the World Conservation Monitoring Centre. IUCN - The World Conservation Union, Gland, Switzerland and Cambridge, UK. lxiv + 862pp.

Walters M.B. and Reich P. B. 1997. Growth of *Acer saccharum* seedlings in deeply shaded understories of northern Wisconsin: Effects of nitrogen and water availability. Canadian Journal of Forest Research 27: 237-247.

Wen J. 1999. Evolution of eastern Asian and eastern North American disjunct distributions in flowering plants. Annual Review of Ecology and Systematics 30: 421-455.

Wen J. 2001. Evolution of eastern Asian-eastern North American biogeographic disjunctions: a few additional issues. International Journal of Plant Sciences 162: S117-S122.

Williams-Linera G. 2002. Tree species richness complementarity, disturbance and fragmentation in a Mexican tropical montane cloud forest. Biodiversity and Conservation 11:1825-1843.

Williams-Linera G., Rowden A., and Newton A.C. 2003. Distribution and stand characteristics of relict populations of Mexican beech (*Fagus grandifolia* var. *mexicana*). Biological Conservation 109: 27-36.

Wilmot T.R., Ellsworth D.S., and Tyree M.T. 1996. Base cation fertilization and liming effects on nutrition and growth of Vermont sugar maple stands. Forest Ecology and Management 84: 123-134.

Wolfe J.A. and Tanai T. 1987. Systematics, phylogeny, and distribution of *Acer* (maples) in the Cenozoic of western North America. Journal of the Faculty of Science Hokkaido University, Series IV 21: 1-246.

Young A.G., Merriam H.G., and Warwick S.I. 1993. The effects of forest fragmentation on genetic variation in *Acer saccharum* Marsh, (sugar maple) populations. Heredity 71: 277-289.

APPENDIX 1

VALUES OF SOIL VARIABLES FOR EACH CLOUD FOREST SUGAR MAPLE SITE SAMPLED

	Ca (ppm)	Cu (ppm)	K (ppm)	Fe (ppm)	Mg (ppm)	Mn (ppm)	Na (ppm)
Tamaulipas							
Plot 1	2914.3	0.116	250	19.93	640.5	226.1	-
Plot 2	2985.8	0.191	343.8	40.1	332.2	743.3	-
Plot 3	4529.1	0	187.5	14.6	1096	521.9	-
Plot 4	2941.6	0.19	125	12.8	782.8	273.4	-
Plot 5	872.6	0	3126.2	11.84	782.8	276.1	-
Plot 6	2267	0	156.25	15.14	731.4	156.6	-
Talpa							
Plot 1	2890	1.1	143	120	171	248	153
Plot 2	1680	0.873	111	96.3	183	167	94.9
Plot 3	4680	1.27	110	87.3	214	191	180
Plot 4	1510	0.859	160	45.8	130	63.5	82.8
Plot 5	442	0.81	52.7	71.8	52.5	62.2	26.4
Plot 6	603	0.876	118	69.8	55.3	55	44.4
Plot 7	338	0.588	89	59	46.3	36.6	20.6
Plot 8	788	0.805	147	124	112	48	58.4
Plot 9	491	0.891	85	100	84.7	39.3	29.5
Plot 10	682	0.701	134	82.3	79.8	24.9	43
Manantlán							
Plot 1	2000	1.56	354	79.9	221	137	105
Plot 2	2770	1.39	291	65.6	249	145	136
Plot 3	2060	1.01	336	59.6	272	81.2	107
Plot 4	1240	1.41	137	85.4	151	115	74.3
Plot 5	975	1.14	219	65.3	100	78.9	57.2
Plot 6	1740	2.31	209	75.9	133	84.7	91.6
Plot 7	1100	2.19	147	65.1	69.7	77.1	47.3
Plot 8	1250	1.33	90.3	79	68.7	119	57.9
Plot 9	688	0.844	162	107	81.3	384	36
Plot 10	1510	0.96	311	85.2	207	119	74.4
Tenejapa							
Plot 1	1012	8.32	147.5	511.5	204.62	241.77	-
Plot 2	843.4	3.75	80	151.87	102.31	82.37	-
Plot 3	337.34	6.53	125	317.7	716.19	248.4	-
Plot 4	7927.4	1.22	105	11.29	1841.6	245	-
Las Minas							
Plot 1	6.24	0.5	53	7	3.7	20	0.22
Plot 2	13.72	0.5	93	23	6.78	57	0.23
Plot 3	8.73	1	30	13	2.26	31	0.29

Appendix 1 cont.

	Zn (ppm)	S (ppm)	P (ppm)	% Organic matter	pH	Ion exchange capacity (meq/100 g)	% Moisture
Tamaulipas							
Plot 1	4.19		2.1	5.58	6.71	19.85	30.7
Plot 2	2.967		5	7.44	5.92	37.85	33.58
Plot 3	4.136		11.9	9.27	6.42	22.1	40.7
Plot 4	2.662		5.85	7.02	6.5	18.52	35.35
Plot 5	4.026		281	11.09	6.23	13.73	31.46
Plot 6	1.491		17.4	4.26	7.22	14.3	23.93
Talpa							
Plot 1	4.11	146	69.2	7.08	5.52	18.3	30.49
Plot 2	2.77	86.5	41.1	6.2	5.4	11.6	39.21
Plot 3	4.19	120	57.2	7.21	6.32	3.3	35.69
Plot 4	2.02	20.3	5.41	5.9	6.01	1.4	31.79
Plot 5	2.26	23.8	5	4.33	5.75	1	33.46
Plot 6	2.08	16.9	7.17	4.09	5.81	1	29.67
Plot 7	2.29	18.5	5	4.43	5.74	0.7	35.76
Plot 8	6.43	13.4	5	4.16	5.92	6.1	34.64
Plot 9	15	15.9	5	4.59	5.83	4	24.06
Plot 10	2.77	17.1	5	4.43	5.97	5	31.02
Manantlán							
Plot 1	2.51	25.9	5	5.5	7.02	14	31.8
Plot 2	5.69	32.5	5	7.21	7.21	2.8	38.79
Plot 3	3.09	27	5	6.67	7.01	2.2	38.62
Plot 4	2.72	41.1	11.5	6	5.45	2	33
Plot 5	2.1	22.3	10.3	6.84	6.84	1.4	35.98
Plot 6	1.44	29	7.24	4.39	6.75	1.7	33.02
Plot 7	1.43	18.3	5	3.12	6.88	7.2	36.69
Plot 8	1.75	19.2	9.04	3.62	6.66	8	36.86
Plot 9	1.95	30	5	6.2	6.03	6.5	33.08
Plot 10	2.3	20.9	16.2	5.74	6.86	11.1	40.26
Tenejapa							
Plot 1	6.99	-	8	5.33	4.26	12.94	26.06
Plot 2	4.06	-	4	8.2	4.23	15.31	21.39
Plot 3	6.15	-	8	7.59	4.28	16.23	33.24
Plot 4	10.11	-	3	20.56	6.29	48.41	36.11
Las Minas							
Plot 1	3	-	0.01	9.99	5.4	22.92	-
Plot 2	3.5	-	0.01	13.84	5.9	24.17	-
Plot 3	3.5	-	0.01	5.73	5.6	23.33	-

Appendix 1 cont.

	NO_3 (ppm)	NO_4 (ppm)	Density (gr/cm^3)	% Sand	% Lime	% Silt	Electric conductivity (mmhos/cm)	Sulfates (ppm)
Tamaulipas								
Plot 1	47.42	529.09	1.52	74.92	9.62	15.46	0.18	308.6
Plot 2	192.4	801.58	1.47	58.74	11.62	29.64	0.728	270.8
Plot 3	521.8	1307.08	1.53	78.38	6.16	15.46	1.513	456.12
Plot 4	64.6	698.1	1.5	66.42	5.98	27.1	0.488	381.02
Plot 5	236.2	928.8	1.56	82.92	0	17.08	0.483	319.18
Plot 6	52.78	305.91	1.5	68.92	12.16	18.92	0.16	246.24
Talpa								
Plot 1	112.8	99.65	-	64.52	12.2	23.28	-	-
Plot 2	47.94	78.29	-	59.34	16.2	24.46	-	-
Plot 3	402.63	85.41	-	58.52	17.2	24.28	-	-
Plot 4	247.05	92.53	-	60.52	15.2	24.28	-	-
Plot 5	773.45	113.88	-	46.34	26.2	27.46	-	-
Plot 6	456.99	71.18	-	58.34	16.2	25.46	-	-
Plot 7	857.55	99.65	-	58.34	18.2	23.46	-	-
Plot 8	174.68	106.77	-	53.52	15.52	30.96	-	-
Plot 9	901.9	92.53	-	53.52	17.2	29.28	-	-
Plot 10	565.08	85.41	-	52.52	21.2	26.28	-	-
Manantlán								
Plot 1	598.72	121	0.83	69.28	16.72	14	-	-
Plot 2	459.44	135.23	0.71	66.72	8.56	24.22	-	-
Plot 3	596.32	121	0.66	62	3.28	34.72	-	-
Plot 4	471.55	128.12	0.72	60	7.28	32.72	-	-
Plot 5	402.93	99.65	0.72	56	5.28	38.72	-	-
Plot 6	62.72	78.29	0.71	54.72	13.28	32	-	-
Plot 7	413.18	113.88	0.77	54.72	9.28	36	-	-
Plot 8	642.76	128.12	0.72	64.22	1.28	34	-	-
Plot 9	556.45	99.63	0.68	64	5.28	30.72	-	-
Plot 10	713.68	135.23	0.78	64.72	7.28	28	-	-
Tenejapa								
Plot 1	17	445.66	1.53	80.38	8.8	10.82	0.42	165
Plot 2	28	497.65	1.52	72.38	6.8	20.82	0.125	50
Plot 3	26	542.04	1.52	76.2	8	15.82	0.32	80
Plot 4	88	0.12	1.53	78.38	9.8	11.82	0.4	50
Las Minas								
Plot 1	-	-	1.2	18.65	55.56	25.79	140	-
Plot 2	-	-	0.9864	18.65	61.86	19.49	156	-
Plot 3	-	-	1.2234	39.65	42.86	17.39	122	-

APPENDIX 2

FOREST SITES INCLUDED IN THE NORTH AND CENTRAL AMERICA ORDINATION

Sites are as follow: BL= Babler State Park; BA= Bankamp State Park; CA= Cary Arboretum; CE= Cedar Bluffs; CU= Cuivre River State park; HBM= Heuston Woods-Beech-Maple; HMF= Heuston Woods-Mixed Forest; KA= Kane Allegheny Forest; LA= Laurel Ridge; MO= Montgomery Place; MT= Mt. St. Hilaire; PO= Potomac; TI= Tridroute; TY= Tyson Reserve Woods; VA= Valley View Glades; WI= Wild Basin Preserve; MI= Milpillas; BU= La Bulera; CG26= Cerro Grande, site 26; CG27= Cerro Grande, site 27; CG28= Cerro Grande, site 28; CG29= Cerro Grande, site 29; CG30= Cerro Grande, site 30; CG25= Cerro Grande, site 25; CG21= Cerro Grande, site 21; CG24= Cerro Grande, site 24; CG18= Cerro Grande, site 18; CG16= Cerro Grande, site 16; CG19= Cerro Grande, site 19; CG20= Cerro Grande, site 20; CG17= Cerro Grande, site 17; CG12= Cerro Grande, site 12; CG13= Cerro Grande, site 13; CG14= Cerro Grande, site 14; CG11= Cerro Grande, site 11; CG15= Cerro Grande, site 15; CG6= Cerro Grande, site 6; CG8= Cerro Grande, site 8; CG9= Cerro Grande, site 9; CG7= Cerro Grande, site 7; CG10= Cerro Grande, site 10; CG2= Cerro Grande, site 2; CG3= Cerro Grande, site 3; CG5= Cerro Grande, site 5; CG4= Cerro Grande, site 4; CG1= Cerro Grande, site 1; BBM4= Sierra de Juárez, site 4; BBM5= Sierra de Juárez, site 5; BBM6= Sierra de Juárez, site 6; BBM7= Sierra de Juárez, site 7; BBM8= Sierra de Juárez, site 8; BBM9= Sierra de Juárez, site 9; BBM10= Sierra de Juárez, site 10; BBM11= Sierra de Juárez, site 11; BBC1= Braulio Carrillo Nacional Park, site 1; BBC2= Braulio Carrillo Nacional Park, site 2; BBC3= Braulio Carrillo Nacional Park, site 3; BBC4= Braulio Carrillo Nacional Park, site 4; BBC5= Braulio Carrillo Nacional Park, site 5; BBC6= Braulio Carrillo Nacional Park, site 6; BBC7= Braulio Carrillo Nacional Park, site 7; BBC8= Braulio Carrillo Nacional Park, site 8; BBC9= Braulio Carrillo Nacional Park, site 9; MQ= Quince Ocotes; MJ= Manantlán, Las Joyas; BE= Benito Juárez, Chiapas; BO= Bosque de Guadalupe, Veracruz; MM= Cloud forest sugar maple, Sierra de Manantlán; T1= Cloud forest sugar maple, Talpa de Allende, site 1; T2= Cloud forest sugar maple, Talpa de Allende, site 2; T3= Cloud forest sugar maple, Talpa de Allende, site 3; TM= Cloud forest sugar maple,Tamaulipas; CM= Cloud forest sugar maple, Tenejapa, Chiapas; GM= Cloud forest sugar maple, Las Minas, Guatemala; CO2= Sierra de Coalcomán, site C2; CO1= Sierra de Coalcomán, site C1; COM3= Sierra de Coalcomán, site M3; COM2= Sierra de Coalcomán, site M2; COM1= Sierra de Coalcomán, site M1; COS1= Sierra de Coalcomán, site S1; COS2= Sierra de Coalcomán, site S2; COS3= Sierra de Coalcomán, site S3; COS4= Sierra de Coalcomán, site S4; GWS1= Mesa de la Yerba, Veracruz; GWS2= Acatlán Volcano Crater, Veracruz; GWS3= Acatlán Volcano top, Veracruz; GWS4= La Mojonera, Hidalgo; GWS5= Casa de Piedra, Tamaulipas.

	BL	BA	CA	CE	CU	HBM	HMF	KA	LA	MO	MT	PO	TI	TY	VA	WI	MI	BU	CG26	CG27	CG28	CG29	CG30	CG22	CG23
Abies																								1	
Abuta																									
Acer	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1										
Aegiphila																									
Aesculus						1	1																		

Appendix 2 cont.

	BL	BA	CA	CE	CU	HBM	HMF	KA	LA	MO	MT	PO	TI	TY	VA	WI	MI	BU	CG26	CG27	CG28	CG29	CG30	CG22	CG23
Ageratina																	1								
Agonandra																									
Aiouea																									
Alchornea																									
Alfaroa																									
Alibertia																									
Allosanthus																									
Alnus																									
Alsophila																									
Amelanchier			1		1			1	1						1										
Amphitecna																									
Annona																		1							
Anthurium																									
Arachnotrix																									
Arbutus																									
Ardisia																		1							
Aristolochia																	1								
Asclepias																									
Asimina				1		1						1													
Asplundia																									
Axinaea																									
Bactris																									
Berberis																									
Besleria																									
Betula		1	1					1	1	1	1	1	1												
Bielschmeidia																									
Billia																									
Blakea																									
Brunellia																									
Buddleja																									
Bumelia																1									
Bunchosia																									
Bursera																									
Calatola																									
Calliandra																	1								

Appendix 2 cont.																									
	BL	BA	CA	CE	CU	HBM	HMF	KA	LA	MO	MT	PO	TI	TY	VA	WI	MI	BU	CG26	CG27	CG28	CG29	CG30	CG22	CG23
Calophyllum																		1							
Calyptranthes																		1							
Canavalia																	1								
Carpinus		1	1	1		1		1		1															
Carya	1	1	1	1	1	1	1			1		1	1	1	1	1									
Casearia																		1							
Cassia																									
Cassipourea																									
Castanea			1																						
Cavendishia																									
Ceanothus																									
Cecropia																		1							
Cedrela																	1								
Celastrus																	1								
Celtis				1	1	1								1	1	1									
Cercis	1			1	1		1					1			1										
Cestrum																		1							
Chamaedorea																									
Chiococca																			1	1	1	1	1	1	1
Chromolaena																									
Chusquea																									
Cinnamomum																	1								
Cissus																		1							
Citharexylum																									
Clarisia																									
Clematis																	1								
Clethra																									
Cleyera																									
Clidemia																									
Clusia																	1		1	1	1	1	1	1	1
Cnidoscolus																									
Comarostaphylis																									
Combretum																									
Connarus																									
Conostegia																									

Appendix 2 cont.																									
	BL	BA	CA	CE	CU	HBM	HMF	KA	LA	MO	MT	PO	TI	TY	VA	WI	MI	BU	CG26	CG27	CG28	CG29	CG30	CG22	CG23
Cornus	1	1	1	1	1	1	1			1		1		1	1		1								
Cosmibuena																									
Costus																									
Coussarea																									
Crataegus		1																							
Critonia																									
Croton																									
Cupania																									
Cyathea																									
Cytharexylum																				1	1	1			1
Dalbergia																									
Dalea																									
Daphnopsis																									
Dendropanax																	1		1	1	1		1	1	1
Deppea																									
Desmopsis																		1							
Dichapetalum																									
Dioclea																									
Diospyros															1	1									
Dirca				1																					
Disterigma																									
Doliocarpus																									
Drimys																									
Dussia																									
Elaeagia																									
Erythrina																									
Erythroxylum																									
Escallonia																									
Eugenia																			1	1		1	1		
Euonymus																									
Eupatorium																									
Euphorbia																	1								
Fagus				1		1	1	1	1	1	1	1	1												
Faramea																		1							
Ficus																									

Appendix 2 cont.																									
	BL	BA	CA	CE	CU	HBM	HMF	KA	LA	MO	MT	PO	TI	TY	VA	WI	MI	BU	CG26	CG27	CG28	CG29	CG30	CG22	CG23
Forestiera																	1								
Fraxinus	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1		1	1	1	1
Fuchsia																									
Gaiadendron																									
Galphimia																									
Garcinia																									
Garrya																1	1			1		1		1	1
Gaultheria																									
Geonoma																									
Gleditsia					1																				
Glossostipula																	1								
Gonocalyx																									
Gonzalagunia																									
Gordonia																									
Gouania																									
Guarea																									
Guatteria																									
Guettarda																									
Gymnanthes																									
Gyrotaenia																									
Hamamelis			1					1	1			1	1												
Hamelia																		1							
Hedyosmum																		1							
Heliconia																									
Helicostylis																	1			1	1	1	1		
Hibiscus																									
Hillia																									
Hoffmannia																									
Hybanthus																									
Hydrangea																									
Hyeronima																									
Ilex															1	1	1					1			
Illicium																									
Inga																		1							
Juglans				1	1	1	1							1											

Appendix 2 cont.

	BL	BA	CA	CE	CU	HBM	HMF	KA	LA	MO	MT	PO	TI	TY	VA	WI	MI	BU	CG26	CG27	CG28	CG29	CG30	CG22	CG23
Juniperus	1			1	1										1	1									
Lacistema																									
Lantana																									
Leandra																									
Leucaena																			1	1	1	1	1		
Liabum																			1	1	1	1	1		
Licania																		1							
Licaria																									
Ligustrum																									
Lindera										1		1													
Lippia																									
Liquidambar																									
Liriodendron						1	1			1		1	1												
Litsea																						1			
Lonchocarpus																									
Lunania																									
Lycianthes																									
Lysiloma																								1	1
Machaerium																									
Magnolia									1				1				1	1							
Malus		1																							
Malvaviscus																	1								
Marcgravia																									
Marsdenia																									
Matayba																									
Matudaea																									
Meliosma																	1								
Mendoncia																									
Meriania																									
Miconia																									
Mikania																									
Mollinedia																									
Montanoa																									
Morus	1				1									1											
Muehlenbeckia																									

Appendix 2 cont.																									
	BL	BA	CA	CE	CU	HBM	HMF	KA	LA	MO	MT	PO	TI	TY	VA	WI	MI	BU	CG26	CG27	CG28	CG29	CG30	CG22	CG23
Myrcia																									
Myrcianthes																	1							1	1
Myrica																									
Myrrhidendron																									
Myrsine																									
Nectandra																									
Neomirandea																									
Nyssa		1											1												
Ocotea																									
Oreomunnea																									
Oreopanax																			1					1	1
Osmanthus																			1						
Ostrya		1	1	1	1		1	1				1	1	1											
Ouratea																									
Palicourea																									
Parathesis																									
Parthenocissus	1	1					1							1											
Passiflora																									
Paullinia																									
Peltostigma																	1								
Perrottetia																			1	1				1	1
Persea																			1			1		1	1
Phenax																									
Philodendron																									
Phoebe																									
Photinia																									
Phyllonoma																									
Picramnia																	1		1	1	1	1	1	1	1
Picrasma																	1	1							
Pinus			1					1		1	1		1												
Piper																									
Pithecoctenium																									
Platymiscium																		1							
Podocarpus																		1							
Podocnemium																									

Appendix 2 cont.

	BL	BA	CA	CE	CU	HBM	HMF	KA	LA	MO	MT	PO	TI	TY	VA	WI	MI	BU	CG26	CG27	CG28	CG29	CG30	CG22	CG23
Polybotrya																									
Populus		1	1																						
Pouteria																									
Pouzolzia																			1						1
Prestoea																									
Protium																									
Prunus		1		1	1	1	1	1	1					1			1		1	1	1	1	1	1	1
Psammisia																									
Pseudolmedia																									
Psidium																		1							
Psychotria																									
Quercus	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Quetzalia																									
Randia																		1							
Rapanea																	1								
Rhacoma																			1		1	1			
Rhamnus															1	1									
Robinia						1	1																		
Roldana																	1								
Rondeletia																	1								
Ruagea																									
Rubus																									
Sabicea																									
Salacia																									
Salix																1									
Sapium																									
Sassafras	1	1		1										1											
Satyria																									
Saurauia																									
Scharadera																									
Schefflera																									
Schlegelia																									
Sebastiana																									
Sebastiania																									
Senecio																									

Appendix 2 cont.																									
	BL	BA	CA	CE	CU	HBM	HMF	KA	LA	MO	MT	PO	TI	TY	VA	WI	MI	BU	CG26	CG27	CG28	CG29	CG30	CG22	CG23
Serjania																									
Sideroxylon																				1	1	1	1		
Siparuna																		1							
Smilax																		1							
Solandra																									
Solanum																									
Sophora																1									
Sphaeradenia																									
Staphylea												1													
Stemmadenia																									1
Styrax																	1		1	1		1	1	1	1
Symplocarpus																									
Symplococarpon																									
Symplocos																									
Synardisia																									
Tapura																		1							
Terminalia																									
Ternstroemia																	1		1	1	1	1	1	1	1
Tetrorchidium																									
Thevetia																									
Thibaudia																									
Ticodendron																									
Tilia	1			1	1	1	1		1	1	1	1	1		1										
Topobea																									
Tournefortia																	1								
Tovomitopsis																									
Toxicodendron					1							1		1					1		1	1	1		
Trema																								1	
Trichilia																			1	1	1	1	1	1	1
Tridimeris																									
Trophis																		1							
Tsuga								1		1	1		1												
Turpinia																									
Ulmus	1	1		1	1	1	1			1		1		1	1	1									
Urera																									

Appendix 2 cont.

	BL	BA	CA	CE	CU	HBM	HMF	KA	LA	MO	MT	PO	TI	TY	VA	WI	MI	BU	CG26	CG27	CG28	CG29	CG30	CG22	CG23
Vaccinium																									
Vallesia																	1								
Verbesina																									
Viburnum	1	1			1		1			1															
Vitis	1	1		1	1		1					1	1	1	1	1									
Weinmannia																									
Witheringia																									
Xylosma																			1	1	1	1	1	1	1
Zanthoxylum																	1								
Zinowiewia																	1		1	1	1	1		1	1

Appendix 2 cont.

	CG25	CG21	CG24	CG18	CG16	CG19	CG20	CG17	CG12	CG13	CG14	CG11	CG15	CG6	CG8	CG9	CG7	CG10	CG2
Abies		1			1		1							1	1	1	1	1	
Abuta																			
Acer																			
Aegiphila																			
Aesculus																			
Ageratina																			
Agonandra																			
Aiouea																			
Alchornea																			
Alfaroa																			
Alibertia																			
Allosanthus																			
Alnus																			
Alsophila																			
Amelanchier																			
Amphitecna																			
Annona																			
Anthurium																			
Arachnotrix																			
Arbutus														1					1
Ardisia																			
Aristolochia																			
Asclepias																			

Appendix 2 cont.																			
	CG25	CG21	CG24	CG18	CG16	CG19	CG20	CG17	CG12	CG13	CG14	CG11	CG15	CG6	CG8	CG9	CG7	CG10	CG2
Asimina																			
Asplundia																			
Axinaea																			
Bactris																			
Berberis																			
Besleria																			
Betula																			
Bielschmeidia																			
Billia																			
Blakea																			
Brunellia																			
Buddleja																			
Bumelia																			
Bunchosia																			
Bursera																			
Calatola																			
Calliandra																			
Calophyllum																			
Calyptranthes																			
Canavalia																			
Carpinus																			
Carya																			
Casearia																			
Cassia																			
Cassipourea																			
Castanea																			
Cavendishia																			
Ceanothus				1															
Cecropia																			
Cedrela																			
Celastrus																			
Celtis																			
Cercis																			
Cestrum																			
Chamaedorea																			

Appendix 2 cont.																			
	CG25	CG21	CG24	CG18	CG16	CG19	CG20	CG17	CG12	CG13	CG14	CG11	CG15	CG6	CG8	CG9	CG7	CG10	CG2
Chiococca	1	1	1																
Chromolaena																			
Chusquea																			
Cinnamomum																			
Cissus																			
Citharexylum																			
Clarisia																			
Clematis																			
Clethra											1		1						1
Cleyera																			
Clidemia																			
Clusia	1	1			1														
Cnidoscolus																			
Comarostaphylis									1	1			1						1
Combretum																			
Connarus																			
Conostegia																			
Cornus	1			1	1	1			1	1	1	1	1	1	1	1	1	1	1
Cosmibuena																			
Costus																			
Coussarea																			
Crataegus																			
Critonia																			
Croton																			
Cupania																			
Cyathea																			
Cytharexylum	1	1	1																
Dalbergia																			
Dalea																			
Daphnopsis																			
Dendropanax	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Deppea																			
Desmopsis																			
Dichapetalum																			
Dioclea																			

Appendix 2 cont.																			
	CG25	CG21	CG24	CG18	CG16	CG19	CG20	CG17	CG12	CG13	CG14	CG11	CG15	CG6	CG8	CG9	CG7	CG10	CG2
Diospyros																			
Dirca																			
Disterigma																			
Doliocarpus																			
Drimys																			
Dussia																			
Elaeagia																			
Erythrina																			
Erythroxylum																			
Escallonia																			
Eugenia																			
Euonymus	1																		
Eupatorium																			
Euphorbia																			
Fagus																			
Faramea																			
Ficus																			
Forestiera																			
Fraxinus	1	1	1	1	1	1	1	1	1	1		1	1						
Fuchsia																			
Gaiadendron																			
Galphimia																			
Garcinia																			
Garrya	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gaultheria																			
Geonoma																			
Gleditsia																			
Glossostipula																			
Gonocalyx																			
Gonzalagunia																			
Gordonia																			
Gouania																			
Guarea																			
Guatteria																			
Guettarda																			

Appendix 2 cont.																			
	CG25	CG21	CG24	CG18	CG16	CG19	CG20	CG17	CG12	CG13	CG14	CG11	CG15	CG6	CG8	CG9	CG7	CG10	CG2
Gymnanthes																			
Gyrotaenia																			
Hamamelis																			
Hamelia																			
Hedyosmum																			
Heliconia																			
Helicostylis																			
Hibiscus																			
Hillia																			
Hoffmannia																			
Hybanthus																			
Hydrangea																			
Hyeronima																			
Ilex															1	1			1
Illicium																			
Inga																			
Juglans																			
Juniperus																			
Lacistema																			
Lantana																			
Leandra																			
Leucaena																			
Liabum			1	1															
Licania																			
Licaria																			
Ligustrum																			
Lindera																			
Lippia																			
Liquidambar																			
Liriodendron																			
Litsea	1																		
Lonchocarpus																			
Lunania																			
Lycianthes																			
Lysiloma		1	1			1	1												

Appendix 2 cont.																			
	CG25	CG21	CG24	CG18	CG16	CG19	CG20	CG17	CG12	CG13	CG14	CG11	CG15	CG6	CG8	CG9	CG7	CG10	CG2
Machaerium																			
Magnolia																			
Malus																			
Malvaviscus																			
Marcgravia																			
Marsdenia																			
Matayba																			
Matudaea																			
Meliosma																			
Mendoncia																			
Meriania																			
Miconia																			
Mikania																			
Mollinedia																			
Montanoa																			
Morus																			
Muehlenbeckia																			
Myrcia																			
Myrcianthes	1	1	1	1	1	1		1		1									
Myrica																			
Myrrhidendron																			
Myrsine																			
Nectandra																			
Neomirandea																			
Nyssa																			
Ocotea																			
Oreomunnea																			
Oreopanax	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Osmanthus																			
Ostrya																			
Ouratea																			
Palicourea																			
Parathesis																			
Parthenocissus																			
Passiflora																			

Appendix 2 cont.																			
	CG25	CG21	CG24	CG18	CG16	CG19	CG20	CG17	CG12	CG13	CG14	CG11	CG15	CG6	CG8	CG9	CG7	CG10	CG2
Paullinia																			
Peltostigma																			
Perrottetia	1	1	1	1	1	1	1	1											
Persea		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Phenax																			
Philodendron																			
Phoebe																			
Photinia																			
Phyllonoma																			
Picramnia	1	1	1			1	1												
Picrasma																			
Pinus	1																1		
Piper																			
Pithecoctenium																			
Platymiscium																			
Podocarpus																			
Podocnemium																			
Polybotrya																			
Populus																			
Pouteria																			
Pouzolzia																			
Prestoea																			
Protium																			
Prunus	1	1	1	1							1			1	1				
Psammisia																			
Pseudolmedia																			
Psidium																			
Psychotria																			
Quercus	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Quetzalia																			
Randia																			
Rapanea																			
Rhacoma																			
Rhamnus																			
Robinia																			

Appendix 2 cont.																			
	CG25	CG21	CG24	CG18	CG16	CG19	CG20	CG17	CG12	CG13	CG14	CG11	CG15	CG6	CG8	CG9	CG7	CG10	CG2
Roldana																			
Rondeletia																			
Ruagea																			
Rubus																			
Sabicea																			
Salacia																			
Salix																			
Sapium																			
Sassafras																			
Satyria																			
Saurauia																			
Scharadera																			
Schefflera																			
Schlegelia																			
Sebastiana																			
Sebastiania																			
Senecio																			
Serjania																			
Sideroxylon					1														
Siparuna																			
Smilax																			
Solandra																			
Solanum																			
Sophora																			
Sphaeradenia																			
Staphylea																			
Stemmadenia																			
Styrax	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Symplocarpus																			
Symplococarpon																			
Symplocos								1			1	1	1	1	1	1	1	1	1
Synardisia																			
Tapura																			
Terminalia																			
Ternstroemia	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Appendix 2 cont.																			
	CG25	CG21	CG24	CG18	CG16	CG19	CG20	CG17	CG12	CG13	CG14	CG11	CG15	CG6	CG8	CG9	CG7	CG10	CG2
Tetrorchidium																			
Thevetia	1																		
Thibaudia																			
Ticodendron																			
Tilia																			
Topobea																			
Tournefortia																			
Tovomitopsis																			
Toxicodendron				1															
Trema																			
Trichilia	1	1	1	1	1	1	1	1	1	1	1	1							
Tridimeris																			
Trophis																			
Tsuga																			
Turpinia																			
Ulmus																			
Urera																			
Vaccinium																			
Vallesia																			
Verbesina																			
Viburnum									1		1								
Vitis																			
Weinmannia																			
Witheringia																			
Xylosma	1	1	1	1	1	1	1	1	1	1	1	1	1					1	
Zanthoxylum																			
Zinowiewia	1	1	1	1	1	1		1	1	1									

Appendix 2 cont.

	CG3	CG5	CG4	CG1	BBM4	BBM5	BBM6	BBM7	BBM8	BBM9	BBM10	BBM11	BBC1	BBC2	BBC3	BBC4	BBC5	BBC6
Abies																		
Abuta									1	1	1	1						
Acer																		
Aegiphila														1			1	1
Aesculus																		
Ageratina																		

Appendix 2 cont.																		
	CG3	CG5	CG4	CG1	BBM4	BBM5	BBM6	BBM7	BBM8	BBM9	BBM10	BBM11	BBC1	BBC2	BBC3	BBC4	BBC5	BBC6
Agonandra																		
Aiouea																		
Alchornea					1	1	1	1	1							1	1	1
Alfaroa																		
Alibertia																		
Allosanthus											1							
Alnus																		
Alsophila						1												
Amelanchier																		
Amphitecna											1	1					1	1
Annona											1	1						
Anthurium						1							1	1	1	1		1
Arachnotrix																		
Arbutus	1	1	1	1														
Ardisia													1	1	1	1	1	1
Aristolochia																		
Asclepias																		
Asimina																		
Asplundia										1	1	1						
Axinaea																	1	
Bactris												1						
Berberis																		
Besleria																1		1
Betula																		
Bielschmeidia					1				1									
Billia					1	1	1	1								1	1	1
Blakea										1				1			1	1
Brunellia								1							1	1	1	
Buddleja																		
Bumelia																		
Bunchosia																		
Bursera																		
Calatola																		
Calliandra																		
Calophyllum																		

Appendix 2 cont.

	CG3	CG5	CG4	CG1	BBM4	BBM5	BBM6	BBM7	BBM8	BBM9	BBM10	BBM11	BBC1	BBC2	BBC3	BBC4	BBC5	BBC6
Calyptranthes					1			1	1	1								
Canavalia																		
Carpinus																		
Carya																		
Casearia										1								
Cassia																		
Cassipourea																		
Castanea																		
Cavendishia								1		1			1	1	1	1	1	1
Ceanothus	1																	
Cecropia									1	1	1	1						
Cedrela																		
Celastrus					1	1		1		1						1	1	
Celtis																		
Cercis																		
Cestrum														1	1			
Chamaedorea																		
Chiococca																		
Chromolaena																		
Chusquea														1	1		1	1
Cinnamomum						1	1		1	1	1	1				1		
Cissus					1		1	1		1						1	1	1
Citharexylum																		
Clarisia											1							
Clematis																		
Clethra			1	1	1		1	1					1	1	1	1	1	
Cleyera																		
Clidemia																		
Clusia						1		1	1	1						1		1
Cnidoscolus																		
Comarostaphylis	1	1	1															
Combretum												1						
Connarus											1	1						
Conostegia																1	1	
Cornus	1	1	1	1												1		

Appendix 2 cont.

	CG3	CG5	CG4	CG1	BBM4	BBM5	BBM6	BBM7	BBM8	BBM9	BBM10	BBM11	BBC1	BBC2	BBC3	BBC4	BBC5	BBC6
Cosmibuena																		
Costus										1								
Coussarea									1	1	1	1						
Crataegus																		
Critonia																		
Croton																		
Cupania											1							
Cyathea					1	1	1	1	1	1		1	1	1	1	1	1	1
Cytharexylum																		
Dalbergia											1							
Dalea																		
Daphnopsis						1												
Dendropanax	1				1	1	1	1	1	1	1	1	1	1	1	1	1	1
Deppea							1											
Desmopsis																		
Dichapetalum										1	1							
Dioclea																		
Diospyros																		
Diría																		
Disterigma													1			1		
Doliocarpus												1						
Drimys								1					1	1	1	1	1	1
Dussia											1							
Elaeagia																		
Eritrina																		
Erythroxylum												1						
Escallonia													1	1	1			
Eugenia						1		1	1	1							1	1
Euonymus																		
Eupatorium						1	1											
Euphorbia																		
Fagus																		
Faramea						1		1	1	1								
Picus												1						
Forestiera																		

Appendix 2 cont.																		
	CG3	CG5	CG4	CG1	BBM4	BBM5	BBM6	BBM7	BBM8	BBM9	BBM10	BBM11	BBC1	BBC2	BBC3	BBC4	BBC5	BBC6
Fraxinus																		
Fucsia							1											
Gaiadendron													1					1
Galphimia																		
Garcinia										1	1	1						
Garrya	1	1	1	1														
Gaultheria																		
Geonoma																1	1	1
Gleditsia																		
Glossostipula																		
Gonocalyx																1	1	
Gonzalagunia																		
Gordonia						1				1	1	1						
Gouania											1	1						
Guarea											1						1	1
Guatteria																		
Guettarda																1	1	
Gymnanthes																		
Gyrotaenia																		
Hamamelis																		
Hamelia																		
Hedyosmum							1	1	1	1						1	1	1
Heliconia																	1	1
Helicostylis																		
Hibiscus							1											
Hillia																		
Hoffmannia							1			1	1				1			
Hybanthus																		
Hydrangea																		
Hyeronima												1				1	1	1
Ilex		1			1	1	1	1	1				1	1	1	1	1	
Illicium																		
Inga						1	1	1		1	1	1						
Juglans																		
Juniperus																		

Appendix 2 cont.																		
	CG3	CG5	CG4	CG1	BBM4	BBM5	BBM6	BBM7	BBM8	BBM9	BBM10	BBM11	BBC1	BBC2	BBC3	BBC4	BBC5	BBC6
Lacistema											1	1						
Lantana																		
Leandra																		
Leucaena																		
Liabum					1		1	1		1		1						
Licania																		
Licaria						1		1		1	1	1						
Ligustrum																		
Lindera																		
Lippia																		
Liquidambar																		
Liriodendron																		
Litsea																		
Lonchocarpus																		
Lunania											1	1						
Lycianthes										1								
Lysiloma																		
Machaerium											1	1						
Magnolia					1											1		
Malus																		
Malvaviscus																		1
Marcgravia																	1	
Marsdenia						1												
Matayba									1	1		1						
Matudaea																		
Meliosma					1	1		1									1	1
Mendoncia												1						
Meriania																	1	1
Miconia					1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mikania					1	1	1	1	1	1	1	1			1	1		1
Mollinedia						1	1	1	1	1	1	1					1	1
Montanoa																		
Morus																		
Muehlenbeckia															1		1	1
Myrcia											1							

Appendix 2 cont.																		
	CG3	CG5	CG4	CG1	BBM4	BBM5	BBM6	BBM7	BBM8	BBM9	BBM10	BBM11	BBC1	BBC2	BBC3	BBC4	BBC5	BBC6
Myrcianthes																		
Myrica																		
Myrrhidendron													1					
Myrsine					1			1					1			1	1	1
Nectandra																		
Neomirandea							1								1	1		1
Nyssa																		
Ocotea					1	1	1	1	1	1		1		1	1	1	1	
Oreomunnea						1	1											
Oreopanax	1	1	1	1	1	1	1		1				1	1	1	1		
Osmanthus																		
Ostrya																		
Ouratea									1			1						
Palicourea									1							1	1	1
Parathesis							1											
Parthenocissus																		
Passiflora																		
Paullinia										1	1	1						
Peltostigma																		
Perrottetia							1											
Persea	1	1	1	1	1	1	1	1	1	1		1						
Phenax																		
Philodendron									1	1	1	1					1	1
Phoebe						1			1									
Photinia																		
Phyllonoma					1												1	1
Picramnia																		
Picrasma																		
Pinus		1																
Piper							1			1	1	1	1	1	1		1	1
Pithecoctenium																		
Platymiscium																		
Podocarpus					1													
Podocnemium																		
Polybotrya												1						

Appendix 2 cont.

	CG3	CG5	CG4	CG1	BBM4	BBM5	BBM6	BBM7	BBM8	BBM9	BBM10	BBM11	BBC1	BBC2	BBC3	BBC4	BBC5	BBC6
Populus																		
Pouteria											1	1						
Pouzolzia																		
Prestoea																	1	1
Protium											1	1						
Prunus					1	1	1	1	1	1					1	1		
Psammisia																1	1	
Pseudolmedia						1	1	1	1	1								
Psidium																		
Psychotria					1	1	1	1	1	1		1				1	1	
Quercus	1	1	1	1	1											1	1	1
Quetzalia						1	1	1		1						1		
Randia																		
Rapanea																		
Rhacoma																		
Rhamnus					1								1		1			
Robinia																		
Roldana																		
Rondeletia					1	1	1	1			1					1	1	
Ruagea																1	1	1
Rubus						1	1	1		1	1							
Sabicea									1		1							
Salacia						1				1	1	1						
Salix																		
Sapium																	1	
Sassafras																		
Satyria									1									
Saurauia							1											1
Scharadera																		
Schefflera													1	1	1	1	1	1
Schlegelia																		
Sebastiana																		
Sebastiania																		
Senecio					1										1	1		
Serjania																		

Appendix 2 cont.																		
	CG3	CG5	CG4	CG1	BBM4	BBM5	BBM6	BBM7	BBM8	BBM9	BBM10	BBM11	BBC1	BBC2	BBC3	BBC4	BBC5	BBC6
Sideroxylon																		
Siparuna												1						
Smilax							1	1									1	
Solandra					1													
Solanum						1	1			1			1	1	1			
Sophora																		
Sphaeradenia																1	1	1
Staphylea																		
Stemmadenia																		
Styrax	1	1	1	1				1										
Symplocarpus																		
Symplococarpon					1	1	1	1		1								
Symplocos	1	1		1		1		1	1						1	1		
Synardisia																		
Tapura																		
Terminalia												1						
Ternstroemia	1	1	1	1		1												
Tetrorchidium																	1	
Thevetia																		
Thibaudia																		
Ticodendron					1	1	1	1	1	1						1	1	1
Tilia																		
Topobea																		
Tournefortia														1	1			
Tovomitopsis																	1	1
Toxicodendron																		
Trema																		
Trichilia								1										
Tridimeris											1							
Trophis						1	1											
Tsuga																		
Turpinia									1	1							1	1
Ulmus																		
Urera																		
Vaccinium													1	1	1	1		

Appendix 2 cont.

	CG3	CG5	CG4	CG1	BBM4	BBM5	BBM6	BBM7	BBM8	BBM9	BBM10	BBM11	BBC1	BBC2	BBC3	BBC4	BBC5	BBC6
Vallesia																		
Verbesina																		
Viburnum								1		1			1	1	1	1	1	1
Vitis									1	1	1	1						
Weinmannia					1	1			1				1	1	1	1	1	1
Witheringia														1	1			
Xylosma																		1
Zanthoxylum								1	1			1		1	1			
Zinowiewia					1													

Appendix 2 cont.

	BBC7	BBC8	BBC9	MQ	MJ	BE	BO	MM	T1	T2	T3	TM	CM	GM	CO2	CO1	COM3	COM2	COM1	COS1	COS2
Abies									1		1										
Abuta																					
Acer								1	1	1	1	1	1	1							
Aegiphila		1	1																		
Aesculus																					
Ageratina																1			1	1	1
Agonandra															1	1					
Aiouea		1	1																		
Alchornea	1	1	1																		
Alfaroa	1																				
Alibertia						1															
Allosanthus																					
Alnus													1								
Alsophila	1	1					1														
Amelanchier																					
Amphitecna	1	1																			
Annona																1					
Anthurium	1		1																		
Arachnotrix																					
Arbutus																					
Ardisia	1	1	1		1								1	1	1	1	1	1			1
Aristolochia																					
Asclepias				1	1																
Asimina																					

Appendix 2 cont.																					
	BBC7	BBC8	BBC9	MQ	MJ	BE	BO	MM	T1	T2	T3	TM	CM	GM	CO2	CO1	COM3	COM2	COM1	COS1	COS2
Asplundia																					
Axinaea			1																		
Bactris																					
Berberis																					
Besleria	1	1	1																		
Betula																					
Bielschmeidia																					
Billia	1	1																			
Blakea	1		1																		
Brunellia																					
Buddleja						1							1								
Bumelia																					
Bunchosia		1					1														
Bursera															1	1					
Calatola	1	1															1				
Calliandra										1					1				1		
Calophyllum																					
Calyptranthes															1	1	1				
Canavalia															1	1					
Carpinus				1	1	1	1	1	1	1	1	1		1			1	1	1	1	1
Carya																					
Casearia	1	1																			
Cassia																					
Cassipourea						1															
Castanea																					
Cavendishia	1		1																		
Ceanothus																					
Cecropia	1	1	1																		
Cedrela																	1	1	1		
Celastrus	1		1	1	1		1														
Celtis																					
Cercis																					
Cestrum		1			1							1	1		1						
Chamaedorea	1																				
Chiococca																					

Appendix 2 cont.																					
	BBC7	BBC8	BBC9	MQ	MJ	BE	BO	MM	T1	T2	T3	TM	CM	GM	CO2	CO1	COM3	COM2	COM1	COS1	COS2
Chromolaena																				1	
Chusquea			1																		
Cinnamomum				1	1		1					1									
Cissus	1	1	1																		
Citharexylum			1	1											1						
Clarisia																					
Clematis					1																
Clethra		1		1			1	1			1	1	1		1	1			1	1	1
Cleyera										1	1			1							
Clidemia									1												
Clusia	1	1	1	1		1			1	1	1				1	1	1		1		
Cnidoscolus																	1				
Comarostaphylis																					
Combretum																					
Connarus																					
Conostegia	1	1	1	1	1			1	1		1				1	1					1
Cornus				1				1	1	1	1		1	1							
Cosmibuena			1																		
Costus																					
Coussarea																					
Crataegus																					
Critonia															1						
Croton														1							
Cupania	1													1							
Cyathea	1	1	1								1										
Cytharexylum																					
Dalbergia																					
Dalea																		1			
Daphnopsis																					
Dendropanax	1	1	1	1	1		1	1	1	1	1			1		1	1	1	1		1
Deppea													1								
Desmopsis																					
Dichapetalum	1	1	1																		
Dioclea				1																	
Diospyros																					

Appendix 2 cont.

	BBC7	BBC8	BBC9	MQ	MJ	BE	BO	MM	T1	T2	T3	TM	CM	GM	CO2	CO1	COM3	COM2	COM1	COS1	COS2
Dirca																					
Disterigma			1																		
Doliocarpus																					
Drimys																					
Dussia																					
Elaeagia	1	1	1																		
Erythrina																	1	1			
Erythroxylum																					
Escallonia																					
Eugenia	1	1					1					1		1							
Euonymus																					
Eupatorium					1																
Euphorbia					1			1													
Fagus												1									
Faramea																					
Ficus																1		1			
Forestiera																					
Fraxinus				1	1																
Fuchsia						1							1								
Gaiadendron	1																				
Galphimia																					1
Garcinia																					
Garrya													1								
Gaultheria																					
Geonoma	1		1																		
Gleditsia																					
Glossostipula																					
Gonocalyx																					
Gonzalagunia		1																			
Gordonia																					
Gouania																					
Guarea	1	1	1	1											1	1	1	1	1		1
Guatteria	1	1	1																		
Guettarda		1																			
Gymnanthes																	1				

Appendix 2 cont.																					
	BBC7	BBC8	BBC9	MQ	MJ	BE	BO	MM	T1	T2	T3	TM	CM	GM	CO2	CO1	COM3	COM2	COM1	COS1	COS2
Gyrotaenia																	1				
Hamamelis																					
Hamelia																					
Hedyosmum																		1			
Heliconia		1	1																		
Helicostylis				1													1				
Hibiscus																					
Hillia	1																				
Hoffmannia		1																			
Hybanthus									1												
Hydrangea	1	1																			
Hyeronima	1	1	1																		
Ilex	1	1					1		1	1	1		1								
Illicium																					
Inga	1		1	1			1		1	1	1			1	1	1	1	1	1		1
Juglans												1					1				
Juniperus																					
Lacistema																					
Lantana																1					
Leandra					1																
Leucaena																					
Liabum																					
Licania																					
Licaria																					
Ligustrum							1														
Lindera																					
Lippia														1							
Liquidambar							1					1		1							
Liriodendron																					
Litsea											1		1								
Lonchocarpus							1								1	1					
Lunania																					
Lycianthes															1			1			
Lysiloma																					
Machaerium																					

Appendix 2 cont.																					
	BBC7	BBC8	BBC9	MQ	MJ	BE	BO	MM	T1	T2	T3	TM	CM	GM	CO2	CO1	COM3	COM2	COM1	COS1	COS2
Magnolia				1	1			1		1											
Malus																					
Malvaviscus	1	1															1				
Marcgravia	1		1																		
Marsdenia															1	1	1				
Matayba	1		1																		
Matudaea				1																	
Meliosma	1	1	1	1	1		1					1									
Mendoncia																					
Meriania		1																			
Miconia	1	1	1			1				1			1			1	1	1		1	1
Mikania			1																		
Mollinedia	1	1	1																		
Montanoa													1								
Morus																					
Muehlenbeckia	1																				
Myrcia	1		1			1															
Myrcianthes									1					1							
Myrica						1							1								
Myrrhidendron																					
Myrsine			1						1				1	1							
Nectandra														1		1	1				
Neomirandea	1																				
Nyssa																					
Ocotea	1	1					1														
Oreomunnea																					
Oreopanax	1	1	1	1	1	1	1						1	1	1	1	1				
Osmanthus											1										
Ostrya				1			1	1	1	1	1	1	1								
Ouratea																					
Palicourea	1	1	1				1							1							
Parathesis				1	1			1						1							
Parthenocissus							1										1				
Passiflora		1																			
Paullinia							1														

Appendix 2 cont.

	BBC7	BBC8	BBC9	MQ	MJ	BE	BO	MM	T1	T2	T3	TM	CM	GM	CO2	CO1	COM3	COM2	COM1	COS1	COS2
Peltostigma																					
Perrottetia					1		1											1			
Persea				1	1				1	1	1		1		1	1	1	1	1	1	1
Phenax																	1		1		
Philodendron	1	1	1																		
Phoebe													1								
Photinia															1		1		1		
Phyllonoma						1															
Picramnia	1						1							1							
Picrasma																					
Pinus						1		1			1		1								
Piper	1	1	1		1		1							1		1	1	1	1		
Pithecoctenium							1														
Platymiscium																					
Podocarpus				1					1	1	1	1									
Podocnemium				1																	
Polybotrya																					
Populus																					
Pouteria	1																1	1			
Pouzolzia																					
Prestoea	1		1																		
Protium																					
Prunus				1								1	1					1			
Psammisia	1	1																			
Pseudolmedia																					
Psidium																					
Psychotria	1	1					1							1							
Quercus				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Quetzalia	1																				
Randia							1							1	1						
Rapanea												1				1					
Rhacoma																					
Rhamnus						1			1			1									
Robinia																					
Roldana																					

Appendix 2 cont.																					
	BBC7	BBC8	BBC9	MQ	MJ	BE	BO	MM	T1	T2	T3	TM	CM	GM	CO2	CO1	COM3	COM2	COM1	COS1	COS2
Rondeletia	1	1	1	1		1			1								1				
Ruagea			1																		
Rubus	1		1																		
Sabicea																					
Salacia																					
Salix																					
Sapium		1													1	1	1				
Sassafras																					
Satyria	1																				
Saurauia		1	1			1	1		1				1						1		
Scharadera			1																		
Schefflera	1	1	1																		
Schlegelia			1																		
Sebastiana				1													1				
Sebastiania																		1	1	1	1
Senecio			1											1							
Serjania					1																
Sideroxylon																					
Siparuna	1	1	1																		
Smilax					1		1								1						
Solandra																					
Solanum				1	1									1							
Sophora																					
Sphaeradenia																					
Staphylea																					
Stemmadenia																					
Styrax						1								1	1	1				1	1
Symplocarpus					1																
Symplococarpon				1				1							1	1	1	1			
Symplocos	1			1		1		1	1	1	1		1								1
Synardisia								1													
Tapura																					
Terminalia																					
Ternstroemia									1	1	1	1					1				
Tetrorchidium	1	1	1																		

Appendix 2 cont.

	BBC7	BBC8	BBC9	MQ	MJ	BE	BO	MM	T1	T2	T3	TM	CM	GM	CO2	CO1	COM3	COM2	COM1	COS1	COS2
Thevetia																					
Thibaudia		1	1																		
Ticodendron			1																		
Tilia					1							1									
Topobea		1	1																		
Tournefortia																					
Tovomitopsis	1		1																		
Toxicodendron							1														
Trema																					
Trichilia			1	1	1		1							1	1		1	1			1
Tridimeris																					
Trophis				1			1							1							1
Tsuga																					
Turpinia				1	1		1														
Ulmus																					
Urera		1													1		1				
Vaccinium	1																				
Vallesia																					
Verbesina													1			1					
Viburnum				1	1	1							1								
Vitis					1		1									1	1		1		
Weinmannia			1																		
Witheringia																					
Xylosma		1		1	1																
Zanthoxylum	1			1											1						
Zinowiewia			1	1	1			1	1	1	1										

Appendix 2 cont.

	COS3	COS4	GWS1	GWS2	GWS3	GWS4	GWS5
Abies							
Abuta							
Acer							
Aegiphila							
Aesculus							
Ageratina							
Agonandra							

Appendix 2 cont.

	COS3	COS4	GWS1	GWS2	GWS3	GWS4	GWS5
Aiouea							
Alchornea							
Alfaroa							
Alibertia							
Allosanthus							
Alnus							
Alsophila							
Amelanchier							
Amphitecna							
Annona							
Anthurium							
Arachnotrix				1	1		
Arbutus		1					
Ardisia	1						
Aristolochia							
Asclepias							
Asimina							
Asplundia							
Axinaea							
Bactris							
Berberis	1						
Besleria							
Betula							
Bielschmeidia							
Billia							
Blakea							
Brunellia							
Buddleja							
Bumelia							
Bunchosia							
Bursera							
Calatola							
Calliandra							
Calophyllum							
Calyptranthes							

Appendix 2 cont.							
	COS3	COS4	GWS1	GWS2	GWS3	GWS4	GWS5
Canavalia	1						
Carpinus	1	1			1		1
Carya							
Casearia							
Cassia							1
Cassipourea							
Castanea							
Cavendishia							
Ceanothus							
Cecropia							
Cedrela							
Celastrus							
Celtis							
Cercis							
Cestrum							
Chamaedorea							
Chiococca					1		
Chromolaena							
Chusquea							
Cinnamomum							
Cissus							
Citharexylum							
Clarisia							
Clematis							
Clethra	1	1	1		1	1	1
Cleyera			1	1	1	1	
Clidemia							
Clusia							
Cnidoscolus							
Comarostaphylis							
Combretum							
Connarus							
Conostegia							
Cornus	1	1					
Cosmibuena							

Appendix 2 cont.							
	COS3	COS4	GWS1	GWS2	GWS3	GWS4	GWS5
Costus							
Coussarea							
Crataegus							
Critonia							
Croton							
Cupania							
Cyathea							
Cytharexylum				1	1		
Dalbergia							
Dalea							
Daphnopsis							
Dendropanax							
Deppea							
Desmopsis							
Dichapetalum							
Dioclea							
Diospyros							
Dirca							
Disterigma							
Doliocarpus							
Drimys			1		1		
Dussia							
Elaeagia							
Erythrina							
Erythroxylum							
Escallonia							
Eugenia				1	1		
Euonymus				1	1		
Eupatorium							
Euphorbia							
Fagus			1	1	1	1	1
Faramea							
Ficus							
Forestiera							
Fraxinus							

Appendix 2 cont.							
	COS3	COS4	GWS1	GWS2	GWS3	GWS4	GWS5
Fuchsia							
Gaiadendron							
Galphimia							
Garcinia							
Garrya							
Gaultheria			1				
Geonoma							
Gleditsia							
Glossostipula							
Gonocalyx							
Gonzalagunia							
Gordonia							
Gouania							
Guarea							
Guatteria							
Guettarda							
Gymnanthes					1	1	
Gyrotaenia							
Hamamelis							
Hamelia							
Hedyosmum							
Heliconia							
Helicostylis							
Hibiscus							
Hillia							
Hoffmannia							
Hybanthus							
Hydrangea							
Hyeronima							
Ilex				1	1	1	1
Illicium							1
Inga	1						
Juglans							
Juniperus							
Lacistema							

Appendix 2 cont.							
	COS3	COS4	GWS1	GWS2	GWS3	GWS4	GWS5
Lantana							
Leandra							
Leucaena							
Liabum							
Licania							
Licaria							
Ligustrum							
Lindera							
Lippia							
Liquidambar			1				1
Liriodendron							
Litsea							
Lonchocarpus							
Lunania							
Lycianthes							
Lysiloma							
Machaerium							
Magnolia			1	1	1	1	1
Malus							
Malvaviscus							
Marcgravia							
Marsdenia							
Matayba							
Matudaea							
Meliosma							
Mendoncia							
Meriania							
Miconia	1	1	1				
Mikania							
Mollinedia							
Montanoa							
Morus							
Muehlenbeckia							
Myrcia							
Myrcianthes							

Appendix 2 cont.							
	COS3	COS4	GWS1	GWS2	GWS3	GWS4	GWS5
Myrica							
Myrrhidendron							
Myrsine							
Nectandra				1	1		
Neomirandea							
Nyssa							
Ocotea							
Oreomunnea							
Oreopanax	1	1	1	1	1		
Osmanthus							
Ostrya							
Ouratea							
Palicourea			1				
Parathesis							
Parthenocissus							
Passiflora							
Paullinia							
Peltostigma							
Perrottetia							
Persea		1	1		1		1
Phenax							
Philodendron							
Phoebe							
Photinia		1					
Phyllonoma							
Picramnia							
Picrasma							
Pinus						1	1
Piper							
Pithecoctenium							
Platymiscium							
Podocarpus				1	1		1
Podocnemium							
Polybotrya							
Populus							

Appendix 2 cont.							
	COS3	COS4	GWS1	GWS2	GWS3	GWS4	GWS5
Pouteria							
Pouzolzia							
Prestoea							
Protium							
Prunus			1	1			
Psammisia							
Pseudolmedia							
Psidium							
Psychotria							
Quercus	1	1	1	1	1		1
Quetzalia							
Randia							
Rapanea							
Rhacoma							
Rhamnus			1		1		1
Robinia							
Roldana							
Rondeletia	1						
Ruagea							
Rubus							
Sabicea							
Salacia							
Salix							
Sapium							
Sassafras							
Satyria							
Saurauia							
Scharadera							
Schefflera							
Schlegelia							
Sebastiana							
Sebastiania	1	1					
Senecio							
Serjania							
Sideroxylon							

Appendix 2 cont.							
	COS3	COS4	GWS1	GWS2	GWS3	GWS4	GWS5
Siparuna							
Smilax							
Solandra							
Solanum							
Sophora							
Sphaeradenia							
Staphylea							
Stemmadenia							
Styrax	1						
Symplocarpus							
Symplococarpon	1	1					
Symplocos					1	1	
Synardisia							
Tapura							
Terminalia							
Ternstroemia	1		1	1	1		1
Tetrorchidium							
Thevetia							
Thibaudia							
Ticodendron							
Tilia							
Topobea							
Tournefortia							
Tovomitopsis							
Toxicodendron							
Trema							
Trichilia							
Tridimeris							
Trophis							
Tsuga							
Turpinia							
Ulmus							
Urera							
Vaccinium			1	1	1	1	
Vallesia							

Appendix 2 cont.							
	COS3	COS4	GWS1	GWS2	GWS3	GWS4	GWS5
Verbesina							
Viburnum							
Vitis							
Weinmannia			1		1		
Witheringia							
Xylosma							
Zanthoxylum							
Zinowiewia							

APPENDIX 3

IMPORTANCE VALUES OF TREES IN CLOUD FOREST SUGAR MAPLE SITES

Site 1 is Tamaulipas, 2 is Talpa de Allende, 3 is Sierra de Manantlán, 4 is Tenejapa, and 5 is Las Minas (Guatemala).

Family	Species	Sites				
		1	2	3	4	5
Pinaceae	*Abies guatemalensis* Rehder var. *jaliscana* Martinez		6.24			
Aceraceae	*Acer saccharum* subsp. *skutchii* (Rehder) E.Murray	16.1	9.64	14.8	4.4	17.24
Betulaceae	*Alnus acuminata* Kunth subsp. *arguta* (Schltdl.)Furlow				9.52	
Myrsinaceae	*Ardisia compressa* Kunth				0.73	2.38
Myrsinaceae	*Ardisia verapazensis* Donn.Sm.					11.48
Buddlejaceae	*Buddleja skutchii* C.V.Morton				4.06	
Leguminosae	*Calliandra anomala* (Kunth) Macbr.		0.19			
Leguminosae	*Calliandra laevis* Rose		0.25			
Betulaceae	*Carpinus caroliniana* Walter	6.05	5.57	10.29		1.34
Juglandaceae	*Carya ovata* var. *mexicana* (Engel.) Manning	0.61				
Solanaceae	*Cestrum elegantissimum* C.V. Morton				1.6	
Solanaceae	*Cestrum laxum* Benth.	1.23				
Solanaceae	*Cestrum luteovirescens* Francey				1.86	
Lauraceae	*Cinnamomum aerolatum* (Lundell) Kosterm		0.19			
Lauraceae	*Cinnamomum bractefoliaceum* Loera-Hern.	1.85				
Lauraceae	*Cinnamomum effusum* (Meisn.)Kosterm.		0.19			
Clethraceae	*Clethra nicaraguensis* C.W.Ham.				3.39	
Clethraceae	*Clethra pringlei* S.Wats	5.52				
Clethraceae	*Clethra vicentina* Standl.		1.34	5.33		
Theaceae	*Cleyera integrifolia* (Benth.) Choisy		2.47			
Theaceae	*Cleyera theoides* (Sw.) Choisy					1.28
Melastomataceae	*Clidemia* sp.		0.38			
Guttiferae	*Clusia salvinii* Donn.Sm.		6.57			
Melastomataceae	*Conostegia volcanalis* Standl. & Steyerm.		2.05	1.11		
Cornaceae	*Cornus disciflora* Sessé & Moc. ex DC.		2.34	3.56	3.34	6.33
Cornaceae	*Cornus excelsa* Kunth	0.61			9.79	
Euphorbiaceae	*Croton niveus* Jacq.					1.57
Sapindaceae	*Cupania dentata* Glaz.					1.84
Cyatheaceae	*Cyathea costaricensis* (Kuhn) Domin		0.23			
Araliaceae	*Dendropanax arboreus* (L.) Decne. & Planch.		1.9	7.75		2.59
Rubiaceae	*Deppea flava* (Brandegee)L.O.Williams				0.6	
Myrtaceae	*Eugenia capuli* Schlecht.	1.12				
Myrtaceae	*Eugenia guatemalensis* Donn.Sm.					1.8
Celastraceae	*Euonymus costaricensis* Standl.	0.61				
Euphorbiaceae	*Euphorbia schlechtendalii* Boiss. var. *pacifica* McVaugh			17.49		
Fagaceae	*Fagus grandifolia* var. *mexicana* Mart. Little	6.88				
Oleaceae	*Fraxinus uhdei* (Wenz.) Lingelsh.		0.19			
Onagraceae	*Fuchsia arborescens* Sims				1.01	
Onagraceae	*Fuchsia bacillaris* Lindl.		0.19			

Appendix 3 cont.

Family	Species	Sites 1	2	3	4	5
Garryaceae	*Garrya laurifolia* subsp. *quichensis* (Donn.Sm.)Dahling				0.54	
Violaceae	*Hybanthus elatus* (Turcz.)Morton		0.19			
Aquifoliaceae	*Ilex brandegeeana* Loes.		3.37			
Aquifoliaceae	*Ilex discolor* Hemsl.	0.61				
Aquifoliaceae	*Ilex dugesii* Fernald		0.19			
Aquifoliaceae	*Ilex* sp.		0.86			
Aquifoliaceae	*Ilex vomitoria* Aiton subsp. *chiapensis* (Sharp)E.Murria				0.52	
Illiciaceae	*Illicium floridianum* Ellis	0.61				
Leguminosae	*Inga flexuosa* Schlecht.					0.79
Leguminosae	*Inga hintonii* Sandwith		1.95			
Juglandaceae	*Juglans mollis* Engelm.	1.64				
Asteraceae	*Koanophyllon* sp.				0.5	
Lauraceae	*Licaria cervantesii* (Kunth) Kosterm.		0.19			
Verbenaceae	*Lippia myriocephala* Schltdl. & Cham.					1.84
Hamamelidaceae	*Liquidambar styraciflua* L.	11.46				4.24
Lauraceae	*Litsea acuminatisima* Lundell				1.62	
Lauraceae	*Litsea glaucescens* H.B.K.		0.19			
Solanaceae	*Lycianthes pilosissima* Bitter					0.73
Magnoliaceae	*Magnolia iltsiana* A. Vázquez			6.57		
Magnoliaceae	*Magnolia pacifica* A. Vázquez var. *pacifica*		1.74			
Magnoliaceae	*Magnolia tamaulipana* A. Vázquez	1.28				
Malvaceae	*Malvaviscus arboreus* Cav.					0.73
Sabiaceae	*Meliosma oaxacana* Standl.	1.04				
Melastomataceae	*Miconia glaberrima* (Schlecht.) Naud.		0.57		3.82	
Polygalaceae	*Monnina sylvatica* Schltdl. & Cham.				0.5	
Asteraceae	*Montanoa hexagona* Robins & Greenm.				8.98	
Myrtaceae	*Myrcianthes fragrans* (Sw.) McVaugh		0.62			2.18
Myricaceae	*Myrica cerifera* L.				1.42	
Myrsinaceae	*Myrsine coriacea* (Sw.)R.Br. subsp. *nigrescens* (Lundell)Ricketson & Pipoly					1.25
Myrsinaceae	*Myrsine coriacea* (Sw.) R. Br. ex Roem & Schult subsp. *coriacea*				3.73	
Myrsinaceae	*Myrsine juergensenii* (Mez)Ricketson & Pipoly		0.87			
Lauraceae	*Nectandra davidsoniana* C.K.Allen					1.86
Lauraceae	*Nectandra mirafloris* van der Werff					0.74
Araliaceae	*Oreopanax echinops* (Cham. Et Schltdl.) Decne & Planch.					1.69
Araliaceae	*Oreopanax peltatus* Linden ex Regel.					0.91
Araliaceae	*Oreopanax xalapense* Decne. & Planch.				2.24	
Oleaceae	*Osmanthus americana* (L.) Benth et Hook.		0.19			
Betulaceae	*Ostrya virginiana* C.Koch	1.59	7.02	4.23	1.29	
Rubiaceae	*Palicourea galeottiana* M. Martens					3.31
Myrsinaceae	*Parathesis pleurobotryosa* Donn.Sm.					0.8
Myrsinaceae	*Parathesis rubriflora* Lundell					0.91
Myrsinaceae	*Parathesis serrulata* (Sw.) Mez.					2.04
Myrsinaceae	*Parathesis villosa* Lundell			9.17		
Celastraceae	*Perrottetia longistylis* Rose			1.42		

Appendix 3 cont.

Family	Species	Sites				
		1	2	3	4	5
Lauraceae	*Persea chrysobalanoides* Lundell				3.32	
Lauraceae	*Persea hintonii* C.K.Allen		1			
Lauraceae	*Phoebe* aff. *saxchanalensis* Lundell				2.43	
Pinaceae	*Pinus maximinoi* H.E.Moore		1.64			
Pinaceae	*Pinus patula* Schlecht. & Cham. subsp. *tecunumanii* (Eguiluz & Perry)Styles				1.55	
Pinaceae	*Pinus pseudo-strobus* Lindl.			1.19		
Piperaceae	*Piper aduncum* L.					3.47
Piperaceae	*Piper amalago* L.					1.61
Podocarpaceae	*Podocarpus reichei* Buchholz & A.Gray	11.32	16.18			
Simaroubaceae	*Picramnia antidesma* Sw.					0.95
Rosaceae	*Prunus brachybotrya* Zucc.				9.11	
Rosaceae	*Prunus serotina* Ehremb.	0.91			7.76	
Rosaceae	*Prunus serotina* Ehrh. subsp. *serotina*					
Rubiaceae	*Psychotria involucrata* A.Rich.					2.42
Rubiaceae	*Psychotria tenuifolia* Sw.					0.95
Fagaceae	*Quercus candicans* Née			1.08		
Fagaceae	*Quercus germana* Schlecht. & Cham.	10.66				
Fagaceae	*Quercus lanceolata* Humb. & Bonpl.				0.5	
Fagaceae	*Quercus lancifolia* Schlecht. & Cham.				0.59	
Fagaceae	*Quercus laurina* Humb. & Bonpl				1.4	
Fagaceae	*Quercus salicifolia* Nee		4.88	1.93		
Fagaceae	*Quercus sapotaefolia* Liebm.					0.92
Fagaceae	*Quercus sartorii* Liebm.	3.98				
Fagaceae	*Quercus skinneri* Benth.					2.28
Fagaceae	*Quercus uxoris* McVaugh		0.33			
Fagaceae	*Quercus xalapensis* Humb et Bonpl.	3.41	0.92			
Rubiaceae	*Randia mitis* L.					0.76
Myrsinaceae	*Rapanea myricoides* (Schltdl.) Lundell	0.62				
Rhamnaceae	*Rhamnus capreifolia* Schltdl.		0.19			
Rhamnaceae	*Rhamnus caroliniana* Walt.	1.39				
Rubiaceae	*Rondeletia amoena* Hemsl.					0.73
Rubiaceae	*Rondeletia leucophylla* H.B.& K.		1.19			
Actinidiaceae	*Saurauia scabrida* Hemsley				0.51	
Actinidiaceae	*Saurauia serrata* DC.		0.83			
Actinidiaceae	*Saurauia villosa* DC.				0.51	
Asteraceae	*Senecio cobanensis* J.M.Coult.					6.63
Asteraceae	*Senecio ghiesbreghtii* Hort.Hal. ex Regel var. *uspantanensis* J.M.Coult.					0.89
Asteraceae	*Senecio petasioides* Greenm.					0.74
Solanaceae	*Solanum brachystachys* Dun			1.08		
Solanaceae	*Solanum nigricans* Mart. & Galeotti					0.74
Styracaceae	*Styrax argenteus* C.Presl					1.79
Theaceae	*Symplococarpon purpusii* (Brandegee) Kobuski			1.78		
Symplocaceae	*Symplocos citrea* La Llave & Lex.		5.71	1.38		
Symplocaceae	*Symplocos* sp.				0.59	

Appendix 3 cont.

Family	Species	Sites				
		1	2	3	4	5
Myrsinaceae	*Synardisia venosa* (Mast.) Lundell			1.08		
Theaceae	*Ternstroemia lineata* DC.		1.3			
Theaceae	*Ternstroemia* sp.	0.61				
Theaceae	*Ternstroemia sylvatica* Schltdl. & Cham.	5.55				
Tiliaceae	*Tilia houghii* Rose	1.39				
Meliaceae	*Trichilia havanensis* Jacq.					2.01
Moraceae	*Trophis involucrate* W.C.Burger					1.23
Staphyleaceae	*Turpinia occidentalis* (Swartz) G.Don	1.36				
Asteraceae	*Verbesina apleura* S.F.Blake				0.51	
Asteraceae	*Verbesina guatemalensis* B.L.Rob. & Greenm.				0.64	
Caprifoliaceae	*Viburnum jucundum* C.V.Morton subsp. *jucundum*				5.12	
Rutaceae	*Zanthoxylun melanostictum* Cham. & Schltdl.		0.67			
Celastraceae	*Zinowiewia concinna* Lundell		7.31	8.77		

VITA

Yalma Luisa Vargas Rodriguez born in Guadalajara, Mexico. She is daugher of Francisco Vargas Aguilar and María Luisa Rodriguez Gutiérrez and the sister of María de los Angeles Vargas Rodríguez and Raúl Vargas Rodríguez. She studied biology at Universidad de Guadalajara. She spent a couple of years assisting research projects at Instituto Manantlán de Ecología y Conservación de la Biodiversidad, in the Sierra de Manantlán Biosphere Reserve (SMBR). While in SMBR, she worked under the direction of Dr. Lázaro Sánchez, M.S. Angela Saldaña, and M.S. Enrique Jardel, in projects of montane forest ecology and *Zea diploperennis* demography. She performed later her undergraduate research in tropical dry forest ecology at SMBR, under the supervision of Dr. Antonio Vázquez-García. She worked some years at the Instituto de Botánica from Universidad de Guadalajara. While at the Instituto de Botánica, she mainly participated in the projects Flora and Vegetation of Jalisco and Colima, Flora of Northern Jalisco, and North Coast of Jalisco Conservation Proposal. She came to LSU to pursue a Master of Science degree under the supervision of Dr. William J. Platt. After her graduation, she plans to pursue a doctoral degree and continue working with forest ecology and tree population genetics.