PROTECTED AREAS OF WESTERN MEXICO:

STATUS, MANAGEMENT, AND NEEDS

Edited by

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A PROJECT OF COLORADO BIRD OBSERVATORY

September 1, 1997

PROLOGUE

The Colorado Bird Observatory (CBO) was founded in 1988 to address the conservation needs of birds in the Rocky Mountains and Great Plains. CBO has employed a broad spectrum of tactics toward this end, including intensive study of endangered species; habitat assessments for the birds of endangered ecosystems; monitoring of population status of Colorado's breeding avifauna; and setting conservation, management, and monitoring priorities for breeding Neotropical migratory birds for all 50 U.S. states. In addition to a strong research program, CBO has implemented programs aimed at improving environmental education in both Mexico and the United States.

Given that many of Colorado's birds are Neotropical migrants, many of CBO's activities have focused on determining habitat requirements, population status, and conservation priorities for these species. Recognizing the critical dependency of Neotropical migrants on adequate wintering habitats, as well as the needs of the many species of birds resident in Mexico, many of which occur nowhere else, CBO began work in western Mexico in the winter of 1991–1992, focusing on the five Pacific coastal states of Jalisco, Colima, Michoacán, Guerrero, and Oaxaca. From these initial explorations, in an effort to contribute to the efficacy of conservation efforts in the region, the present effort was born—a summary and analysis of the status and needs of western Mexico's protected natural areas.

Principal objectives of this effort are the following:

(1) To compile a list of protected areas in western Mexico
(2) To assess adequacy of protection accorded to these areas
(3) To identify needs of individual protected areas
(4) To identify areas of importance in terms of biodiversity that lack protection
(5) To promote cooperative international conservation efforts in western Mexico

With these goals in mind, we present this book. It is a unique product because it represents a collaboration among many communities of people interested in conservation in Mexico: conservationists, land managers, and academics—Mexicans and U.S. Americans. Moreover, instead of trying to resolve the conservation problems of the entire Neotropics, we have focused on partnerships within western Mexico, and feel that our efforts are made more fruitful by commitment to work with colleagues, collaborators, and friends within that one region.

It is our hope that much of the information compiled here will prove useful to land managers, conservationists, and biologists both within and outside Mexico. Conservation workers within Mexico are the people working "at the front" of the battle, and additional information may assist them in their efforts. We do, however, consider our primary audience to be outsiders—conservation groups, biologists, and land managers in the U.S. and other countries—looking to initiate or increase their commitment to conservation in Mexico.

With regard to information provided in this book, the reader will note some inconsistencies in details between areas. To some degree, these differences can be attributed to the number of authors contributing. On the other hand, they also reflect part of the reality of Mexico. Some sites have well-documented and reasonably complete avian inventories and other information relevant to conservation, whereas many others have only the most rudimentary information—some lack even basic bird lists. Hence, to provide many potentially useful details consistently across areas and states becomes quite challenging. Other discrepancies arise from lack of information and variable methodologies for identifying potential conservation sites. High priority areas may have been overlooked, and sites recommended provide only a preliminary list. Their inclusion does serve a purpose, however, if for no other reason, than to draw attention to the need for additional protected areas. Overall, these gaps in knowledge gaps make offering realistic comparisons or conservation appraisals virtually impossible.

This book, then, is a compilation of information regarding the protected natural areas of seven states in western Mexico. Much of it was written by specialists from Mexico—people who work towards conservation and understanding the biology of the areas and their faunas and floras—we are convinced that these are the

people who best understand the situations at each site, and across each state. Although the information we present here is certainly incomplete, our hope is that it is sufficient to provide an impulse towards gathering more information, and towards protecting better natural habitats across western Mexico. We anticipate publishing future versions of this book electronically over the World Wide Web, so as to make possible revisions and updates as necessary.

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ACKNOWLEDGMENTS

The Colorado Bird Observatory's work in Mexico has been assisted by generous support from the following agencies and organizations:

- Bureau of Land Management (Oregon State Office)
- Kaytee Avian Foundation
- National Fish & Wildlife Foundation
- The Nature Conservancy (Western Region & Mexico Program)
- U.S. Fish & Wildlife Service ●Region 1
- U.S. Fish & Wildlife Service ●Region 6
- U.S. Forest Service ●Rocky Mountain Region
- The University of Kansas Natural History Museum
- Victor Emmanuel Nature Tours
- Weeden Foundation
- Wray Trust

We express our grateful thanks to these institutions for their help. Special thanks are extended to Peter Stangel and Alison Dalsimer of the National Fish & Wildlife Foundation, Coppelia Hays of the Office of Migratory Bird Management, and Stephanie Jones of the U.S. Fish & Wildlife Service ● Region 6, all of whom generously offered counsel, support, and encouragement. Additional support has been provided by CBO members and the CBO Songbird Art Show.

We are especially pleased to have the opportunity to thank our cooperators in Mexico whose contributions have been essential to the success of this project. *Muchisimas gracias* to Elizabeth E. Aragón Piña, Jeffrey R. Bacon, Leonardo Cabrera García, Federico Casillas, Patricia Escalante Pliego, Griselda Escalona Segura, Alfredo Garza Herrera, Adriana Guzmán, Leticia Hernández, Enrique Jardel, Angeles Morales García, Adolfo Navarro Sigüenza, Carlos Palomera García, Jorge A. Rojas, Rosa M. Salazar, Neyra Sosa, Arturo Villaseñor Gómez, Fernando Villaseñor Gómez, and Laura Villaseñor Gómez. Biól. Fernando Vargas Márquez and other officials at SARH, SEDESOL, and SEMARNAP kindly made critical information available to contributors to this volume. Richard Hutto, Victor Sánchez-Cordero, *, and * provided valuable reviews of the entire manuscript. Additional assistance in Mexico has been received from Bruce Benz, Humberto Berlanga, Manuel Blanco, Yuriria Blanco, Oscar Cárdenas, Gerardo Ceballos, Alfredo Figueroa, Sergio Graf, Sandy Laham, Sarahy Contreras Martínez, Andrés García, Brian Miller, Angelica Narvaez, Jorge Nocedal Moreno, Silvia Salas, Victor Sánchez-Cordero, Eduardo Santana, Leo Schibli, and Osvaldo Tellez. We are particularly indebted to Richard Hutto and Adolfo Navarro Sigüenza for inspiring our interest in western Mexico.

A final thanks goes to the people of western Mexico, who have made us feel at home on every visit we have made to their beautiful land.

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ACRONYMS AND ABREVIATIONS

Acronym	Organization
CBO	Colorado Bird Observator
CFE	Comisión Federal de Electricidad
CIIDIR	Centro Interdisciplinario de Investigaciones para el Desarollo Integral Regional
CIPAMEX	Consejo Internacional para la Preservación de las Aves, Mexico, Mexican section of BirdLife International
CISIMA	Centro de Investigación Silvícola e Industria de la Madera
CONACyT	Consejo Nacional de Ciencias y Technologica
FECU	Fundación Ecológica de Cuixmala A.C.
IMECBIO	Instituto Manantlán de Ecología y Conservación de la Biodiversidad
INE	Instituto Nacional de Ecología
INEGI	Instituto Nacional de Estadística, Geografía e Informática
INIFAP	Instituto Nacional de Investigación Forestal y Agropecuaria
IPN	Instituto Politécnico Nacional
IUCN	International Union for the Conservation of Nature
ORSTOM	Institut Francais de Recherche Scientifique pour le Developpment en Cooperation
PAIR	Programa de Aprovechamiento Integral de Recursos
PIF	Partners in Flight
PROFEPA	Procuraduría Federal de Protección al Ambiente
SAHOP	Secretaría de Asistancia Humana y Obras Públicas
SARH	Secretaría de Agricultura y Recursos y Hidráulicos
SEDESOL	Secretaría para el Desarrollo Social

SEDUE	Secretaría de Desarrollo Urbano y Ecología (now SEDESOL)
SEMARINA	Secretaría de Marina
SEMARNAP	Secretaría del Medio Ambiente, Recursos Naturales y Pesquerías
SEP	Secretaría de Educación Publica
SEPESCA	Secretaría de Pesca
SINAP	Sistema Nacional de las Areas Protegidas
SPP	Secretaría de Programación y Presupuesto
SRA	Secretaría de la Reforma Agraria
SRH	Secretaría de Recursos Hidráulicos
UAEM	Universidad Autónoma del Estado de Morelos
UCODEFO	Unidad de Conservación y Desarrollo Forestal
UJED	Universidad Juárez del Estado de Durango
UMSNH	Universidad Michoacana de San Nicolás de Hidalgo
UNAM	Universidad Nacional Autónoma de México

PREFACE: WESTERN MEXICO ● A GLOBAL CONSERVATION PRIORITY -

Charles S. Aid, Enrique J. Jardel, Carlos Palomera Garcia, and A. Townsend Peterson

The narrow Pacific Slope of western Mexico, between the Tropic of Cancer and the Isthmus of Tehuantepec, is biologically both rich and highly unique. Across a wide variety of taxonomic groups, the same pattern is repeated: concentrations of unique—endemic—species are found in western Mexico, both in the lowlands along the coast and in the different mountain ranges that parallel it (Ramamoorthy et al. 1993, Peterson et al. 1993). Although the focus of this volume is on birds in protected areas in the region, it is important to bear in mind that many other taxonomic groups show foci of endemism in the region, making its effective protection a critical priority for biodiversity conservation efforts.

One of the world's richest congregations of migratory songbirds occurs in western Mexico (Hutto 1986). Roughly 75% of all western North American migratory birds spend the winter in this topographically complex region. John Terborgh, in his book *Where Have All the Birds Gone?* (1989), listed threatened species of Neotropical migrants, stating that Mexico "stands in the first place as the most significant winter destination of these potentially endangered species." Terborgh also pointed out that the preponderance of western migrants among species at risk results from their wintering in such narrowly represented habitats in western Mexico.

Although the conservation biology literature has concentrated principally on Neotropical migrants in Mexico, many other concerns need to be addressed. Considerations of the concentrations of endemic forms of many taxonomic groups in the region must also be included in the design of conservation strategies in the region—in fact, among birds alone, 40-80 species are endemic to the region, depending on taxonomic philosophy (Navarro and Peterson, in prep.). Other groups, such as mammals, butterflies, and plants, contribute many hundreds of additional forms (Ramamoorth et al. 1993). All in all, then, western Mexico represents a conservation priority at a global scale, on which many efforts both within and outside Mexico should focus.

Despite western Mexico's importance to migratory songbirds, the region has been largely ignored by land managers in both the U.S. and Mexico. Typically, the dominant voices of Eastern migratory bird conservation, coupled with those promoting "rainforest" conservation, have largely focused on the Atlantic Slope, the Yucatan Peninsula, and the state of Chiapas. Largely neglected in that approach is tropical deciduous forest, less than 2% of which remains, making it the most threatened tropical forest habitat in the New World (Janzen 1988, Greenberg and Reaser 1995). Also neglected is Mexico's rich store of endemic bird species, which are heavily concentrated in western Mexico, and next to absent in the southeastern lowlands (Escalante *et al.* 1993). Many of these species are highly threatened or endangered, and merit immediate attention from conservationists (Flores Villela and Gerez 1988). From the Mexican perspective, endemics are a far more important and immediate concern than migrants, and migratory bird conservation that benefitted endemics would be a positive step towards international "partnering."

Only recently has change become evident. The first international symposium devoted specifically to the conservation of Neotropical landbirds in Mexico was held in 1993, with 32% of the papers having a western Mexico emphasis (Wilson and Sader 1995). In 1997, CIPAMEX declared the El Carricto del Huichol area of Jalisco as Mexico's first Important Bird Area, thereby helping to gain international support for this important western Mexico site. Now, many efforts are coming to life to promote conservation of biodiversity in the region.

Conservation efforts within western Mexico are influenced by complex social dynamics and associated environmental problems. Although the western Mexican states of Oaxaca, Guerrero, Michoacán, and Jalisco rank among the top six in terms of biodiversity, they also rank among the highest in economic marginality (Flores Villela and Gerez 1988). Between 56% and 79% of the people within these states live on less than two minimum salaries (Consejo Nacional de Población 1993), creating situations like that in Jalisco, in which over half of the state's population is concentrated in the Guadalajara metropolitan area, with an impressive annual growth rate of 2%. This and other urban agglomerations are now facing critical problems of pollution, water supply, and environmental degradation, and are rapidly absorbing and destroying surrounding natural areas. Much of the region faces severe problems with erosion (Cureil 1990), and the quantity and quality of fresh

water sources are decreasing. Deforestation and extinction rates are increasing daily; coastlines are being polluted; and the quality of beaches and coastal lagoons is diminishing as a result of pressure from tourism (Ortega 1995).

Existing parks and reserves, by international standards, are too few and too small (Flores Villela and Gerez 1988). In comparison with Costa Rica, 9% of which is protected (WRI 1988), less than 1% of western Mexico is protected (Flores Villela and Gerez 1988). Furthermore, existing reserves often do not correspond to foci of regional biodiversity, often being located in non-native or degraded habitat. Finally, many western Mexican reserves suffer from ineffective management, lack of funding, lack of continuity, and lack of effective protection. On the positive side, Mexico has far more potential sites than Costa Rica, and has begun to successfully apply the biosphere reserve model to a few outstanding areas.

In the past decade, land managers in the United States have begun understanding the necessity of viewing conservation from a hemispheric perspective, rather than a national one. In this context, the appropriateness of supporting Mexican conservation efforts becomes increasingly obvious. This lesson is especially true with regard to birds, a shared biological resource through which mutual concern and understanding can lead to international cooperation. In the western United States, the importance of western Mexico to our shared migratory birds must now be understood, and work must begin to understand better the conservation issues affecting the wintering grounds of these birds. It is imperative, also, that this new perspective appreciate the rich biodiversity in many taxa in the region as part of our own North American natural heritage. Political borders should not preclude our taking an active interest in this important region, and extending our capacity for assisting conservation accordingly.

Thus far, little attention has been given by U.S. governmental and non-governmental organizations to conservation in western Mexico. However, growing pressures on natural resources force a constant race against time. Viable conservation initiatives that can provide results in the short term must be begun, or we may forever lose the opportunity to conserve the rich biodiversity found in western Mexico. Our hope in the present effort is that, by describing both the current situation and future opportunities, we may assist our readers in making their own contributions in terms of time, knowledge, assistance, and/or financial support to conservation efforts in western Mexico, and that the end result will be a richer legacy to the future of Mexico's natural diversity.

Chapter 1. BIODIVERSITY OF WESTERN MEXICO - Enrique J. Jardel, Leticia Hernández, Carlos Palomera Garcia, A. Townsend Peterson, J. Fernando Villaseñor Gómez, and Charles S. Aid

Mexico ranks among the most biologically diverse countries on Earth, and as a consequence is considered a "megadiverse" country (Mittermeier 1988). This designation suggests that on a global basis, Mexico ranks among the ten countries with highest levels of diversity and endemism. Although many habitats and geographic features of eastern and southern Mexico are continuous north into the United States and south to Central America, western Mexico holds many isolated habitats that represent a storehouse of biological diversity completely unique to the country. In fact, much of what distinguishes the country in terms of its biodiversity is found in western Mexico.

Many features of the Mexican landscape have worked together to produce western Mexico's diverse and unique fauna. In this chapter, several features of Mexican geography are reviewed, followed by a summary of the diversity of vegetation types in the region. Finally, we outline the biological diversity of western Mexico in an attempt to illustrate the dimensions of the region as a world focus of biological diversity deserving of earnest conservation attention.

GEOLOGY

Geologic history has served to create the mosaic nature of the Mexican landscape. North and South America were separate continents whose plants and animals evolved independently of one another. While North America had important connections with Eurasia, South America was isolated for 60 million years, permitting the evolution of a unique and diverse biota (Raven and Axelrod 1974). Approximately seven million years ago, as a result of continental drift, North and South America began to effect a biological exchange through a chain of intermediate islands. The islands also afforded ample opportunity for new species to develop in isolation. Central America fully emerged four million years later, becoming a land bridge that completed the process of exchange (Raven and Axelrod 1974, Gentry 1982).

The montane portion of this area is known as the Mesoamerican Montane Transition Zone (Halffter 1978), consisting of a mixture of plants and animals of different biogeographic origins. Within the transition zone, which extends north as far as Jalisco or even Sonora, are unique communities such as cloud forest that have species of origin both in the North Temperate and Neotropical realms (Rzedowski 1978, Jardel *et al*. 1994). These conditions are seen in just a few other places in the world, such as the Himalayas and Indonesia.

Most of the major mountain ranges of Mexico are old, especially the Sierra Madre Occidental, Sierra Madre Oriental, and the Sierra Madre del Sur, all of which date at least to the early Tertiary, *ca.* 50-65 million years ago. In the past four million years, however, the Transvolcanic Belt—the line of high and often active volcanoes crossing central Mexico—was created as a geologic hotspot moved west-to-east under Mexico. These mountain ranges determine much of the geography of habitats in Mexico, creating humid montane areas, dry interior valleys, and other geographic features. Hence, most major topographical features of Mexico were in place approximately four million years ago.

PHYSIOGRAPHY

Western Mexico, as treated herein, extends south and southeast from southern Sonora through Sinaloa, Durango, Nayarit, Jalisco, Colima, Michoacán, and Guerrero, to Oaxaca and the Isthmus of Tehuantepec (Fig. 1.1). Major physiographic provinces in this eight-state region include the Sierra Madre Occidental, Central Mexican Plateau, Transvolcanic Belt, Sierra Madre del Sur, Balsas Basin, northern Pacific coastal plains, and southern Pacific coastal plains (Fig. 1.2). The region includes more than 2600 km of coastline.

Topographically, the region is extremely complex, rising from coastal plains to mountain summits over 3000 m in a few tens of kilometers, and reaching 4330 m at the summit of the Nevado de Colima. Throughout the region are vast highlands with steep canyons and mountainous terrain, creating numerous isolated valleys and basins, many of which drain internally to form closed watersheds. The Pacific coastal plains are generally only a few kilometers wide, meeting abruptly the steep coastal mountain ranges. In places, the sierras drop so

precipitously to the ocean that the coastal plain vanishes as at Acapulco where the mountains form the city's famed amphitheater. The Transvolcanic Belt, which crosses Mexico almost from coast to coast, separates the Central Mexican Plateau from regions to the south; the Balsas Basin, where the nation's hottest temperatures are recorded, separates the highlands of the Transvolcanic Belt from those of the Sierra Madre del Sur. The low plains of the Isthmus of Tehuantepec serve both as a corridor between the Pacific and Atlantic coastal plains, and as an interruption of the highland regions of Mexico and northern Central America.

As a result, western Mexico has a highly complex and discontinuous physiography. Landforms, combined with climate and historical factors, determine the habitats to be found in a region, so western Mexico's extreme physiographic complexity has been translated into a mosaic of isolated patches of many and varied habitats. This complexity has also led to discrepancies in physiographic region boundaries depending on whether geologic, faunistic, or other criteria are used, as is evident even among the contributions to this book.

CLIMATE

Mexico includes the northern limit of tropical climates in the New World. Interestingly, because of its dramatic topography, tropical, temperate, and even arctic conditions all are often present in the space of a few kilometers. Generally, tropical climates prevail along the lowlands of both coastal slopes, and temperate conditions in the interior.

The Pacific Slope of Mexico has an arid climate that results not from a lack of rainfall, but from extreme seasonality, with rains generally concentrated May–October. These are often heavy, in the tropical lowlands averaging 750–1500 mm per year. The temperate highlands are not as dramatically seasonal, receiving rain year round from clouds coming off the ocean, averaging 1200–3000 mm. The highlands can be quite cool, with the possibility of frost and snow down to 2400 m during winter months. Middle elevations (900–2300 m) serve as a transition between tropical lowlands and temperate highlands, and are referred to as subtropical. Overall, the pattern of uneven rainfall and abrupt temperature gradients makes for a diverse climatic mosaic.

Adding an historical dimension, over the past few million years, the climatic pendulum swings of Pleistocene glaciations produced cycles of connection and isolation of habitats. Tropical species, during the cold, dry climates at the glacial maxima, were forced into the few remaining pockets of warm, humid habitats. In contrast, temperate species that had dispersed southward during the glaciations later became isolated in cooler habitats on the higher slopes of the sierras. For both tropical and temperate species these periods of isolation helped promote differentiation and speciation of many new taxa. Many of these relictual populations persist today as endemic species.

VEGETATION

The diversity of physiography and climates, in conjunction with exposure and soil types, leads to a considerable variety of habitats in western Mexico. In fact, most habitats in Mexico are present in the region. The principal habitats of western Mexico are as follows:

(1) *Tropical Evergreen Forest* (Bosque Tropical Perennifolio). Tall trees of this humid forest often have large buttresses, with branches covered with a variety of epiphytic mosses, lichens, bromeliads, and orchids. Two canopy layers are present, the upper at 25-35 m, the lower at 10 m. A thick layer of dead leaves covers the ground with some patches of dense herbaceous growth. Some loss of leaves occurs during the relatively drier winter, while during the summer rainy season leaves often drip moisture. Remnants of this forest type are located only in the most protected and humid lowland areas in western Mexico.

(2) *Tropical Semideciduous Forest* (Bosque Tropical Subcaducifolio). Not as extensive as tropical deciduous forest, this habitat occurs in locally humid pockets along the tropical lowlands. Trees 15–35 m high form a closed community with two well defined strata. Usually, a dense shrub understory is present, and epiphytes, lianas, and small ferns are common. Some trees drop their leaves during the dry season, while others are evergreen. This forest is found in areas not experiencing the full winter drought like tropical deciduous forest, nor the full effect

of the year-round rains and clouds of higher elevation habitats. At lower elevations it is found along watercourses; at its upper limit (about 1000 m), it merges with pine-oak and cloud forests.

(3) *Tropical Deciduous Forest* (Bosque Tropical Caducifolio) or *Thorn Scrub* (Bosque Espinoso). This dense and spiny forest is found in arid lowland tropical regions (0–1500 m), with trees up to 20 m tall. Generally, a fairly dense shrub layer is present, and epiphytic plants can be numerous; the ground is bare or covered with leaf litter or grass. During the dry season, the trees lose most of their leaves, making it possible to see clearly through the forest, but with the advent of the rainy season, the trees turn lush and green.

(4) *Montane Cloud Forest* (Bosque Mesófilo de Montaña). This forest type occurs in humid subtropical areas with steep terrain and rich soil, and has trees reaching 40 m. It depends on plentiful moisture derived year-round from clouds rising along coastal slopes. It usually occurs at 800–2400 m, but reaches as low as 600 m, depending on local patterns of humidity (Rzedowski 1978). It is the most lush and humid habitat in western Mexico, with trees often completely covered with dense ferns, epiphytes, mosses, lianas, bromeliads, orchids, and lichens. A dense shrub layer is usually present, including tree ferns up to 8 m tall. The ground is covered by thick, moist leaf litter and moss-covered logs.

(5) *Oak Forest* (Encinar). Occurring as both forest and woodland, oak forest is often mixed with coniferous forests at 400–3000 m, principally at 2000–2600 m. Oak forest ranges from a dark and dense forest 15–25 m tall in higher and moister zones, to low, open woodlands 4–10 m tall in the driest areas at middle elevations.

(6) *Pine Forest* (Bosque de Pino). This forest is a characteristic habitat of the highlands (400–3000 m), generally above 1500 m. Forty-nine pine species occur in Mexico. This habitat occurs under both dry and humid conditions with related variation in canopy density and understory development.

(7) *Pine-Oak Forest* (Bosque de Pino-Encino). Pine-oak forests generally occur as closed forests 15–30 m tall. In more humid areas, a dense understory often exists. At lower elevations (1000–2000 m), and under drier conditions, such as on the slopes of the Transvolcanic Belt and Sierra Madre del Sur, pine-oak forests are often more open.

(8) *Fir Forest* (Bosque de Abeto). These uncommon highland (2500–3100 m) forests develop on nutrient-rich soils, with trees 20–40 m tall. They develop in the coldest and most humid portions of mountain peaks, almost always on north-facing slopes. In western Mexico, these forests are found principally in the Transvolcanic Belt, with a few patches in the Sierra Madre del Sur.

(9) *Subtropical Scrub* (Matorral Subtropical) or *Desert Scrub* (Matorral Xérico). Found in interior regions, this dense community is characterized by mesquite 3–8 m tall, in conjunction with species of *Yucca*, *Agave*, and *Opuntia* and other cacti.

(10) *Mangrove Swamp* (Manglar). This community is dominated by woody species that grow in deep soils where they are exposed to saline waters of the ocean along coastal lagoons, protected bays, and estuaries. The trees grow up to 20 m high, and often form a dense continuous foliage, with characteristic long-legged roots.

(11) *Halophytic Vegetation* (Vegetación Halófila). Comprised of plants that can tolerate highly saline soils, this vegetation type is found along the coastal plain and in the interior where high evaporation rates leave salt deposits.

(12) *Palm Forest* (Palmar). Forests of palms are distributed discontinuously along the tropical coastal plains, often bordering coastal lagoons. This community consists of trees 8–40 m tall, with few herbs or shrubs, and the ground is covered with leaf litter. It occurs in sandy soils having good drainage, but which are periodically flooded during the rainy season. A distinct type of palm forest grows in the arid subhumid interior on limestone soils.

(13) *Coastal Dunes* (Dunas Costeras). This habitat is found on low sand dunes between sandy beaches and lagoons. They are covered with grass, low trees, and sparse shrubs adapted to sandy, saline soils exposed to strong

sunlight and marine dew.

(14) *Grasslands* (Pastizal). Grasslands occur principally on flat and rolling terrain of the coastal plains below 1800 m, as well as in central Mexico where they alternate with desert scrub. Most native grasslands have been altered by excessive grazing. At high elevations, open woodlands of pine and bunch-grass occur.

The complex mosaic of vegetation types in western Mexico becomes less confusing when combined with an understanding of the underlying geography. The coastal plain holds a variety of salt-associated tropical habitats such as mangroves, coastal dunes, and palm forest, although much of the area is occupied by tropical deciduous forest. In the most sheltered and humid areas, tropical semideciduous forest is found. Ascending the coastal slopes of the mountains, cloud forest, humid oak and pine forests, and finally fir forest are found, and descending into the interior, aridland habitats such as arid oak and pine forests, tropical deciduous forest, and subtropical scrub again prevail. This basic schematic plan allows a predictive understanding of where different habitat types will occur.

BIODIVERSITY

The rich concentration of wintering migratory birds found in western Mexico constitutes only a small part of the overall biological richness found in the region. Although Mexico's biodiversity is well known, with its legendary mixture of Nearctic and Neotropical species, the numerous endemic species found in western Mexico push it to international preeminence as a megadiversity country (Mittermeier 1988). What follows, therefore, is a summary of patterns of biodiversity in several taxonomic groups, showing the almost ubiquitous pattern of concentration of endemism in western Mexico.

Among plant taxa, 50▪60% of Mexico's approximately 30,000 plant species are endemic to the country (Ramamoorthy and Lorence 1987). Within western Mexico lies the greatest evidence of this endemism, coupled with high species richness. For example, ferns reach highest species richness in Oaxaca, with especially high levels of endemism in the Sierra Madre del Sur (Riba 1993). Oaxaca is also a refugium for relictual species from many other plant families (Hunt 1993).

More than 50% of the world's pine species are found in Mexico, with greatest species richness in the mountains of the west and south (Styles 1993). In all, 1151 species of grass are known from Mexico, with Jalisco having the greatest number of endemic species (Valdés Reyna and Cabral Cordero 1993). The family Lamiaceae is represented by 512 species in Mexico, of which about 75% are endemic to the country; endemism is highest in Oaxaca, Puebla, Guerrero, Michoacán, and Jalisco (Ramamoorthy and Elliot 1993). Approximately 2700 species of Asteraceae are found in Mexico; 1707 aster species are considered endemic to the country, concentrated in the Sierra Madre del Sur and Transvolcanic Belt, with 386 and 370 endemic species, respectively (Turner and Nesom 1993).

For fauna, 9% of Mexico's approximately 25,000 butterflies and moths are endemic, occurring principally along the Pacific coastal plain, Balsas Basin, and Sierra Madre del Sur (LLorente Bousquets and Luis Martínez 1993). Mexico has 2122 fish species, of which 384 are exclusively freshwater; degrees of endemism among fish vary between river basins, with the rivers Lerma▪Santiago and Balsas having 66% and 35% endemism, respectively (Espinosa Pérez *et al*. 1993). As for reptiles and amphibians, 367 of Mexico's 693 reptiles, and 128 of Mexico's 285 amphibians are endemic to the country (Flores Villela 1993), being concentrated in the Transvolcanic Belt, Sierra Madre del Sur, and Pacific coastal plain; states ranked by herpetofaunal endemism for the country are Oaxaca, Chiapas, Veracruz, Guerrero, Michoacán, and Jalisco (Flores Villela 1993). Among Mexican mammals, 142 of the country's 449 species are endemic, concentrated in the Transvolcanic Belt and Sierra Madre del Sur (McNeely *et al*. 1990, Fa and Morales 1993).

For vertebrates, 786 of Mexico's 2401 species are endemic to the country (Flores Villela and Gerez 1988). Of these endemics, 194 are considered threatened. States ranked by vertebrate endemism are Oaxaca, Michoacán, Guerrero, Jalisco, and Veracruz. States ranked by vertebrate diversity are Oaxaca, Chiapas, Vera Cruz, Guerrero, Michoacán, and Jalisco. Highest numbers of species narrowly restricted to one Mexican state

are found in Oaxaca, Baja California Sur, Veracruz, and Guerrero (Flores Villela and Gerez 1988). Endemic forms are generally concentrated in montane areas, as compared with lowland tropical habitats (Peterson et al. 1993).

Hence, the concentration of species diversity and endemism in western Mexico extends across many taxonomic groups, with names of the same physiographic regions and associated states emerging time and again. The overall message emphasizes the significance of western Mexico as a region warranting increased conservation attention owing to its status as a focus of endemism for many taxa.

Birds constitute an important group for conservation efforts. Many other groups hold undescribed species, complicating site inventories and regional summaries because taxa must be recognized and described scientifically; avifaunas, on the other hand, are more than 99% known to science over the entire surface of the Earth, making them more tractable for study. Perhaps more importantly, considerable data exist regarding distribution and habitat use of most bird species, permitting investigators to synthesize and understand new information, and place a site in regional and global contexts quickly and efficiently (Peterson et al. 1997). Concordance between high avian endemism and endemism in other taxa has been noted from other regions as well (Simpson and Haffer 1978, Hauge *et al.* 1986, Collar and Stuart 1988, Peterson et al. 1993).

About 769 bird species breed in Mexico. An additional 257 species occur as migrants, winter residents, or accidentals, bringing the county's total to more than 1000 species (Escalante *et al*. 1993). Among Mexico's breeding bird species, 16% are endemic or nearly endemic to the country; over 33% are endemic to Mexico and Central America (Escalante *et al.* 1993, Howell and Webb 1995). The region highest in Mexican endemic species is the central Sierra Madre Occidental (46 endemic species), followed by the Transvolcanic Belt (37), southern Sierra Madre Occidental (35), southern Sierra Madre Oriental (33), Sierra Madre del Sur in Guerrero (33), and the Sierra Madre del Sur of Oaxaca (31) (Escalante *et al.* 1993), all of which fall in the region covered by this book. In fact, 72% of Mexico's endemic birds, 25% of which are threatened, are found on the Pacific Slope and the adjacent interior and highlands of western Mexico (Howell and Webb 1995). In addition, an increase in percent and number of endemic bird species, from north to south through this region, results in a concomitant conservation importance whose apex is reached in Oaxaca. This pattern is echoed by other taxa (Ramamoorthy et al. 1993).

Hence, Mexican biodiversity patterns lead to a strange contrast. Species richness within the country is focused in the tropical southeastern lowlands (Escalante *et al.* 1993), the region currently garnering the most research and conservation interest. If conservation goals are to conserve biodiversity within Mexico then the emphasis should remain in the southeast. However, if conservation in Mexico is to be part of a *global* plan to preserve biodiversity, then emphasis needs to be placed on regions of high endemism●where species unique to the country are concentrated (Peterson et al. 1993). In striking contrast to the concentratiion of species diversity in southeastern Mexico, the majority of Mexico's endemics occur in the west (Escalante *et al.* 1993). Hence, the focus of the present volume is on the natural areas of western Mexico.

Chapter 2. THE PROTECTED AREAS OF MEXICO: AN OVERVIEW - Enrique J. Jardel, Carlos Palomera Garcia, and A. Townsend Peterson

Protected areas are sites recognized for some outstanding natural value that have been granted at least nominally some level of legal protection for their long-term preservation. A variety of categories has been developed, each with different degrees of protection and restriction of activities, including bosphere reserves, national parks, natural monuments, wildlife refuges, natural resource protection areas, and urban parks among others (Table 2.1). These areas can play important roles in conserving biological diversity, regulating and maintaining essential environmental processes, as well as conserving the natural resource base upon which humans depend. Many areas also offer opportunities for recreation, scientific research, environmental education, and development of appropriate management techniques for sustainable use of natural resources.

As of 1989, more than 4500 protected areas had been created worldwide, encompassing 485 x 10^6 ha (McNeely *et al.* 1990). However, many of these areas face critical situations of weak legal bases, lack of funding, conflicts with local communities, insufficient or inappropriate management, and competition between government agencies for the allocated budget and administration (McNeely 1990). Hence, "protection" must extend beyond the initial decree to the implementation and long-term fulfillment of conservation goals.

In Mexico, over 166 natural protected areas have legal decrees, and an additional 146 areas have "proposed" status. Decreed areas total 14.2 x 10^6 ha, and proposed areas another 5.6 x 10^6 ha; these areas represent 7% and 3% of the country's extent, respectively. Of these totals, biosphere reserves make up 46%, natural resource protection areas 26%, and special biosphere reserves 12%; national parks form but 5% of the total protected (Flores Villela and Gerez 1994). The critical importance of protecting natural resources has been recognized amply by the Mexican government, as reflected in the creation and empowerment of agencies such as SEDESOL, SEMARNAP, INE, and CONABIO.

In spite of governmental recognition and support, the degree to which these reserves successfully fulfill their stated objectives is open to question. In fact, broad studies of the situation of protected areas in Mexico (e.g., Flores Villela and Gerez 1994) have indicated that the system may not protect adequately many areas of substantial importance to the country's natural heritage. Remedying this situation is a multifaceted challenge that will have to be implemented at many organizational levels. However, in a social and ecologically diverse country like Mexico, detailed assessments at the level of region, state, and even specific conservation units are critical to understanding the dimensions of the challenge.

EXISTING AREAS

Many of the areas already decreed solvent or not include large expanses of natural habitat. Although their establishment was often based on criteria other than biodiversity, if conservation efforts seek maximal protection of natural resources and biodiversity, a logical beginning is to review those areas already established. Some portion of the 166 existing areas will certainly prove to be priorities for conservation action after detailed study. Conservation action in these cases can be much more tractable, given that their legal status has already been established.

A clear priority in this respect is therefore the analysis of the relative merits of different already-protected areas on biodiversity criteria. An important first step in this direction is the work of Vélez Tirado (1991), in which the mammal faunas of Mexican protected areas were analyzed quantitatively. Parallel studies of other taxonomic groups are badly needed to make this country-wide perspective complete, and the analyses maximally meaningful. With this improved basis, taking advantage of the important advances already made in biodiversity conservation in Mexico becomes possible.

LAND OWNERSHIP

An important issue for the design and implementation of an effective Mexican reserve system is land ownership. As a perusal of the reserve descriptions that follow will amply demonstrate, even within areas already under protection, land is frequently not under exclusive control of reserve managers. Rather, areas are

owned by a variety of groups, including ejidos, private citizens, companies, and various levels of government. To compound difficulties, defined boundaries are often lacking, and land tenure questions unresolvable.

Of Mexico's 196 x 10^6 ha, 71% (140 x 10^6 ha) are potentially exploitable. Half of this area is in the hands of individuals; the other half belongs to indigenous communities and ejidos, which closely resemble each other in economic organization and land tenure arrangements. Ejidos are communally owned farming and ranching communities, and generally have group decision-making processes. Land that can be cultivated is allotted among community members, and can be confiscated if the parcel is misused, abandoned, or illegally leased; pastureland and forest belonging to the ejido are generally open to use by all members. A recent survey indicated that only about a quarter of ejidal lands is parcelled out for agriculture.

Communal ownership and decision-making over large parts of Mexico has the potential to be a major hindrance to land exploitation and over-development. If, thinking positively, local populations can be helped to see the merit of conservation for themselves, communal land ownership could constitute a major motivating force in biodiversity conservation. Here, then, is a major regional challenge—the need for environmental education.

THE IMPORTANCE OF SOCIOECONOMIC CONSIDERATIONS

In a dense human landscape such as Mexico, the connection between humans and environment is critical in conservation efforts. Rather than focusing on absolute and exclusive protection, as is often the goal in conservation efforts in the United States, sustainable use and development of natural resources for both conservation and human benefit may often be key in making a protected area successful. This goal can be achieved only if local populations see the merit of conservation for themselves. If not, subsistence agriculture, farming, wood gathering, and daily needs will eat away at a reserve.

Historically, protected and potential areas have remained intact by means of isolation, lying on the periphery of areas most severely impacted (Jardel 1995). With burgeoning human populations, this isolation becomes increasingly unlikely in the long term. Rather, modern conservation and biological assessments must be integrated into Mexico's socioeconomic context, and success is impossible without full appreciation of economic and social factors determining patterns of land use.

CURRENT MANAGEMENT OBSTACLES

Numerous obstacles challenge the successful management of parks and reserves in western Mexico, including legal battles, forest fires, grazing, logging, lack of funding, and conversion to agriculture. In coastal areas, tourism and its related development, urban growth, and illegal hunting and fishing are dominant concerns. Additional adverse factors may include geothermal exploitation, mining, road construction, dams, and urbanization, as well as invasion by non-native species, water and air pollution, and waste disposal. The worst problem often is simply that information is unavailable or woefully incomplete (Ortega 1995, Jardel 1994).

Looking at problems confronting Mexican reserve managers (E. Santana pers. comm.), many are universal across the country. A partial list of these factors is the following:

(1) Inadequate legal protection
(2) No on-site protection
(3) No formal administration of reserve
(4) Lack of local, national, and international cooperation
(5) Lack of environmental education programs
(6) Lack of recognition by local population
(7) Lack of recognition by population at large
(8) Lack of recognition of value of reserve
(9) Inadequate funding
(10) Lack of management plan
(11) No research plan or structure

(12) Lack of operation plan to implement management plan
(13) Inadequate training
(14) Inadequate equipment

These factors and others stand as obstacles to successful operation of protected areas for long-term conservation. Resolving and removing them from the panorama of challenges for land managers and reserve directors in Mexico will pay off directly in conservation results.

POTENTIAL AREAS

A 1981 study indicated that over 60% of western Mexico held intact natural vegetation (SAHOP 1981). Although natural habitats have seen continued degradation in succeeding years, this immense quantity of land holds ample opportunities for conservation efforts. A critical focus of conservation efforts should be identification and inventory of the largest expanses of natural habitats that are not currently protected. The identification phase of this effort could be accomplished efficiently using remote sensing applications; the inventory phase inevitably requires intensive field studies by trained biologists. Areas should be catalogued and described, and available information used to prioritize them for conservation initiatives.

NEEDS

The needs of Mexican protected areas for the successful realization of their objectives are many and varied. Areas with strong university commitments, such as the Chamela Research Station and the Manantlán Biosphere Reserve in Jalisco, often have management plans and active research programs. Areas under private ownership, such as El Jabalí Forest Protection Area in Colima, also often have management plans with strong conservation components. The existing structure of areas such as these permits ongoing maintenance activities, extension of operations to neighboring areas, addition of buffer zones, and promoting exchange with other institutions. Research, wildlife monitoring, resource management, administration of resources, establishing links with local communities, environmental education, ecologically appropriate rural development models, institutional consolidation, training, and graduate education are all sectors in which external collaboration and support can be important to these institutions.

Other Mexican protected areas—perhaps the great majority—have much more basic needs. Many areas desperately need assistance with definition of legal status and boundaries, supplementing basic operating budgets, inventorying resources present, implementing protection and vigilance programs, and producing viable management plans. These basic needs are often so great as to prohibit constructive conservation action.

CONCLUSION

Mexico's protected areas system has enormous potential to preserve the natural resources and biodiversity of its landscape. Large extents of natural habitat remain intact in areas of critical biodiversity importance, under legal and social circumstances that could permit effective conservation measures to be implemented. Nevertheless for a variety of reasons, this potential is frequently not fulfilled. That success is contingent on overcoming numerous challenges and obstacles that have become amply evident in the compilation of the chapters of this book.

Chapter 3. GUIDELINES TO INTERNATIONAL COOPERATION IN MEXICO - and

Michael F. Carter and Charles S. Aid

INTRODUCTION

This book will serve many purposes; none is more desirable, however, than fostering cooperative conservation efforts between Mexico and its northern neighbors, Cananda and the United States. These long-distance partnerships either sink or swim depending on the quality of interactions between representatives of the two countries. Successful cooperative efforts begin with greater cultural awareness, understanding of why past projects failed, and appreciation of the intricacies required for working with one another. While we recognize the variety of challenges, ranging from amusing to aggravating, that we as ■gringos• present to Mexicans, it is not our purpose here to guide Mexicans in their dealings with us. Suffice it to say that ignorance on our part has created some difficulties. The purpose of this chapter rather is to guide U.S. efforts on behalf of Mexico conservation. Hopefully, Canadian projects in Mexico will benefit as well.

U.S. and Canada, with their multitude of resources, could offer significant assistance to conservation in Mexico. They helped pilot the initial documentation and study of Mexico's biodiversity; they have great interest and enthusiasm for conservation action; and their involvement has much to offer to the conservation of Mexican biodiversity.

Mexicans, for their part, have a country with immense stores of natural resources and biodiversity, combined with a rich cultural diversity of people and history. Although hampered by economic difficulties, higher education and scientific research have entered a phase of rapid growth in Mexico, and many changes that have implications for international conservation are taking place. Mexican land management agencies, conservation organizations, and academic communities have become enormously capable, scientifically-based groups that must be taken into account when international groups begin to promote conservation action in Mexico (Soberón 1993). Indeed, efforts to complete a national biological inventory are more advanced in Mexico than in the United States (Soberón 1993, Peterson and Sánchez-Cordero 1993, Peterson et al. 1997).

Beginning in the 1980's, the realization of the importance of the continental link formed by Neotropical migratory birds●wintering in Mexico and breeding in Canada and the United States has grown; an awareness has been gained that these species will be lost if habitats throughout the continent, both breeding and non-breeding, are not conserved. More recently, an understanding has emerged that conservation efforts focused on the wintering grounds of migratory birds may also have positive implications for conservation of numerous other plant and animal communities. From a conservation perspective, steps must be taken now, or key habitats will be lost forever. Politically, encouragement for international endeavors is perhaps as strong as can ever be expected. The 1993 North American Free Trade Agreement, having wedded economically Canada, the U.S., and Mexico, ushers in the potential for a much needed continental approach to biodiversity conservation and resource management.

The following material summarizes some of the lessons gained by the Colorado Bird Observatory in its Mexico collaborations. We acknowledge our lack of formal training in cross-cultural communications, and suggest the potential value in other sources of information (e.g. Riding 1984, Pastor and Castañeda 1988, Kraus 1989), although we have yet to encounter a cross-cultural resource that fully echoes our experiences. Frankly, none of us will ever know all that we could for increasing our abilities in these efforts, but we should not be deterred from our goals. We cannot afford to wait, and mutual concern and commitment count for a lot as we collectively stretch into this arena of cooperative international conservation.

OVERALL GUIDELINES FOR PROJECT SUCCESS

International projects often encounter so many political and personal obstacles that they have trouble getting off the ground. While scientists and conservationists from the U.S. have a long history of field studies and conservation efforts in Mexico, their presence has not tended to smooth the way for subsequent endeavors. Despite making substantial contributions to the body of knowledge regarding biodiversity in Mexico, some

U.S. Americans have not appreciated the delicacy of international relations, making mistakes that served to create misunderstandings, destroy trust, and distance potential colleagues and collaborators.

We present the following list of important steps to help avoid pitfalls, to aid the potential for project success, and to gain support from Mexico.

1. Encouraging Participation and Recognizing Mexican Achievements

An optimal manner for obtaining Mexican input, as well as avoiding the initiation of poorly designed projects, is to incorporate Mexican counterparts from the outset. Many from the U.S. have failed to perceive how cooperative endeavors can dramatically improve a project, and that recognition of the instrumental roles played by Mexican partners lends an added dimension of credence and respect. The process begins by identifying partners, understanding and acknowledging their accomplishments, and seeking their advice and involvement, which is often greatly facilitated if a long-term commitment can be made to the proposed project. Collaboration with Mexican scientists and conservationists is more than simply fulfilling common courtesy; rather, Mexican counterparts often are the most capable and best informed people for the job. Specifically, the Mexican conservation and academic communities are often ignored, without the recognition that, in all likelihood, Mexicans "know" Mexico better than visitors from the north. Hesitation on the part of a Mexican to be a cooperator may arise as a result of past projects having been dominated by the U.S. partner, not necessarily because of professional ability, but as a result of financial backing. The disinclination of many U.S. researchers to become proficient in Spanish continues to cause problems.

Mexican scientists and conservationists have made important advances in understanding Mexican biodiversity and its conservation; unfortunately, these achievements have not always been appreciated in Canada and the United States. For example, in a recently published guide to Mexican birds, a chapter on the history of ornithology in Mexico mentions contributions by only three Mexicans in all of history, while emphasizing the efforts of non-Mexicans.

2. Benefits to Mexico and Need for Conservation Emphasis

All too often in the past, scientific focus from the U.S. on natural resources in Mexico has emphasized research, being primarily academic with little related conservation or management component. Minimal effort has gone into considering the impact of projects on Mexico's natural resources, or into designing studies that benefit Mexico. Long-term commitments have often remained unfulfilled, and "quick and dirty" projects have been the norm. Copies of data have not been given to Mexicans; results have rarely been presented or published in Mexico; and Mexicans have often been left with nothing more than a report in English of a project conducted by non-Mexicans.

Returning a tangible result is a reasonable courtesy in return for the opportunity to work in the host country, particularly for individuals or institutions aiming to extend involvement beyond the current project. This benefit could be a contribution to Mexico's conservation community, providing educational or training opportunities at a variety of levels, or application of results to conservation issues within Mexico. Even details, such as separate membership categories for scientific societies or assistance in attending international meetings, can make a big difference. Not to be overlooked is the necessity for U.S. Americans to follow the lead and acknowledge the needs as defined by Mexicans for themselves, and to avoid paternalism.

3. Recognition of Differences

U.S. Americans need to understand environmental issues in Mexico, and recognize that although conservation goals are often shared, priorities can differ. By far, the most feasible path to effective conservation of Mexico's natural resources lies in sustainable development. This approach requires the involvement of local residents who may be struggling for survival, and who may depend upon development or destruction of natural areas. This lesson can be difficult for many U.S. Americans to appreciate that only by addressing the needs of local residents can conservation efforts proceed effectively.

Conservation and scientific research are integrally linked in Mexico. From a Mexican perspective, researchers must also be conservationists, and U.S.-initiated projects should include a substantial conservation component. In this manner, projects produce not only scientific results, but also concrete advances for the preservation of Mexican natural resources.

4. Human Resources and Infrastructure in Mexico

By necessity, involvement by non-Mexicans in Mexican conservation entails helping Mexicans and their institutions increase capacity for developing and carrying out their own projects. Goals on projects imported to Mexico must incorporate this perspective. Meeting this challenge may include providing workshops and training as a component of virtually every project. On a more practical level, it may include efforts to make available field equipment, bibliographic material, computers, and fax machines. A larger commitment with potentially immeasurable benefits is to provide support and opportunities for Mexican biologists to study towards advanced degrees.

PRACTICAL STEPS

A number of steps are important to beginning international programs in Mexico. What follows are important elements:

Before Contact

1. *Assess your level of commitment to work in Mexico*.●International projects seldom proceed as smoothly, or as quickly as desired; hence strong, long-term organizational and personnel commitments are necessary, and anticipation of alternative courses of action.
2. *Assess financial resources for work in Mexico*.●Strong financial commitments are necessary, and hence the need to determine levels of current and future funding. Knowing what resources are definitely available, what will have to be secured externally, and what can be committed to international programs, will aid project implementation.
3. *Identify personnel resources*.●Expertise with Mexico culture, international travel, Spanish, technical support, fundraising, and grant writing may all be needed.
4. *Learn about Mexico*.●Knowledge about Mexico is an enormously powerful tool in successfully designing a project to be carried out there. Reading about subjects as diverse as culture, history, politics, science and economics is highly recommended. For example, do you know who is the current president of Mexico? If you do this is only a start.
5. *Develop an implementation plan*.●Although the intricacies of international collaboration make it difficult to define plans quickly, focus and direction should be given to a fledgling project as soon as is practical. Adaptability can be an important asset. Any project with a potential research component necessitates permits (contact, at least six months ahead of time, Science Office, Angelica Narvaez, U.S. Embassy, Paseo de la Reforma 305, Col. Cuauhtemoc, Mexico, D.F. 06500; Tel: (521) 10042 x 3791; Fax: (551) 19980, (520) 83373).
6. *Networking with others interested in western Mexico*.●Reinventing the wheel is a perpetual danger in international cooperative efforts. An effective means of avoiding this trap is to take advantage of the newsletters and other publications put out by such organizations as the Partners In Flight International Working Group. Do not operate in a vacuum; maintain close contact with all stateside groups that have conservation interests in Mexico, and remember that working cooperatively with them may enhance cooperative efforts with Mexicans.

Making Contact

1. *Identify Mexican counterparts*.●Organizations appropriate as counterparts can be identified through the contact lists in this book. Contacts may include universities, the largest of which is UNAM in Mexico City,

but many provincial universities have active programs as well; government organizations such as SEDESOL, SEMARNAP, INE, or SARH, especially within their state and local offices; or nonprofit organizations and civil associations.

2. *Write the letter*.●The first letter should introduce one's organization or institution as well as oneself. Broad objectives, as well as specific ideas, should be discussed, and reasons for contact outlined explicitly. Letters are often best faxed, although the original should be mailed as well.
3. *Verify receipt of letter*.●Many organizations have only one one phone for faxing and talking, compounding the difficulty of getting through. Even with the advent of increased e-mail use in Mexico, computers are often shared, and may not be connected to a printer. Do not assume that letters have been received until so informed. Long-distance calls to Mexico are preceeded by 011-52, followed by an eight-digit number.
4. *Follow-up*.●It is important to follow up letters with phone calls to make sure that letters were received. The telephone call in turn should be followed up with a letter of thanks, and important details that were agreed upon put in writing. Remember, that Mexicans have grown accustomed to hearing a lot of nice sounding talk from north of the border, and then a year later they hear it again and nothing has happened in the interim. Many state-side organizations and agencies have spent a lot of time on planning, but few have focused on implementation.
5. *Convenios*.●An important detail can be the development of inter-institutional agreements, or convenios. These documents, brief outlines of the dimensions of a collaborative project, are often critical to the Mexican counterpart's ability to participate.

Implementation

1. *Go to Mexico*.● An initial visit to establish working relationships is crucial to project success. Correspondences can be transformed into personal interactions, agreements signed, and project goals further refined. On-site visits to areas of interest will give both counterparts more realistic views on the project. Use the opportunity provided by traveling to Mexico to take items in person that may assist Mexicans with their work. While some Mexico projects may have secured ample funding support from international sources or from within Mexico, others may not have been so fortunate.
2. *Carry out the project*.● Goals and activities will vary enormously from project to project. However, fulfilling the complete project plan to the mutual satisfaction of both counterparts is critical.
3. *Finishing up and filing reports*.●An important point in which many U.S. participants in projects fail is that of concluding projects. Letters of thanks should be sent to counterparts, especially noting their active participation, and copies of data, reprints, and other forms of information should be included.

SUMMARY

Keys to successful international cooperative conservation in Mexico by U.S. Americans require flexibility, sincere interest in Mexico and its culture, skill in human relations, and ability to communicate in Spanish or at least a willingness to make the effort. In contacting Mexicans, it is important to go through appropriate channels, and to treat them as you would want to be treated. In visiting Mexico, go with the attitude of making friends. More than anything, though, behaving in a formal, professional manner is the key, taking good care to carry through on all promises and commitments, and treating all involved as full participants and professionals.

Chapter 4. PROTECTED AREAS OF DURANGO - Alfredo Garza H., Elizabeth E. Aragón P., Jeffrey R. Bacon, Angeles Morales G., Federico Casillas O., and Jorge A. Rojas T.

INTRODUCTION

The topographic variation and geographic location of Durango (123,181 km^2) have produced considerable plant and habitat diversity. Habitats range from arid dunes to fir forests. Between these extremes are oak, oak-pine, and pine forests (31% of the state), tropical deciduous forest (3%), desert scrub (38%), and shrubby grassland, among other habitats (Madrigal 1977, González Elizondo 1983). Owing to a variety of human activities, many habitats have been modified, such as agricultural areas, pasture, and woodlands managed for commercial wood production (28%). The state's economy depends largely upon activities associated with livestock, agriculture, and forestry production; as a result, large areas are no longer in their natural condition, although they may still be important as feeding and cover sites for wildlife.

The biological diversity of Durango is high, with over 5000 species of vascular plants (González Elizondo *et al.* 1992). One hundred twenty-eight species of mammals are known (Baker and Keever 1962), and more than 160 species of birds have been reported (Thiollay 1981, Nocedal 1988). Bird studies have focused primarily on long-term ecological aspects of populations and communities, and relationships between resident and migratory birds (Nocedal 1988, 1994, 1995). Other studies have addressed site variation in the altitudinal and local movements of resident species (Nocedal 1984, 1995), resident insectivorous bird reproduction (Garza 1988, Hermosillo 1989, Hermosillo *et al*. 1991), ecological studies of particular species (Ficken and Nocedal 1992, Hutto 1987), and raptor ecology (Hiraldo *et al*. 1991, Rodríguez Estrella and Ortega Rubio 1993).

Approximately one-quarter of the state consists of Chihuahuan Desert and associated habitats (González Elizondo 1983). The desert has a high level of biological diversity, and studies, at least in the U.S. portion of the desert and the adjacent Sierra Madre Occidental, indicate a high degree of endemism (Wauer and Riskind 1977, DeBano *et al.* 1995). In fact, a recent countrywide review identified the Sierra Madre Occidental as the region most rich in species endemic to Mexico (Escalante et al. 1993).

Durango, partially due to its relatively low human population, holds large areas of continuous habitat important for many migratory and resident species. These include various aquatic habitats important to waterbirds and bats, and many habitats, particularly oak forests, that have been identified as important wintering and migratory stop-over areas. In addition, the rich diversity of the western portion of the state, especially in the region known as the Quebradas, contributes greatly to the state's potential for conservation of biodiversity (Bacon 1995a, Bacon and Unzueta Avila 1995).

PROTECTED AREAS

Despite the great habitat and species richness in Durango, the state has few protected areas. These include two Biosphere reserves established by presidential decree, Mapimí Biosphere Reserve and La Michilía Biosphere Reserve, which are part of an international conservation program, and six areas that have been established by secretarial agreement, Las Bufas Thick-billed Parrot Sanctuary, Monte Oscuro Eared Trogon Sanctuary, Tufted Jay Sanctuary, Sierra del Promontorio, El Tecuán Park, and the Laguna de Santiaguillo Waterbird Refuge (Fig. 4.1). These areas have legal status as protected areas, but this status is temporary, and does not guarantee long-term conservation, protection, or management.

Mapimí and La Michilía were the first Biosphere Reserves established in Mexico to be integrated into the International Network of Biosphere Reserves within the framework of the Man and Biosphere (MAB) program of UNESCO (Halffter 1984). Both have been considered as indicators of the concept called "la modalidad mexicana" (the Mexican modality), in which the relation between research and the local populations of protected areas is direct, and has a strong conservation orientation. This arrangement permits the use and management of biological resources in a rational way (Halffter 1984, 1988). The objectives of the Biosphere

Reserves have been the conservation of natural resources and germ plasm, promoting lines of research that permit the development of alternative uses and management of the biotic resources in the area and encouraging possibilities for certain productive activities which benefit local populations (Halffter 1984, 1988). The active participation of the Durango state government, CONACyT, SPP, and SEP, have been essential to the establishment and development of Durango's Biosphere Reserves.

Mapimí Biosphere Reserve

Location: This reserve comprises 172,000 ha located in northeastern Durango in the Bolsón de Mapimí, 50 km northeast of the town of Ceballos, with center at 26°41' N and 103°45' W (Montaña 1988).

Physiography: The area consists of a basin and range topography with broad plains, playas, and rocky bajadas at 1100 m, divided and surrounded by isolated mountain ranges up to 1350 m (Martínez and Morello 1977).

Climate: Arid, with mean monthly temperatures varying 11▪28°C. Average annual precipitation is 230 mm, with pronounced yearly variation, and with 80% of the total occurring June▪September.

Habitat: Chihuahuan Desert scrub, dominated by microphyllous shrubs including numerous endemic plants (Rzedowski 1978, Wauer and Riskind 1977). Dominant scrub types include *Agave*, *Opuntia*, and creosote bush (*Larrea tridentata*); large areas of Tobosa grassland (*Hilaria mutica*) are common (González Elizondo 1983, Montaña 1988).

Fauna: Five species of amphibians (Grenot 1983) and 37 species of reptiles (Adest *et al.* 1989a, 1989b, Grenot 1983, Barbault and Maury 1981) are found, two of which are endangered and endemic (Bolson Tortoise and Sand Lizard). Forty-two mammal species have been recorded (Grenot and Serrano 1982, Grenot 1983, Aragón in press), including Big Long-nosed and Mastiff bats, Mountain Lion, Kit Fox, Badger, and the previously extirpated Pronghorn Antelope. Bird densities are relatively low, and communities are dominated by granivorous species. Of the 121 bird species recorded to date, 51 are resident (Nocedal, Garza, unpubl. data).

Many species of migratory and resident bats are of uncertain status or are endangered (Aragón in press). The status of the medium-to-large carnivores is unknown. Mule Deer populations appear to have diminished in numbers, although no hard data are available to support this observation in developing a cogent management plan.

Research: Research in the reserve began in 1974, and participation in the MAB▪UNESCO program began in 1977. Studies have included characterization of environmental landscape units (Montaña 1988), forage production and water-soil-erosion-vegetation relations (developed by ORSTOM), structure and function of vertebrate communities and identification of sensitive species (Aguirre and Morafka 1982), foraging patterns of domestic and feral cattle (Hernández 1995), and influence of herbivores on vegetation structure (begun in 1966 by Long Term Ecological Research Program of New Mexico State University with the Instituto de Ecología, A.C.). Additional research has included biological inventories and studies of spacial-temporal relations between sympatric species, community ecology, population ecology, life cycles, feeding habits, reproduction, and life histories (Barbault and Maury 1981, Thiollay 1981, Grenot and Serrano 1982, Adest *et al.* 1989a, 1989b, Aragón and Baudoin 1989, Baudoin and Aragón 1991, Aragón *et al.* 1993, Hernández and Delibes 1994, Aragón in press). Studies of invertebrate communities have emphasized epigeous arthropods and grasshoppers (Rivera 1986, 1990, Rivera and Viggers 1991). Diverse archeological (González 1984, 1986), and anthropological (Kaus 1992) studies have also been conducted.

Land Ownership: Small property owners and ejidal communities. In both cases, grazing with pasture rotation

is widely practiced as the principal economic activity.

Management: Administration is the responsibility of the Instituto de Ecología, A.C., a research center of CONACyT. Within the reserve, with the cooperation of local inhabitants, human activity has been instrumental in efforts to maximize principal socioeconomic activities while protecting the environment. In particular, the Bolson Tortoise management and captive breeding program has assisted conservation and economic stability in the area (Aguirre and Morafka 1982, Adest *et al.* 1989a, 1989b). Studies are being conducted by ORSTOM and the Instituto de Ecología to develop a watershed management plan that addresses the ongoing degradation of soil and vegetation by livestock (Delhoume 1991, Reyes 1995, Reyes *et al.* in press).

Comments: Mapimí has many species requiring protection and conservation management. The hills and bajadas have the highest diversity and species richness, making them a management priority and the first phase of a management plan is being implemented in 1996.

La Michilía Biosphere Reserve

Location: In the municipality of Súchil, in southeastern Durango (23°27' N, 104°18' W), consisting of 42,000 ha, with a 7000 ha core area.

Physiography: Elevation averages 2600 m, reaching a maximum of 3150 m. The "altiplano" of the reserve averages 2400 m. Lying on the eastern side of the Sierra Madre Occidental, topography varies from flat plains to steep mountains, valleys, and canyons (González Elizondo *et al.* 1993). Two basins are present, one in the north, with ephemeral water, and one in the central and southern parts that holds permanent water.

Climate: Temperate subhumid, with some temperate semiarid (CETENAL 1970). Annual precipitation fluctuates 600-860 mm, with summer rains May to September. The dry season lasts February through May. Annual mean temperature is 11°C (15°C in June and 6°C in January).

Habitat: Dominated by oak and oak-pine woodlands typical of the eastern side of the Sierra Madre Occidental, as well as Douglas Fir, cypress, juniper, grassland, chaparral, thorn scrub, and aquatic and subaquatic vegetation associations (González Elizondo *et al.* 1993).

Fauna: Studies have provided lists of amphibians and reptiles (Álvarez and Polaco 1984), and 314 insect species have been identified (Morón 1991). Mammals include rodents, Eastern Cottontail, three species of squirrel, bats, Coyote, Gray Fox, Mountain Lion, Bobcat, White-tailed Deer, and Collared Pecary. To date, 123 species of birds have been reported, including Wild Turkey, Montezuma Quail, Band-tailed Pigeon, and such threatened species as Spotted Owl and Eared Trogon; the list may eventually reach 150 species (Nocedal and Garza, unpubl. data).

Research: Two research stations exist, the Instituto de Ecología's La Piedra Herrada and El Alemán, belonging to the Ejido San Juan de Michis. Research began in 1974, with the majority of studies addressing population and community ecology of lizards (Ortega 1986, Ortega and Gutierrez 1986). Other studies include Coyote ecology and predator-prey relationships (Servín and Huxley 1991); diet and habitat preference of White-tailed Deer (Gallina 1993, 1994a, and 1994b; Morales 1993); insectivorous bird community ecology and foraging behavior (Nocedal 1988, 1994,1995); behavior and reproduction of the endangered Mexican Wolf, with possibilities of reintroduction (Servín 1991); ecology of the Wild Turkey (Garza and Servín 1993); and systematics of butterflies (Díaz Batres and Boudinot 1986), dragonflies (González and Novelo 1991, Novelo and González 1991), and beetles (Morón and Deloya 1991, Terrón *et al.* 1991). González Elizondo *et al.*

(1993) examined floristics, and Nocedal (1988) the contribution of pines to vertical habitat heterogeneity.

Land Ownership: Divided between federal, ejidal, and small private holdings.

Management: La Michilía became part of the MAB-UNESCO program in 1977, with administration and management provided by the Instituto de Ecología, A.C. As of yet, no general management plan exists. Major projects include captive breeding programs for Mexican Wolf (since 1977) and Coues' White-tailed Deer (since 1989) (Morales 1993). The wolf program has had little success owing to the loss of captive young and adults. In coordination with the ejidos, legalization of Wild Turkey hunting has been proposed, with the objective of dedicating the Ejido San Juan de Michis as a hunting area with a monitoring and management program. The program seeks to provide economic benefits for the rural communities and conserve the ecosystem in general (Garza and Martínez in press).

Comments: A timber company recently approached the local populace proposing harvest of oaks for cellulose production, providing short-term economic benefits. Such activity, however, would drastically alter the predominantly oak and oak-pine buffer zone. An alternative, also having economic incentive, would be to manage local cattle production and grazing regimes more effectively (Garza and Martínez in press). Even if occasional overgrazing were to continue, negative impacts would be far less than those created by deforestation (Garza and Martínez in press). Legalization of hunting within specified areas would allow for greater law enforcement in those areas restricted to hunting. Local inhabitants would thus receive direct economic benefits from activities protecting the ecosystem. An immediate need is for a broad scale, integrated management plan that addresses flora, fauna, as well as non-biological aspects.

The Río Mezquita runs along the western edge of La Michilía, serving as a natural corridor along which tropical flora and fauna come in contact with temperate elements. This natural corridor may also be used by both long-distance Nearctic-Neotropical migrants and west Mexican local migratory birds, when moving to their wintering grounds (Nocedal 1995). For this reason, Nocedal (1995) has proposed enlarging the size of the La Michilía Biosphere Reserve to include the Río Mezquital and its western slope, a step that would also increase habitat diversity within the reserve.

El Alemán Biological Research Station

Location: Consisting of 5 ha within the La Michilía Biosphere Reserve buffer zone, in the Ejido San Juan de Michis (23E10' N, 104E10' W).

Physiography: At 2250 m, with rugged terrain crossed by the Río Temascal.

Habitat: Oak forest and woodland (*Quercus hartwegii*, *Q. grisea*, *Q. eduardii* and *Q. chihuahuensis*), with Manzanita (*Arctostaphylos pungens*) and Alligator Juniper (*Juniperus deppeana*). Diverse herbaceous and shrubby species, such as *Bouvardia* spp., *Muhlenbergia* spp., and *Agrostis* spp., are abundant in the understory (González Elizondo *et al*. 1993). Agriculture and livestock activities occur in surrounding areas.

Fauna: Fauna is similar to that found at La Michilía (see above). Additional vertebrates, such as aquatic turtles and native and introduced fish, are found in the river. Feral hogs were recently introduced, and have caused severe problems in both cultivated areas and native habitat (Weber 1995).

Research: As a result of a census demonstrating population declines of Coues' White-tailed Deer in the presence of commercial livestock grazing (Galindo Leal *et al*. 1993, 1994, Morales *et al*. 1989), El Alemán Research Station, with CONACYT support, was founded in 1989. The station has three objectives: (1) to serve

as a captive breeding center for deer repopulation, thereby increasing populations in the buffer zone; (2) to carry out research on deer and complement existing studies (Galindo Leal *et al*. 1993, 1994, Gallina *et al*. 1994a, Morales *et al*. 1989, Weber *et al*. 1994); and (3) to create an avenue for public education. The area has 3 ha of corrals capable of holding up to 30 deer, and is the only legally recognized Coues' deer breeding facility in Mexico. The station is capable of producing and breeding animals for the establishment of new core populations in other areas, and to house deer confiscated by PROFEPA and SEMARNAP.

Land Ownership: Installations and land were provided by the Ejido de San Juan de Michis through a formal agreement.

Management: The program began in 1989, and official registration and federal support were obtained from SEDUE in 1991 (Morales 1993). The area's research personnel are in charge of management. A cabin, hay barn, quarantine area, and forage cultivation area are all present.

Comments: Inappropriately scheduled hunting seasons, coupled with excessive harvesting, are the probable causes of long-term declines in local natural deer populations (Galindo *et al*. 1993, Morales 1993, Weber *et al*. 1994). An interdisciplinary program that includes sociological, anthropological, and economic aspects to achieve a comprehensive understanding of the rural community and its problems is badly needed. Only in this manner is it possible to approach the local community with a workable plan that adequately manages and conserves the area.

Las Bufas Thick-billed Parrot Sanctuary

Location: Close to Las Bufas de San Rafael, at approximately 24°22' N, 106°11' W, south of the village of Guachimetas, in the municipalities of San Dimas and Tamazula, and continuing south into neighboring Sinaloa. The Durango portion consists of 14,708 ha, whereas the Sinaloa portion adds an additional 5937 ha.

Physiography: Consists primarily of mountainous terrain at 1500▪2960 m, with the majority of the area above 2500 m. Three principal mountain ranges are present: one extending toward Cerro de las Aguilas and the Río de San José de Viborillas, another extending toward Cerro de la Cueva de Rivas and Las Bufas de San Rafael, and a third northeast of the Río Verde.

Climate: Cool temperate, with summer rains.

Habitat: Pine-oak with areas of Douglas Fir, fir, and tropical deciduous forest at lower elevations. A rare mix of *Abies* and *Pseudotsuga* exists on mesa tops where foresters have yet to reach (Alvarado *et al.* in press*)*. Overall, the habitat is in good condition.

Fauna: Several species endemic to western Mexico occur in this region. At higher elevations the endangered Thick-billed Parrot is found, whereas the Tufted Jay occurs in the lower parts. The threatened Eared Trogon and Spotted Owl occur here, and the declining Military Macaw has been observed in the vicinity. The most important mammals in the area include Mountain Lion, Collared Pecary, and White-tailed Deer.

Research: This area was included in a study conducted by IUCN and CIPAMEX regarding threatened birds of the Sierra Madre Occidental, and Lammertink *et al*. (1995, 1996) considered it important for its ornithological richness.

Land Ownership: Disputed, with principal ownership appearing to lie with the Ejido El Maguey de San

Dimas, the community of San Isidro, and an unknown ejido or communal property owner in Sinaloa.

Management: Capture of birds has been prohibited in the area since 1993, and hunting has been prohibited since 1994. Future considerations, with regard to conserving Thick-billed Parrots, may include limiting the harvesting of both dead and live timber (SEDESOL 1994a, 1994b). The forest area proposed for protection consists of the total area above 2500 m plus Thick-billed Parrot nesting areas.

Comments: Although the area is not readily accessible, or commercially developed, it could have potential for ecotourism programs, particularly given the possibility of access from the Pacific side. En route to the high forested areas, one crosses a wide variety of habitats containing diverse bird faunas.

Lammertink *et al*. (1996) reported numerous large trees, relatively rare in western Mexico, and an increasingly scarce resource for species potentially requiring mature forest. The area is seriously threatened by the encroachment of human occupation and other activities. Due to its importance, Lammertink *et al*. (1996) recommend purchasing the area to ensure its conservation. The importance of forestry activities to the local residents and their relative isolation calls for a program of integrated management and socio-economic development.

Monte Oscuro Eared Trogon Sanctuary

Location: In the Monte Oscuro area of the indigenous community, San Bernardino de Milpillas Chico, in the municipality of Pueblo Nuevo at 23°17' N, 104°58' W.

Physiography: Mountainous, with broken topography and steep slopes at 1500▪2900 m.

Climate: Temperate, with considerably warmer ambient temperature than surrounding areas (Lammertink *et al*. 1995), likely due to air masses rising from the Pacific coast.

Habitat: Lush primary mesic pine-oak forest along an ephemeral stream holding large pines, firs, and hardwoods, including wild cherry (*Prunus* sp.). Canyon slopes are dominated by xeric pine-oak forest (Lammertink *et al*. 1995).

Fauna: Eared Trogon, a threatened west Mexico endemic, descends in large wintering groups to the warm, humid, riparian forests found in the canyons of Monte Oscuro (SEDESOL 1994b, Lammertink *et al.* 1995). Spotted Owls also occur in this area.

Research: A joint expedition conducted in 1995 by BirdLife International and CIPAMEX surveyed Monte Oscuro for rare birds of the Sierra Madre Occidental.

Land Ownership: Rural communities.

Management: Initially recognized for its uniqueness in 1995, during the BirdLife International - CIPAMEX rare bird surveys. Although steps are being considered to prohibit commercial logging and capturing of birds, and potentially close the area to hunting, no plan has yet been implemented.

Comments: The birds of the area have legal protection related to their being hunted and captured, but reinforcement of these broad decrees has yet to occur.

Tufted Jay Sanctuary

Location: Close to Las Bufas de San Rafael, at approximately 24°22' N, 106°11' W, south of the village of Guachimetas, in the municipalities of San Dimas and Tamazula.

Physiography: Mountainous terrain above 2500 m.

Climate: Cool temperate, with summer rains.

Habitat: Pine-oak, Douglas Fir, fir, and tropical deciduous forest.

Fauna: The Tufted Jay is a microendemic species of the Sierra Madre Occidental in northern Nayarit and west-central Durango. Three other rare, threatened, or endangered bird species present are Golden Eagle, Military Macaw, and Spotted Owl.

Research: None.

Land Ownership: Rural communities.

Management: The site was discovered in 1987, on a joint expedition of the World Wildlife Fund and CIPAMEX. The area is protected by secretarial agreement, which established the Calendar for Rational Capture, Transport, and Harvest of Songbirds and Ornate Birds, according to the 1995–1996 Hunting Calendar.

Comments: None.

Sierra del Promontorio

Location: Comprising 139,400 ha (Servín 1986), north of Durango and west of Tepehuanes at 25°20' N, 105°10' W. This range is also known as San Francisco y Coneto.

Physiography: This isolated mountain range, rising from 1900 to 3000 m, abuts the Laguna de Santiaguillo to the north, and is otherwise surrounded by dry plains.

Climate: Temperate subhumid, with summer rains and median temperature of 16°C.

Habitat: Predominantly oak forest at 1900–2100 m, oak-pine forest at 2100– 2300 m, pine-oak forest at 2300–2500 m, and pine forest above 3000 m. Fir forest exists in more mesic sites.

Fauna: Similar to Las Bufas and Monte Oscuro.

Research: The area was identified by the Instituto de Ecología for its potential for supporting populations of Mexican Wolf (Servín 1986).

Land Ownership: Private property and rural communities.

Management: The area has been proposed for flora and fauna protection. A captive wolf pack is being maintained for breeding and possible reintroduction in the area, although the program has never been fully

implemented.

Comments: The area is protected by secretarial agreement via the Official Hunting Calendar since the 1987▪1988 hunting season. The area is proposed for possible reintroduction of the Mexican Wolf, given its mountainous terrain, relative isolation, and inaccessibility, all of which have prevented exploitation by foresters.

El Tecuán Park

Location: Consisting of 834 ha at km 58 on Durango State Highway 40, in the municipalities of Durango and El Salto.

Physiography: The area lies within the Sierra Madre Occidental, including plains and irregular steep slopes at 1600▪2300 m.

Climate: Temperate subhumid, with summer rains of 700▪1200 mm (García 1988).

Habitat: Pine, fir, and oak forests, juniper woodlands, chaparral, and grasslands.

Fauna: A number of vertebrates and invertebrates are found, including typical birds of the Sierra Madre Occidental, squirrels, Coyotes, foxes, Bobcats, and White-tailed Deer. Introduced fish (Carp and Large-mouthed Bass) are found in ponds in the park.

Research: None.

Land Ownership: The property that makes up El Tecuán was donated by the "El Carmen" Livestock Company in 1981 to the Durango State Government, with the objective of establishing a national park for recreation. In 1983, the donation was transferred to the Federal Government to establish a national park. In 1994, the State Government requested a reversal of the donation to state lands because the park was never decreed as a federal park. The request was fulfilled because the state government seeks to make the area a protected area for recreation for inhabitants of the city of Durango.

Management: The area is protected by secretarial agreement, established by the Official Hunting Calendar, since the 1985▪1986 hunting season. Cattle are grazed within the park, whose boundaries are marked by a barbed wire fence. The grazing is so extensive that it presently prevents all understory growth. Given the presence of Wild Turkey and White-tailed Deer, El Tecuán has been proposed as a managed hunting ranch that could help conserve other wildlife (Secretaría de Desarrollo Rural 1992).

Comments: El Tecuán is too small to meet IUCN specifications for a national park.

Laguna de Santiaguillo Waterbird Refuge

Location: An area of 46,750 ha, located 80 km north of Durango City (29°7' N, 104°57' W), and accessible from Federal Highway 39.

Physiography: The Laguna de Santiaguillo lies within a closed watershed of approximately 260,000 ha. It is bounded on the north by the Sierra de Promontorio-San Francisco (reaching 2800 m), to the east by the Sierra

de Coneto, to the west by the Sierra de Tejamen (with elevations of 3,000 m), and to the south by the low hills of Serranía de La Silla.

Climate: Temperate semiarid, with annual mean precipitation of 500 mm and median annual temperature of 18°C.

Habitat: This freshwater lagoon is surrounded by marshes, cultivated areas, desert scrub, and large grazed pastures. Principal cultivated crops are corn and beans, as well as barley, sunflower, oats, wheat, and apples.

Fauna: Waterfowl include ducks, geese, coots, Sandhill Cranes, and White Pelicans. Mammals include Bobcat, hares, rabbits, and White-tailed Deer. Carp, sunfish, and Large-mouthed Bass were introduced by a local fishing cooperative. The area is an important stopover for large numbers of migratory waterbirds. Habitats surrounding the lake may hold numerous terrestrial species of conservation value.

Research: Studies have demonstrated that local soils are not well adapted to agricultural use owing to high salinity (SARH 1979). In 1979, an agreement was made between the Subsecretaría Forestal y de la Fauna and Ducks Unlimited of Mexico, A.C., to establish a refuge for migratory birds (SARH 1979).

Land Ownership: Land surrounding the lake is owned primarily by rural communities. The area containing the bird refuge belongs to the community of Los Lirios. Some private Mennonite properties are found along the lake's southwest shore.

Management: The lake has been managed for its fish resources, which are harvested by local communities. Poaching is a frequent, year-round problem. Grazing by cattle, sheep, goats, and horses is inadequately managed, and so extensive that native grasslands face severe erosion.

Comments: The Laguna de Santiaguillo is a scenic reserve with a large quantity of wildlife, principally migratory waterbirds of the central flyway. Regarding wildlife, the lake is one of the four most important in Mexico, given its size and key position as a migratory stopover point. Recreational hunting and fishing are on the increase. Increased local human populations have increased water demand and consequent drought, pollution, and change in flow of irrigation water. The area is protected by secretarial agreement that was established by the Official Hunting Calendar in the 1982–1983 hunting season. This agreement was established to protect the waterfowl. However, other habitats in the surrounding area should also be included in the lake's management program.

La Tecolota Ecological Reserve and Las Bayas Forestry Reserve

Location: La Tecolota consists of 400–600 ha, in the Las Bayas Forestry Reserve about 55 km south of Durango City at approximately 23°27' N, 104°51' W. The site's boundaries are undefined, and the exact size is not known.

Physiography: La Tecolota consists of an arroyo that at its upper end has a wetland with a meandering stream beneath an impressive geologic formation. The arroyo descends abruptly through a steep walled section that provides a cool, moist refuge for a relictual community of mixed conifers. The stream becomes ephemeral through this section, with several permanent pools.

Climate: Temperate subhumid, with summer rains.

Habitat: Fir, Douglas Fir, and juniper dominate the well-preserved central portion of the site. Oak-pine forest dominates the lower arroyo, while pine, oak, and pine-oak forest dominates the upper reaches. The wetland at the upper end of the arroyo, adjacent to the stream, is small and highly disturbed. The proximity of Las Bayas to the subtropical region of the Sierra Madre Occidental has resulted in a flora of mixed origin.

Fauna: Fauna has not been studied. The area has Mexican Spotted Owls, and may serve as an occasional feeding or roosting area for Thick-billed Parrots.

Research: Little research has been conducted at La Tecolota. García Arévalo (1992) discovered a previously undescribed species of *Maianthemum*. Biologists from CIIDIR conducted a general floristic inventory, but results are not yet published. Bacon inventoried oaks (*Quercus* spp.), and Spellenberg and Bacon (in press) found an interesting oak hybridization site.

Land Ownership: Owned by the Univ. Juárez del Estado de Durango (UJED).

Management: UJED exercises passive management in La Tecolota. Under the authority of the previous regional forestry management, Unión de Conservación y Desarrollo Forestal, much of the upper and lower arroyo was harvested while the central portion appears to have been only lightly disturbed, leaving it in fairly good condition. The uppermost portion has been heavily overgrazed, and most of its original habitat structure and diversity have been damaged irreversibly. However, with a wetland and a striking rock formation, it could serve well for a wetland conservation and restoration project. The site was donated to UJED in 1978, which recognizes the area's conservation value, and is at least not harvesting trees. However, a formal management plan has not been authorized, and undefined boundaries could allow for damaging harvest activities. CISIMA-UJED has proposed the development of a site management plan, and has begun preliminary development of the plan.

Several factors threaten the reserve's integrity: heavy erosion, reduced cover, invasive weeds, and altered vegetation structure have resulted from over-harvesting. Fires are frequent, and could potentially devastate the lower portion, where dry oak forest predominates. Site workers have suggested that poaching may be a problem. Although livestock are restricted to specific parts of the forestry reserve, past stocking rates are poorly documented, fences have been cut, and evidence of livestock has been found in restricted areas.

Comments: La Tecolota is one of several refugia of mixed coniferous forest in this region, and a regional conservation plan including these sites and others is recommended. The proximity of subtropical areas has greatly influenced the regional flora. The area is probably important for migratory birds that depend upon tropical and subtropical wintering sites, as well as migratory and resident species dependent upon temperate forests. Although much of La Tecolota has been disturbed, it appears to have maintained its general structure, and has a diverse understory flora with some elements apparently not common in other areas of the Las Bayas forestry reserve. A site inventory, development of an active management plan, and funding for management activities are the principal needs of the area.

POTENTIAL AREAS

A number of other areas have been identified as holding important habitats for birds (Fig. 4.2), primarily based upon the presence and abundance of rare plant species. This is not an all inclusive list, as the biology of Durango is simply not well enough known. Here we suggest areas, but stress the need for additional work throughout the state so that the list may become more comprehensive in the near future.

Región de Calaveras

Description: Located on the eastern edge of the Sierra Madre Occidental at 800▪2400 m (105°22' W, 23°11' N) (Ceballos *et al.* 1987). The topography of this region marks the beginning of the steep descent to the Pacific coast, with habitats of pine-oak, fir, and subtropical forest.

Comments: The 108 bird species recorded in the spring of 1987 included the geographically-restricted Tufted Jay, Crested Guan, Lilac-crowned Parrot, Stygian Owl, White-naped Swift, Aztec Thrush, and Red-headed Tanager. Ceballos *et al*. (1987) proposed protection of the Región de Calaveras (ca. 2000 ha) as an ecological reserve and emphasized the need to establish a no-hunting zone southwest of Calaveras, which would permit conservation of fir forest and effective protection of the Tufted Jay populations.

Arroyo de Las Causas, La Guacamayita, and Arroyo del Infierno

Description: These sites are notable for the presence of Chihuahua Spruce (*Picea chihuahuensis*), an indicator of good-quality mature forest important to a number of bird species. A number of other prospective sites have been identified tentatively, but the presence of important biological elements has not yet been verified (Bacon 1995b).

Comments: The Arroyo de Las Causas is particularly important, as it contains one of the largest populations of Chihuahua Spruce and mature mixed conifer forest (Bacon 1995a, 1995b). Thick-billed Parrots have been observed feeding in the site and are assumed to nest on the nearby Pacific slope (Bacon pers. obs.). Presently, the site is informally protected by an unwritten no-harvest policy instituted by UCODEFO, El Huehuento (UCODEFO No. 5), and it is managed passively. However, no formal protection or management plan exists. Although UCODEFO No. 5 is interested in preservation of the site (J. Emilio Saenz A., pers. comm.), it lacks financial and human resources for implementation of site management activities.

Savanna del Norte de la Sierra de la Candela

Description: Located just north of the Sierra de la Candela at 105°30' W, 25°40' N, this area holds a small savanna with relatively intact vegetation (Bacon pers. obs.); soil structure has been identified by Dr. Luc Descroix and research scientists of ORSTOM. The exact location, size, and name of the site are not presently available publicly, but have been filed with CISIMA-UJED for future use.

Comments: This area is potentially important to wintering and breeding grassland seed-eating birds.

Mesa del Carpintero

Description: Located close to Vencedores, in southwestern Durango, the Mesa del Carpintero contains relatively good quality mature pine-oak forest. *Pinus durangensis*, *Quercus mcvaughii*, and *Pinus teocote* dominate the overstory and Ericaceous shrubs and herbs and grasses are common in the understory.

Comments: The known area of the mesa is small (less than 5 ha), but nearby slopes also offer conservation opportunities. Also, parts of the mesa are unexplored. The site has been studied by fire ecologists (Alvarado *et al*. in press) and plant taxonomists (Spellenberg and Bacon in press), owing to its unusual flora and the presence of older trees. Local foresters have visited the site, and are considering harvesting.

Mesa de los Ladrones

Description: A site with relatively large trees and good overstory structure, located in southwestern Durango, near Vencedores, the quality of the understory has been diminished because of numerous disturbances by fire and grazing.

Comments: The abundance of older trees and relative isolation of the site may make it worthwhile for preservation of fauna. The site is fairly accessible, and local foresters have visited the site and may consider harvesting.

El Huehuento

Description: This site includes Durango's highest point above sea-level. A small cave penetrates the peak and opens into an impressive panorama of the sierra of southwestern Durango and eastern Sinaloa.

Comments: Aside from its aesthetic value, the area may be biologically valuable given a small area of open juniper woodland near the peak. The surrounding forest area appears to have been fairly well-maintained, but economic pressure is forcing exploitation of the commercial species.

Golden Eagle Nesting Refuges

The following are potential nesting areas for Golden Eagles, based upon site characteristics, and are candidates for protection for efforts aimed at this species (Nocedal and Garza 1991). Corresponding municipalities are given in parentheses.

I. Isolated mountains surrounded by open habitat, such as grasslands, desert scrub, or open, savanna-like habitats,
    A. High mountains on the eastern edge of the Sierra Madre Occidental characterized by pine forests.
        1. Cordón Madre, Cordón el Saucillal and Cordón el Mesón (Tepehuanes).
        2. Cerros La Bandera and El Alazan (Santiago Papasquiaro).
        3. Cordón de Enmedio or Cerro La Higuerita (San Dimas).
    B. Isolated mountain regions in the valley region, characterized by semi-arid and arid woodlands (oak-pine and oak forests) and scrublands.
        1. Sierra de Guanaceví (Guanaceví).
        2. Sierra La Candela (Tepehuanes, El Oro and Santiago Papasquiaro).
        3. Cordón La Cumbre (Santiago Papasquiaro).
        4. Sierra del Promontorio-San Francisco (El Oro and Coneto de Comonfort).
        5. Sierra del Oso or Cerro San José (Ocampo).
        6. Sierra Atotonilco (Hidalgo).
        7. Sierra de Mapimí (Mapimí).
        8. Sierra San Lorenzo (Lerdo and Cuencamé).

2. Canyons with steep slopes and little accessibility along wide river banks.
    A. River valleys on the Pacific Slope of the Sierra Madre Occidental, containing mesic pine-oak forests and, at higher elevations, dry oak-pine and oak forests. At the base of these canyons, low deciduous tropical forests occur.

1. Valle del Río Humaya (Topia).
2. Cañada del Río Galindo (Durango and Pueblo Nuevo).
3. Valle del Río Baluarte (Pueblo Nuevo).
4. Valle del Río Topia (Topia and Canelas).

B. Isolated mountains in the semi-arid region, characterized by the dominance of desert scrub, with prickly pears, spiny shrubs, agavaceous plants, and succulents:
1. Valle del Río Nazas (Rodeo and Nazas).
2. Sierra Gamón (Peñón Blanco).

In these areas, diverse vegetation types are present, including pine and oak forests, low tropical forest, secondary successional woodlands, natural and artificial grasslands, desert scrub and related habitats, mesquite scrub, shrub forests, and riparian systems. Such habitat complexity suggests that the areas are of biological interest, and could also provide good nesting habitat for eagles.

Lammertink *et al*. (1995) located two areas where pairs of Golden Eagles were breeding near the villages of La Formación (23E27' N and 105E36' W), at 2000 m in elevation and El Gallo (23E13' N and 105E29' W), at 1900 m. They concluded that significant numbers of Golden Eagles might be found in the rich canyons on the western slope of the Sierra Madre Occidental. Nocedal and Zúñiga (unpubl. data) observed Golden Eagle nests on Cerro de San Ignacio, near the Laboratorio del Desierto of the Mapimí Biosphere Reserve. Garza (pers. obs.), in 1993, observed an adult perched in a pine at the deer corral at the El Alemán Biological Research Station (EIBA) in La Michilía. Hence, many areas may prove to be used by the eagles.

To assist the program, a Golden Eagle protection network is recommended. Such a system would guarantee preservation of nesting sites, enhance ability to estimate numbers of breeding pairs, facilitate evaluation of habitat, facilitate determination of site ownership, and promote development of environmental education programs focused on the species conservation (Nocedal and Garza 1991).

NEEDS AND RECOMMENDATIONS

Durango's conservation priorities need to be redefined, and areas identified whose protection will best protect conserve the state•s rich biological resources. Sites apart from those here proposed, need to be identified, and conservation actions prioritized. The majority of the state has been poorly explored by qualified biologists, so taxonomy is poorly known for many groups, *i.e.* orchids, cacti, bromeliads, oaks, and small mammals. Many areas are in danger of losing biological value without ever having been inventoried systematically. Such inventories could potentially reveal the presence of many additional sites worthy of protection, and they could form the bases for site-specific individualized conservation management plans.

Due to the prevailing economic situation in the country, and in this region in particular, inhabitants and companies of the region may exploit unprotected areas without knowledge or interest in their potential conservation value. It is therefore important to generate management plans that include the needs of rural communities. Such integration of socio-economic and conservation goals is important to the maintenance of long-term regional economic and ecologic stability and compatibility. Development of integrated programs or plans should include interaction between local managing institutions and rural communities in or near the protected areas, with the objective of promoting cultural, biological, and socio-economic studies. The management of protected areas in the state should be the responsibility of a research institute or other competent authorities, such as SEMARNAP, with the objective of developing viable resource conservation plans.

A major problem in Durango, as in much of the country, is the inability of law enforcement agencies to put conservation law into action. Stricter enforcement of laws, rules, and regulations is necessary. Updating obsolete laws represents a further challenge. Programs are needed to monitor and control poaching. This effort would include training qualified personnel and increasing the number of conservation law enforcement agents

in Durango. Conservation monitoring of this type should, ideally, be carried out in the entire state, if possible, or at least in protected areas. Uncontrolled harvest of animals and plants for sale on the black market is another important problem. It is common to find endangered species of parrots and plants sold in the streets of cities like Durango and border cities like Ciudad Juárez. Above all, integration of local inhabitants (including a environmental education programs which emphasize the importance of natural resources) is necessary to avoid poaching and illegal forest exploitation.

Important habitats in Durango include the oak forests of the Sierra Madre Occidental that provide important wildlife habitats (Garza and Martínez in press) and hold populations of many resident and migratory bird species (Bacon in press). Although several plant species not previously known from Durango have been discovered in these areas (Bacon unpubl. data), few detailed floras have been prepared (Casas et al. 1995, Bacon and Spellenberg in press, Spellenberg and Bacon in press). The state's grasslands also should be accorded priority in consideration of potential conservation sites, particularly since the state's focus on livestock production threatens to eradicate all native grassland habitat. Numerous resident and migratory bird species are grassland dependent. Conservation attention must be given to low and mid-elevation tropical deciduous forests, restricted principally to the remote western slope of the Sierra Madre Occidental, and whose biological diversity remains largely undocumented.

Further exploration is necessary in the Chihuahuan Desert and adjacent arid regions because a single conservation area, Mapimí, is not necessarily adequate for conservation of this ecosystem in Durango. The work of Wauer and Riskind (1977) in the northern Chihuahuan Desert, and that of DeBano *et al.* (1995) in the sky islands of the Sierra Madre Occidental, provide strong evidence that the region contains endemic and endangered species in need of conservation attention.

The large region known as "Las Quebradas," on the western slope of the Sierra Madre Occidental, is floristically rich and diverse, and distinct from the flora of the eastern slope (González Elizondo 1983). These differences are likely to be reflected in differences in regional faunal diversity. Various resident bird species probably depend critically on the area because of local migrations, in which the birds move seasonally between high and low elevation forests. Additional conservation sites need to be identified in this unique region.

Of the established areas having only temporary protection, Las Bufas, a breeding area for Thick-billed Parrots, is probably the most important. El Tecuán Park has some conservation value as an educational area accessible to the general public, already being designated as a park and containing principal elements of pine forest. Among the potential areas, the most important are probably Arroyo de Las Causas and the other sites that support populations of mature *Picea chihuahuensis* forest and house Thick-billed Parrots. The savanna located north of the Sierra de la Candela is possibly important, due to the rarity of good-quality savanna on a world-wide scale; however, its biological richness has not yet been inventoried.

Aside from the sites we have listed, numerous others await evaluation and determination of their importance as well. Our intent herein was to identify those sites presently known, and to suggest the need for further exploration in the region to identify other important areas.

CONCLUSIONS

In the protection and conservation of species in critical situations, participation of local communities is especially important. Such is the case when management of these species is susceptible to effects of economically motivated activities, especially in natural areas. The success of well-intentioned efforts can be assured or damned, depending on the base of local support. Reintroduction of extirpated species, such as the Pronghorn Antelope in Mapimí, also requires organized participation by local communities, government agencies, and academic institutions. Programs to reintroduce carnivores, such as the endangered Mexican Wolf, could be perceived as incompatible with livestock production activity, even though it has been demonstrated that actual predation is less common than generally thought (Servín 1986). However, such projects could be better received, and experience greater success, if limited to isolated wilderness areas or if a

base of local support were to exist.

Traditional game species have diminished both in population and geographic distribution. Creation of effective harvest and management programs could contribute to the conservation of these species, as well as benefit non-game species and general habitat conservation. These advances, however, depend on successfully building bases of local support and understanding. The use of endemic species as indicators of conservation importance has proven useful in biodiversity conservation in Mexico, as in many parts of the world. Consequently, endemic species with restricted habitat distributions should be considered for establishment of one of the protected areas. Examples of bird species in Durango meriting such attention are Thick-billed Parrot, Tufted Jay, and Eared Trogon. Similarly, habitats with poor representation in Durango, and limited distribution elsewhere, should be considered important for conservation, including mature forest, and riparian areas with abundant native vegetation, wetlands, and pristine examples of many habitats.

The continuous presence of the Instituto de Ecología in Durango's biosphere reserves as responsible administrator and site manager has been of great importance to conservation efforts. This example can serve as a model, in which reserve establishment is coordinated with a responsible and stable institution. Research conducted in collaboration with local rural communities has permitted the generation of conservation programs compatible with local economic and land use activities. Hence, we consider local interaction with rural activities to be vital to preservation of these areas.

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Chapter 5. PROTECTED AREAS OF NAYARIT - Patricia Escalante Pliego

INTRODUCTION

Nayarit is a relatively small state on the Pacific coast of Mexico, with 27,864 km^2 and 1.4% of the country•s total area. Despite its size, Nayarit encompasses portions of the Pacific coastal plain, Sierra Madre Occidental, Transvolcanic Belt, and Sierra Madre del Sur. It is topographically diverse, with a rich variety of habitats (74% natural), including subtropical scrub (20%); pine, oak, pine-oak, and montane cloud forest (25%); tropical deciduous forest (9%); tropical semideciduous forests (12%); agricultural (22%); and mangroves, halophytic vegetation, coastal dunes, and palm forest (Flores Villelea and Gerez 1994). The most important wetlands in western Mexico lie on the Pacific coastal plain of Nayarit; these vast wetlands, known as the Marismas Nacionales, are 50 km wide and extend 100 km north into neighboring Sinaloa. Off the coast, several islands belong to Nayarit, among them the Tres Marias, Isabel, and the Tres Marietas. These islands hold a rich store of endemic flora and fauna. In addition, especially in the Tres Marias, the islands hold important seabird breeding colonies.

A total of 395 bird species have been reported from Nayarit, of which 269 are breeding residents, 87 wintering migrants, 27 transients, and 12 are accidental visitors (Escalante 1988). Notwithstanding its rich biodiversity, very little of Nayarit is protected in biological reserves (Fig. 5.1). The best preserved areas are the unpopulated Tres Marias Islands and the coastal wetlands. The latter, though, could be negatively impacted if neighboring Sinaloa•s shrimp industry were to spread south. Large extents of natural habitats have been lost via conversion to agricultural production of fruit, tobacco, corn, and coffee, as well as to impacts from forestry, cattle ranching, and mining. Research on the flora and fauna of Nayarit has also lagged behind, having focused mainly on the island biota and only recently on the mainland (Tellez 1995).

The largest groups of indigenous people in Nayarit are the Coras and Huicholes, who inhabit the sierras. Although much of their territory is roadless, the land has nonetheless been widely transformed from its natural state. The few remaining undisturbed areas are listed later in this chapter as potential sites for conservation action.

PROTECTED AREAS

Isla Isabel National Park

Location: A small island 28 km off the coast near Laguna de Mezcaltitlán at 25E52' N, 105E54' W, 72 km northwest of San Blas, and 61 km northeast of the Tres Marias Islands. Its size is given variously as 194 (SARH 1992) or 98 ha (Gaviño and Uribe 1981).

Physiography: Of volcanic origin, Isla Isabel has an irregular shape, with numerous cliffs and small beaches. It is 2 km long, 900 m wide, and reaches maximum elevation of 80 m. Two lagoons are present, the larger being Lago del Cráter. No streams or fresh water bodies exist. On the island's northwest extremity, a formation called •Cerro Pelón• is separated from the island at high tide. Northeast of the island are two 40 m high rock formations called •Las Monas.•

Climate: Warm humid, with summer rains.

Habitat: Seventy percent of the island is tropical deciduous forest with patches of grassland. Some areas are cultivated with sugar cane, papaya, coconut, banana, and pineapple. A more complete description can be found in Gaviño and Uribe (1981).

Fauna: Isla Isabel is one of the most important seabird breeding sites off the Pacific coast of Mexico (SEDUE 1989). Primary species are: Red-billed Tropicbird, Blue-footed Booby, Brown Booby, Red-footed Booby, Brown Pelican, Magnificent Frigatebird, Heermann's Gull, Sooty Tern, and Brown Noddy. Forty-two bird species have been recorded (Gaviño and Uribe 1981), of which 24 are aquatic and 18 are landbirds. Red-footed Boobies were only recently found breeding on the island, increasing from one pair in 1977 to ten pairs in 1985. Two other species recently recorded breeding are Yellow-crowned Night-heron and American Oystercatcher. Among the herpetofauna are Spiny-tailed Iguana, Green Iguana, Spiny Lizard, Whiptail Lizard, and Milk Snake (McDiarmid *et al.* 1976, Casas Andreu 1992). The island until recently held introduced mammals (rats and cats) that negatively impacted the seabird breeding colonies and the endemic fauna in general.

Research: The Instituto de Biología, UNAM, conducted most of the recent biological surveys, and negotiated with government officials to achieve the island's current protected status. For more than a decade, personnel of UNAM's Centro de Ecologia have conducted numerous investigations regarding the seabird breeding colonies (e.g. Drummond *et al.* 1991, Drummond 1993).

Land Ownership: Federal.

Management: Decreed in 1980 to conserve natural resources and to manage for recreational, cultural, and scientific uses, the island is managed as a special biosphere reserve. In 1996 an administrator was designated to help coordinate visiting scientists. Access is permitted only to scientists and small tourist groups. Historically, for more than sixty years, the island has been used as a base for fishing activities, and in the 1940s shark fishing camps were established. A few buildings were erected by fisherman at Playa Tiburones, and the government has built dormitories, a dining hall, and a cold room at Playa Iguanas next to the lighthouse.

Comments: Students from Centro de Ecología have apparently been successful in eliminating mammal pests from the island, an essential step in conserving the island's fauna. Also, as the fragility of the island's ecosystem could be impacted by excessive tourism, steps are being taken to limit the number of visitors.

Sierra de San Juan Special Biosphere Reserve

Location: Consisting of 25,977 ha, within the municipalities of Tepic and Xalisco, with center roughly at 21E26' N, 104E58' W.

Physiography: This high coastal sierra lies only 22 km from the coast, rising from 980 to 2400 meters. Its extensive watershed makes it an important water source for a large surrounding area. Some active volcanic sites are present.

Climate: The topographic relief and proximity to the sea make for a subhumid semi-warm climate in the lowlands (900-1600 m), more humid on the coastal slopes, and drier on the interior slopes. Above 1600 m, the climate is temperate subhumid, with permanent mists. Rainfall varies 1300-1800 mm annually.

Habitat: Cloud forest, dry and humid oak forest, pine forest, and grassland. This sierra holds a rich flora, including many endemic species or species having disjunct distributions. Botanical studies have recorded 1250 plant species in a 400 km^2 area, including 30% of Nayarit's total plant species (Blanco 1994, Tellez 1995).

Fauna: To date, 167 bird and 34 mammal species have been recorded.

Research: Botanical research has been conducted by Manuel Blanco (1994) of the Univ. Autónoma de

Nayarit. Avian data come from seven monthly bird surveys (Babb and Rojas 1993).

Land Ownership: Seventy-one percent ejidal, 21% small private owners, 6% communal, and 3% urban.

Management: Decreed in 1987, without consultation with local landowners, who fear expropriation of their land. As a result, no management plan exists, nor do ecological and land use assessments that could lay the basis for a plan.

Comments: The Sierra de San Juan watershed provides clean water to many people, towns, and agricultural areas. Immediate threats include wildfires on the drier interior slopes, some of which are quite serious; urban sprawl from Tepic and Xalisco invading the protected area; mining; and deforestation for agriculture.

It is imperative that the local populace be included in the formulation of the management plan, and that steps be taken to educate the 15,273 people within the reserve regarding how the reserve can benefit them. Living standards among local people are relatively good, as evidenced by the availability of education through high school and medical services. Their livelihood depends on sugar cane and coffee; within the reserve, land use is allotted primarily to coffee, banana, and fruit plantations. Successful conservation efforts elsewhere in Mexico indicate that it would be preferable for an academic institution from within Nayarit to take the lead in the study, management, and protection of this reserve.

POTENTIAL AREAS FOR CONSERVATION IN NAYARIT

Marismas Nacionales

Description: Located 60-210 km south-southeast of Mazatlán, Sinaloa, at 22E8' N, 105E32' W (Fig. 5.2). Part of the area belongs to the state of Sinaloa (known as the Sistema Estuarino Teacapan-Agua Brava). Marismas Nacionales is a vast complex of coastal lagoons of brackish waters, mangroves, mud flats, and shores, where several rivers drain into the Pacific, principally Río Acaponeta and its tributaries, and Río San Pedro. The wetlands vary a great deal annually depending on local precipitation; during a heavy rainy season vast areas transform into lagoons. Habitats include estuaries, deltas, mud flats, sandy beaches, mangroves, salt flats, slow-flowing streams, and permanent streams.

Several botanical and zoological studies have been conducted in the area. In 1980-1983, N. J. Scott studied breeding waterfowl, making recommendations for the establishment and management of protected areas. Recent bird counts reported 4200 cormorants, 10,000 American White Pelicans, 1320 Brown Pelicans, 1560 Great Blue Herons, 8360 Great Egrets, 9400 Snowy Egrets, 3150 Little Blue Herons, 8940 Cattle Egrets, 1430 White Ibis, 1590 Roseate Spoonbills, 6280 Wood Storks, 15,200 Fulvous Whistling-ducks, 2200 Snow Geese, 500 Canada Geese, 42,000 Green-winged Teal, 58,000 Pintail, 37,500 Blue-winged Teal, 10,000 Northern Shoveler, 29,300 Gadwall, 2,300 Ruddy Ducks, 43,000 American Coots, and around 204,000 shorebirds. In 1979-1982, the average number of wintering waterfowl was 178,000. Common breeding birds are Neotropic Cormorant, Anhinga, Great Blue Heron (250 pairs in 1979), Great Egret, Snowy Egret, Tricolored Heron, Black-crowned Night-heron, Yellow-crowned Night-heron, Boat-billed Heron, Roseate Spoonbill, Wood Stork, Fulvous Whistling-duck, and Black-bellied Whistling-duck. Muscovy Duck and Masked Duckare also breeders, though less common. During winter, Ospreys are common (106 in 1982). Important numbers have been recorded for other faunal elements such as Jaguar and American Crocodile.

Comments: The area is not protected. Illegal settlements, tourism, excessive fishing, and hunting of both breeding and wintering waterfowl create serious problems, especially near San Blas. The main threat, however, comes from the potential development of shrimp farming. These proposed farms could occupy as much as 40,000 ha (Tellez 1995), displacing the natural halophytic vegetation, and large amounts of natural habitat.

Furthermore, these farms bring plague that victimizes cormorants, pelicans, Great Blue Heron, Osprey, and some gull species. In addition, mangroves are drying out and being lost at a rate of 2.3% annually (Callejas 1991).

Nevertheless, the Marismas are still one of the last and best-preserved aquatic habitats in western Mexico. Recent censuses identified them as the second most important waterbird area on the Pacific Coast, noting especially numbers of Black-necked Stilts, American Avocets, and other shorebirds (Harrington, pers. comm.). INE constitutes the Mexican counterpart of the North American Waterfowl Management Plan, which has identified Marimas Nacionles as one of 32 priority wetlands in Mexico. Its importance has also been affirmed by the Convention on Wetlands of International Importance convened in Ramsar in 1971.

Islas Tres Marías

Description: This small archipelago consists of four islands which from northwest to southeast are San Juanito, María Madre, María Magdalena, and María Cleofas, between 21E45' and 21E15' N, and 106E42' and 106E16' W. San Juanito, the smallest of the four, is 8 km^2, with highest point at 45 m, and lies 3.7 km northwest of María Madre. María Madre is 144 km^2, with highest point at 616 m, and is 7.4 km northwest of María Magdalena. María Magdalena is 84 km^2, with highest point at 457 m, and is located 15.7 km northwest of María Cleofas. Lastly, María Cleofas is 25 km^2, with highest point at 402 m. San Juanito and María Cleofas are 152 and 80 km from Punta Mita, Nayarit, respectively. The islands average 617 mm of rain annually. The three larger islands have tropical deciduous and semideciduous forests with patches of trees up to 35 m tall; María Magdalena has mangroves. The smaller San Juanito has tropical deciduous forest and subtropical scrub reaching only 3 m (Zweifel 1960, Neri 1986).

Konrad (1985) has reported 99 species of birds, of which 34 are landbirds and at least 27 are endemic forms (Grant and Cowan 1964). Of insects, 52 species of Psocoptera have been identified, seven of which are endemic to the islands (Neri 1986). Studies of amphibians and reptiles have focused on biogeography and conservation (McDiarmid *et al.* 1976, Casas Andreu 1992). Huerta *et al.* (1976 in Casas Andreu 1992) reported 15 mammal species with four endemic forms. The Instituto de Biología, UNAM, has conducted some recent surveys.

Comments: As of 1985, María Madre had 5000 inhabitants. It has 10 permanent campgrounds, a road circles the island, some land has been converted to agriculture, and a federal prison was established in 1905. Introduced fauna is numerous, including cows, sheep, goats, horses, burros, rabbits, pigs, rats, and cats. On María Magdalena goats, rats and cats are present, as well as White-tailed Deer. Apparently, María Cleofas is the best preserved of the islands. Some amphibians are considered vulnerable due to a scarcity of the humid microclimate they require. Reptiles, in particular Spiny-tailed Iguana and Boa Constrictor, are used by local inhabitants for food and leather. In addition, they eat the freshwater Mud Turtle, restricted to Arroyo Hondo at María Madre (Casas Andreu 1992).

There is an urgent need to control introduced mammals before they damage irreversibly the natural biota. The islands merit official conservation status because of the many endemic taxa present—in fact, Escalante et al. (1993) identified this archipelago as an important concentration of endemism on a national scale. Regulation of current land use practices needs to be formalized in a conservation-oriented management plan.

Islas Tres Marietas

Description: These two small islands have a combined area of 70 ha, and are located 8 km from Punta Mita, Nayarit, at 20E41' N, 105E36' W. They have a warm subhumid climate, and are characterized by rocky cliffs

with grasses and some shrubs, cacti, and ferns (Gaviño and Uribe 1981). The smaller Isla Redonda (28 ha) has no beaches, whereas Isla Larga (42 ha) has several small beaches. Grant (1964a) reported 37 bird species, of which seven breed: Blue-footed Booby (550 pairs), Brown Booby (400 pairs), Brown Pelican, Brandt's Cormorant, Magnificent Frigatebird, Heermann's Gull (550 pairs), and Brown Noddy. Eight species of reptiles have been identified (Casas Andreu 1992).

Comments: Seabird eggs are occasionally stolen by people (Casas Andreu 1992). Instituto de Biología, UNAM, has conducted biological surveys of the island on several visits. Recently, the Facultad de Ciencias, UNAM, used the islands to conduct observational studies of whales and other marine mammals, as well as to observe breeding bird colonies. These islands, with their fragile, yet relatively intact, ecosystems, should be conserved.

OTHER POTENTIAL SITES

The following areas were singled out by Tellez (1995) for their undisturbed native vegetation, and as centers of floristic endemism in the state. Although faunal inventories for these areas are unavailable, conservation action is desirable as these areas represent the best examples of intact ecosystems in the state.

La Tovara (San Blas)

Description: At the south end of Marismas Nacionales, and close to the town of San Blas, La Tovara is an important ecological and recreational site. Its location provides for the influence of both fresh and salt water, resulting in mangroves intermixed with tropical semideciduous forest and semiaquatic vegetation. Birds of prey, numerous egrets, and other waterbirds are present in abundance.

Comments: Local authorities recognize the area•s value, and have interest in designating protection status for it. Already, San Blas residents have begun instituting some degree of protection, as they perceive the attraction the area provides for foreign tourists.

Mesa del Nayar surroundings

Description: In northeastern Nayarit, this area is part of the Sierra Madre Occidental, with a complex topography rising from 600 to 2000 m, with many abrupt canyons. Habitats vary with increasing elevation from tropical deciduous forest to cloud, pine, oak and pine-oak forest. Thus far, 55 endemic plant species have been identified in the immediate area, and many rare and restricted-range vertebrate species are known from the region.

Comments: Most natural habitats of the Mesa del Nayar have been disturbed; those portions remaining that have been impacted less merit protection. These areas have remained undisturbed because of inaccessibility dictated by complex topography. However, this factor cannot be relied upon for long-term protection.

Compostela surroundings

Description: This area encompasses numerous canyons between 500 and 1000 m in southwestern Nayarit. Principal habitats are pine and oak forests providing rich ecotones with tropical deciduous forest. Thirty-five

plant species endemic to Nayarit have been recorded.

Comments: As with the Sierra de San Juan Biosphere State Reserve, this area is also part of the southern sierras of the state, and thereby compliments that reserve by encompassing the lower-elevation habitats of the region. Nearby Las Varas was a traditional collecting locality for birds.

Meseta de Pedro y Pablo

Description: This area is located at 500▪1000 m on the slopes of the Sierra Madre Occidental in northern Nayarit. Predominant habitats are tropical deciduous, pine, and pine-oak forest. Twelve plants endemic to Nayarit have been identified here.

Comments: No information is available regarding the fauna of the area; however, given habitat quality and the potentially associated avifauna, the site should be considered for protection. At present, neither the government or any other entity appear to intend to provide conservation status to the area.

Tellez (1995) identified the following additional sites as having relatively intact habitats rich in endemic plant species: in the Sierra Madre Occidental, **Huajicori**, **Santa Teresa**, **Huasemota**, **Zopilote**, and **Cohamiata**; in the Transvolcanic Belt, **Pochotitlán**, **Santa María del Oro**, **El Refugio**, **Ahuacatlán**, **Plan de Barrancas**, **Mirador del Aguila**, and **Jumatán**; and in the southern sierras, **Bahía de Banderas**.

POTENTIAL AREAS PROPOSED BY THE MEXICAN GOVERNMENT

Government officials of SEMARNAP▪Nayarit are considering several other areas in the state for conservation action, but available information is almost nonexistent. The selection does not seem to result from a comprehensive study, but rather appears to be the product of interests promoting the protection of specific sites. Their list includes, in addition to Isla Isabel National Park and Sierra de San Juan State Biosphere Reserve, the following:

- **Los Negros:** A 2920 ha area north of San Blas, at the southern end of the Marismas Nacionales in the municipality of San Blas; presently a municipal park for the conservation of aquatic flora and fauna, to be considered for National Park status.
- **Laguna Santa María del Oro:** A 270 ha area southeast of Tepic, to be decreed as a national park due to the natural beauty of the lake and surrounding oak forest.
- **Singayta:** A 1760 ha area north of San Blas, at the southern end of the Marismas Nacionales, including a combination of mangroves, mud flats, and palm and tropical semideciduous forest, to be protected as a state ecological reserve. As many as 223 species of birds have been reported in this area.
- **Volcán El Ceboruco:** A 1500 ha area rising to 2164 m in the Jala municipality of southeastern Nayarit, to be protected as a geological park because of its complex lava formations.
- **Platanitos:** A 33 ha coastal area in southwestern Nayarit, south of San Blas in the municipality of Compostela, to be protected for breeding sea turtles.
- **Laguna El Quelele:** A 240 ha area inland from the Bahía de Banderas in southeastern Nayarit, to be protected as a wildlife reserve.
- **Aguamilpa Reservoir:** A 12,800 ha reservoir east of Tepic on the Río Santiago. The area is intended to protect migratory waterbirds. However, the dam was finished only in the past three years and no historical concentrations of waterbirds are known from this area.

- **Cordillera Cerro de las Lumbres (Rosa Morada y Tecuala):** An area where the captures of birds for pets is regulated (Alcérreca *et al.* 1988).

ASSESSMENT OF CURRENT SITUATION

In Nayarit, government plans have repeatedly identified steps necessary for biodiversity conservation, including habitat restoration, creation of natural parks and wildlife refuges, and others. Very little, however, has actually been done, especially in comparison with states such as Quintana Roo and Chiapas. Thus, ecological conservation successes in Nayarit are few, while conflicting interests such as logging, mining, and tourism continue to grow. Only recently have nongovernmental organizations begun encouraging management agencies to provide the environmental damage assessments that Mexican law dictates. In general, the only voices raised in defense of the environment have come from academics at the Univ. Autónoma de Nayarit, in Tepic, and subsequently from SEMARNAP officials following their lead in recognizing the national and global need for increased emphasis on biodiversity conservation.

The indigenous cultures of Nayarit have traditionally treated the natural environment with reverence, particularly in regard to certain species, such as deer and turkey for the Huicholes. Transplanted populations of these peoples now living in cities have negatively impacted that part of their traditional culture valuing nature, and have contributed to reduction in size of historical territories. At the moment, culturally important sites are not considered for conservation at all, and are slowly being destroyed; particular examples include the island of Mezcaltitlán and San Felipe Aztatlán, where Aztec culture originated, and other examples on the Mesa del Nayar (Lilly, pers. comm.).

The portion of the northern Pacific coastal pain where the Marismas Nacionales is located should be a high national conservation priority, with three important rivers draining the area (Acaponeta, Santiago and San Pedro). Forestry, mining and tourism are poorly developed here. Agriculturally, however, this region is the most productive in the state, having extensive irrigation, and with the impact of the Aguamilpa dam yet to be fully appreciated. Conservation goals need to be identified before additional agricultural conversion takes place.

The Sierra Madre Occidental covers 43% of Nayarit; principal industries are cattle ranching, forestry, and mining. These activities are extensive, and even though much of the Sierra is remote and of difficult access, the natural environments throughout the region have been severely impacted. Plans are underway to construct a highway across the mountains between Tepic and Zacatecas, which will increase habitat degradation. With so much of the habitat within the Nayarit portion of the Sierra Madre Occidental negatively impacted, creation of an ecological sanctuary or reserve is a high priority.

Currently, the state=s most important reserve is the Sierra de San Juan Biosphere State Reserve, within the province of the Transvolcanic Belt, the region of Nayarit with the highest population density, commerce, and tourism. Unfortunately, the process leading to the reserve=s decree failed to establish support from the local people, an essential component of successful conservation in Latin America. A solution could lie with the thoughtful development of a management plan that purposefully seeks input from all sectors involved with the reserve. All voices need to be heard with regard to identifying core areas in the reserve, as well as establishing regulations and determining potential compensations.

Although the southern sierras are the least well represented physiographic province, they provide Nayarit with rich industries, especially mining and tourism. Main attractions are the lakes of Santa María del Oro and San Pedro Lagunillas; others include Tepetiltic, Volcán Ceboruco, and the archeological sites at Ixtlán del Río. In spite of the many important areas identified for ecological conservation, information about them is rudimentary, or lacking. Badly needed is a program of survey and inventory, and little is being done to provide these areas with protection status.

The islands of Nayarit have received far more attention, and some conservation has been ensured for Isla Isabel, primarily due to constant presence and management by scientists. Much less is being done for the

Islas Tres Marías, which represent an impressive concentration of endemism. The smaller and relatively less important Tres Marietas are currently receiving some attention, although long-term protection is not assured. Island environments are fragile and sensitive to invasive forces; accordingly, they too should constitute a high priority in Nayarit.

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Chapter 7. PROTECTED AREAS OF JALISCO AND COLIMA - Leticia Hernández López, Enrique J. Jardel, and Carlos Palomera García (translation by Carlos Palomera García)

INTRODUCTION

Jalisco (80,836 km^2) and Colima (5191 km^2) exhibit considerable habitat diversity owing to their abrupt topography and location intermediate between temperate and tropical America, resulting in disjunct temperate forests surrounded by subtropical conditions and consequent mixing of Nearctic and Neotropical species (Rzedowski 1978, Jardel 1994). Approximately 2000 genera and 7500 species of vascular plants have been recorded from the biogeographic region known as Nueva Galicia (McVaugh 1991); of which Jalisco and Colima comprise 68% of the total area. These numbers are equivalent to one third of the flowering species found in Mexico (Rzedowski 1993).

Some plant families show remarkable diversification in this region. For instance, the Compositae has a higher number of species in Nueva Galicia than in any other place in the world (McVaugh 1984); the region is also a center of diversity for Euphorbiaceae (McVaugh 1961, 1995) and Malpighiaceae (Cuevas 1991). It has an impressive variety of pines and oaks: 27 pine species and 46 oak species (out of totals for Mexico of 69 and 150, respectively) (Critchfield and Little 1966, González Villarreal 1986, McVaugh 1974, 1992). The region also represents the world's greatest concentration of wild maize species, two of which are local endemics: *Zea perennis*, found on the slopes of the Nevado de Colima, and *Z. diploperennis*, known from the Sierra de Manantlán (Iltis *et al.* 1979; Guzmán 1982). Preliminary studies suggest that 5.4% of the estimated flora of Jalisco is endemic to the state (Hernández López 1995a). Major habitat divisions in Jalisco include oak, pine-oak, pine, and fir forests (30%), tropical semideciduous and deciduous forests (8%), subtropical scrub (20%), and agricultural and secondary growth (40%); for Colima these divisions are oak, pine-oak, pine, montane cloud, and fir forest (8%), tropical semideciduous and deciduous forests (43%), subtropical scrub (1%), and agricultural and secondary growth (45%).

Biological diversity in the two states is also high: 173 species of mammals (four endemic) are found in Jalisco, 39% of Mexico's total (Iñiguez and Santana 1993), while 525 bird species have been reported, 51%of Mexico's avifauna (Palomera *et al*. 1994). Although herpetofaunal inventories remain incomplete, preliminary data show that 20% and 18% of the Mexican reptile and amphibian species are found in the area (Flores Villela and Gerez 1988); of the 66 reptile and 19 amphibian species known from the coast of Jalisco, 42 are endemic to Mexico (García and Ceballos 1994). Regarding the aquatic fauna, 94 species of invertebrates and 209 vertebrates have been reported (Guzmán Arroyo 1990); of the approximately 100 freshwater fish species described for west-central Mexico, 70% are endemic (Lyons *et al.* 1995). Although Colima is one of the smallest Mexican states, it holds 227 vertebrate Mesoamerican endemics, with eleven species endemic to the state (Flores Villela and Gerez 1994). In addition, one fourth of Mexico's endemic mammals are found in Colima and adjacent areas of Michoacán and Jalisco (Fa and Morales 1993). Colima also has 94 species of aquatic vertebrates and, though data are lacking, 21 species of invertebrates have been recorded (Guzmán Arroyo 1990).

Despite the fact that ornithological surveys and descriptions have a long history in Mexico (Escalante *et al*. 1993), some states still lack bird lists. The first comprehensive list published for Jalisco is in Palomera *et al*. (1994); the birds of Colima were reviewed by Schaldach (1963, 1969). A few censuses and ecological studies have been prepared for particular areas, guilds and species, most of these sites coinciding with current protected areas (e.g., Schaldach 1969, Hutto 1980, 1987, Ornelas *et al.* 1993). Reports of bird observations and censuses before and after establishment as reserves exist for the Nevado de Colima area, the Sierra de Manantlán, and along the coast in both states (e.g., Zimmerman and Harry 1951, Davis 1960; Schaldach 1969, DesGranges and Grant 1980, Arizmendi *et al.* 1990). Lists also exist for some of the potential conservation areas considered in this chapter (e.g., Arellano and Rojas 1956, Selander and Giller 1959, Grant 1964b, Santaella and Sada 1991). The region is recognized as an important winter destination for a significant number of latitudinal migratory birds (Hutto 1980) as well as playing host to many altitudinal migrants (Ornelas and

Arizmendi 1995), further emphasizing the importance of local wetlands and forested habitats in the sierras.

PROTECTED AREAS

The first protected area created in the region was the Nevado de Colima National Park in 1936. Since then, 16 additional reserves and parks have been added, mostly following incidental rather than ecological criteria. It is only recently that the latter, as well as the role of local communities in conservation strategies, have been incorporated into the planning and implementation of newly created protected areas. Jalisco has 199,886 ha of its territory legally protected in 12 reserves with six different management categories (Fig. 7.1). One protected area, the Sierra de Manantlán Biosphere Reserve, encompasses 66% of this total area, while four others protect narrow coastal strips of minimal area. These parks and reserves are concentrated in the central and southwestern portions of the state. In Colima, 650,962 ha are protected in seven reserves (two shared with Jalisco) in five different management categories, with almost 98% of the total belonging to the Revillagigedo Archipelago Biosphere Reserve.

Nevado de Colima National Park

Location: Southwest of Ciudad Guzmán, in southern Jalisco, the access roads branch out from the paved road linking with Autlán. Center at 19°33' N, 103°37' W, size 10,153 ha, in the municipalities of Ciudad Guzmán, Tuxpan, Venustiano Carranza, and Zapotitlán of Jalisco, and Cuauhtémoc of Colima.

Physiography: Located in the western confines of the Transvolcanic Belt at 3350▪4330 m, the park includes the peaks of the Nevado de Colima (4330 m) and Volcán de Fuego (3958 m). The Nevado is part of an older inactive volcano, while the Volcán is the most active in Mexico (Flores 1987). Topography is very steep, with slopes of 30▪100%.

Climate: Cool subhumid below 4000 m with annual temperature of 5▪12°C , and cold above 4000 m with annual mean temperature of ▪2▪5°C.

Habitat: High-mountain pine forests and bunch grasslands or "zacatonales."

Fauna: Mammals include White-tailed Deer, Coyote, Mountain Lion and Collared Peccary. Schaldach (1963) reported 61 families and 340 species of birds for the park and its surroundings. The park itself (above 3200 m) holds 102 bird species (Contreras Martínez *et al.* unpubl.), including Long-tailed Wood-Partridge, White-striped Woodcreeper, Russet Nightingale-Thrush, Brown-backed Solitaire, Gray Silky-Flycatcher, Chestnut-sided Shrike-Vireo, Golden-browed Warbler, Red Warbler, Crescent-chested Warbler, Rufous-capped Brushfinch, Green-striped Brushfinch, and Collared Towhee.

Research: Several botanical (McVaugh 1972) and zoological surveys (Schaldach 1963, González and Pérez 1987) have been conducted.

Land Ownership: Indefinite.

Management: Decreed in 1936, this park initially included 22,200 ha and extended west to Cerro Grande, which is now part of the Sierra de Manantlán Biosphere Reserve, but was modified in 1940. As a result, 46% of its area was assigned to the forest concessionaire Unidad Industrial de Explotación Forestal de Atenquique. The relinquished area included pine, mountain cloud, alder, and fir forests, and have been exploited since the

end of last century.

There is no operative administration. Its control was transferred from SARH to SEDUE in 1982. The latter maintained a guard post from 1989 until 1991, when, due to legal changes, the park administration was returned to SARH. In 1995, the newly formed SEMARNAP was given responsibility for national park administration. No personnel are assigned to the area, and infrastructure is limited to dirt access roads and a poorly kept guard's post and shelter. The area is subject to degradation related to cattle grazing, illegal hunting, timber cutting, and forest fires. Although some unsuccessful control measures against bark beetles and mistletoe have been implemented, these activities have only increased the general damage to the area. The park receives numerous visitors on weekends and holidays, contributing problems related to solid refuse. Furthermore, important and threatened habitats for the protection of watersheds, such as fir and cloud forests, were left out with the reduction of the park's size.

Comments: Visitors are attracted to the park area by scenery, forests, opportunities to hike, and when conditions permit, snow. The Nevado de Colima and the always smoking Volcán de Fuego are the first and second highest mountains of the region, holding several unique high-montane forest types. This park is important in the protection of watershed basins that provide water to cities in both states.

Arcos de Vallarta Marine Park

Location: In Banderas Bay, 11 km south of Puerto Vallarta, and seen from the road to Barra de Navidad. Center at 20°33' N and 105°19' W, totalling 314 ha, within the Puerto Vallarta municipality.

Physiography: Rocky coast with sea stacks having natural arches and underwater passageways.

Climate: Warm humid tropical.

Habitat: Rocky seacoast.

Fauna: The area has reefs with coral polyps of the genus *Dendrophyllia* and *Tubastrea*, and numerous fish and sea birds.

Research: None.

Land Ownership: Federal.

Management: Decreed in 1975, the park has been under the combined jurisdictions of the Secretary of Industry, SAHOP, and SEPESCA, without any on-site administration or management. Although originally created as a refuge for the protection of marine flora and fauna, it is not recognized by SINAP, and the park's location is ambiguous, boundaries are not clearly defined, and no protection or management plan exists. Despite being a tourist attraction (20 boats visit daily), local authorities and the general public are unaware that it is a protected area (Hernández López 1991). Solid waste and extraction of marine organisms are some of the critical problems faced.

Comments: The rocks are important for breeding sea birds and numerous marine fauna.

Bosque La Primavera Forest Protection Area and Wildlife Refuge

Location: Totalling 30,500 ha, located 15 km west of Guadalajara in the Sierra de la Primavera. Center at 20°41' N, 103°31' W, including parts of the municipalities of Tala, Zapopan, Arenal and Tlajomulco.

Physiography: La Primavera is characterized by irregular topography at 1400▪2200 m. The forest has 20 permanent streams and numerous springs.

Climate: Warm subhumid with annual mean rainfall of 980 mm; annual mean temperature is 21°C.

Habitat: Pine-oak forest. More than 772 plant species have been reported, including 80% of the orchids reported for the state (Curiel 1988).

Fauna: About 125 species of birds (Elorsa Reyes 1992), 73 mammals, 23 reptiles, and 3 amphibians have been recorded. The ichthyofauna includes two fish families endemic to Mexico, Poecilidae and Goodeidae (Curiel 1988). Birds include Lesser Roadrunner, Berylline Hummingbird, Russet-crowned Motmot, Black-throated Magpie-Jay, Spotted Wren, Brown-backed Solitaire, Blue Mockingbird, Rusty-crowned Ground-Sparrow, Collared Towhee, Blue Bunting, and Black-vented Oriole.

Research: The University of Guadalajara, through the Laboratorio Bosque La Primavera, leads the research and environmental education activities.

Land Ownership: Half the land is private, 15% is state, and the rest is ejidal.

Management: Decreed in 1980. Despite the area's having no formal administration, several institutions are involved in its management (SARH and SEDESOL until 1994, and now SEMARNAP; the Comisión de Ecología; and the municipal authorities of Zapopan, Tala and Tlajomulco). The University of Guadalajara has proposed a management plan which has not yet been accepted by the federal authorities. Nonetheless, the plan has helped as a framework to achieve inter-institutional compromise for the management of the refuge. The category "wildlife refuge" was established in the Forest Law in 1986, and the areas under this designation were not recognized as part of SINAP. Recreation, agriculture, grazing, and housing are principal human activities; additional activities, including vandalism, illegal hunting, forest fires, and mineral extraction, contribute to the deterioration of the area. A geothermal power plant is operated by the CFE.

Comments: La Primavera is considered to be Guadalajara's primary climate regulator and one of the city's favorite recreational areas. In spite of having a proposed management plan, lack of effective protection and funding to control access to the forest makes its preservation a difficult task. Increasingly, proximity of the city with its growing population and associated economic and political interests contributes additional management problems (Curiel 1988).

Sierra de Quila Forest Protection Area and Wildlife Refuge

Location: Of 15,192 ha, 100 km southwest of Guadalajara along the road to Barra de Navidad, near Tecolotlán. Includes parts of the municipalities of Tecolotlán, Cocula, Tenamaxtlán, and San Martín Hidalgo.

Physiography: This mountainous refuge lies in the Transvolcanic Belt, elevation 1400▪2560 m.

Habitat: Pine, oak, and pine-oak forests, as well as areas of tropical deciduous and cloud forests. A preliminary study reports more than 770 plant species (Guerrero 1994).

Climate: Temperate subhumid and warm subhumid.

Fauna: White-tailed Deer, Collared Peccary, and Mountain Lion are known from the area. A preliminary survey found 107 bird species for the area, including Thick-billed Parrot, Lesser Roadrunner, Buff-collared Nightjar, Berylline Hummingbird, Blue-throated Hummingbird, White-striped Woodcreeper, Sinaloa Wren, Russet Nightingale-Thrush, Brown-backed Solitaire, Blue Mockingbird, Rufous-capped Brushfinch, Green-striped Brushfinch, Collared Towhee, Crescent-chested Warbler, Black-headed Siskin, and Black-vented Oriole (Contreras Martínez *et al.* unpubl.).

Research: None.

Land Ownership: Divided between private owners and ejidos.

Management: Decreed 3 August 1982, Sierra de Quila is practically abandoned, with no physical boundaries, protection, administration, or financing. SARH occasionally undertakes activities to control mistletoe, and bark and wood-boring insects. Illegal hunting, agricultural clear-cutting, forest fires, and forest parasites also affect the area (Hernández López 1991).

Comments: Proposed for protection since 1956, the Sierra de Quila is vital to the protection of the Ayuquila River basin (the third in importance in Jalisco). It holds numerous impressive waterfalls during the rainy season.

El Jabalí Forest Protection Area and Wildlife Refuge

Location: Located near Comala, constituting 5178 ha in the municipality of the same name, in the state of Colima. Center at 19°28' N, 103°39' W.

Physiography: At 1200▪2300 m, contains several lagoons (La María, El Calabozo, El Jabalí, and La Escondida) and permanent streams from the slopes of the Volcán de Fuego and Nevado de Colima.

Climate: Temperate, with annual mean temperature of 12▪18°C.

Habitat: Oak, pine, and relicts of tropical deciduous and cloud forests, with walnuts, cedars and ash.

Fauna: Numerous mammals include Raccoons, Nine-banded Armadillos, White-tailed Deer, foxes, and Coyotes. There have been 180 bird species recorded including Long-tailed Wood-Partridge, Banded Quail, Sparkling-tailed Woodstar, Golden-cheeked Woodpecker, Gray-crowned Woodpecker, White-striped Woodcreeper, Spotted Wren, White-bellied Wren, Brown-backed Solitaire, Slaty Vireo, Golden Vireo, Fan-tailed Warbler, and Rusty-crowned Ground-Sparrow.

Research: None.

Land Ownership: Eighty percent of the land is private, while the rest is ejidal.

Management: Decreed 14 August 1981, no administration or management plan exists. The few management activities are restricted to some reforestation efforts in the ejidos area. SARH-Colima has a tree nursery and a guard post. SEDESOL ran a deer nursery, which was started originally by SARH in collaboration with members of the ejido La Yerbabuena. The private portion, known as Rancho El Jabalí (where the ruins of the

Hacienda San Antonio were remodeled into an exclusive hotel) has its own personnel, administration, and permanent protection. The best conserved areas surround the lagoons. One of these, Laguna La María, has been adapted as a tourist center by the ejido community. Except for Rancho El Jabalí, the area is threatened by illegal hunting, forest fires, cattle raising, and clearing for agriculture.

Comments: With its permanent lagoons, the area is important as a water reservoir. It has outstandingly beautiful arroyos and diverse wildlife.

Chamela Biological Research Station

Location: Located in southwestern Jalisco at km 59 on the coastal highway between Barra de Navidad and Puerto Vallarta. Size 1600 ha, center at 19°31' N, 105°1' W, within the municipality of La Huerta.

Physiography: This is a region of low hills with no permanent streams, at elevations of 10–580 m.

Climate: Hot subhumid with annual mean rainfall of 724 mm, and mean temperature of 25°C.

Habitat: Tropical deciduous forest which, with more than 1100 plant species, is considered one of the richest representations of this vegetation type in the world (Lott 1993). Portions of tropical subdeciduous forest and spiny shrubs are also present.

Fauna: The wildlife comprises more than 2000 species of insects (Morón 1989), 69 reptiles, and 20 amphibians (Ramírez Bautista in press), 270 birds (Arizmendi *et al*. 1990), and 75 species of mammals (Ceballos and Miranda 1986). Among the birds are West Mexican Chachalaca, Banded Quail, Yellow-headed Parrot, Lesser Roadrunner, Balsas Screech-Owl, Buff-Collared Nightjar, Sparkling-tailed Woodstar, Golden-cheeked Woodpecker, Flamulated Flycatcher, Gray-collared Becard, San Blas Jay, Happy Wren, Sinaloa Wren, Rufous-backed Robin, Black-capped Gnatcatcher, Golden Vireo, Fan-tailed Warbler, Red-breasted Chat, Blue Bunting, Orange-breasted Bunting, Black-chested Sparrow, and Yellow-winged Cacique.

Research: One of the better-known research sites in the country, with extensive projects over the last two decades. Its main objectives are preservation of natural communities; studies of biological diversity, structure, and functions of these communities; and facilitation of scientific research and education about the local flora and fauna.

Land Ownership: UNAM.

Management: Decreed January 1971, the area was established, and is administered and managed by UNAM. In December 1993, it was included as one of the four Chamela–Cuixmala Biosphere Reserve core areas. Despite being a scientific research facility, no committee evaluates research priorities, nor does any zonification or management plan exist. Personnel are involved only with the maintenance and protection of the research infrastructure.

Comments: The station's main problems are illegal hunting, logging, forest fires, and agriculture. Chamela is an area of high scientific value as one of few biological stations in tropical deciduous forest that has international recognition and a long research history.

Las Joyas Research Station

Location: Of 1245 ha in extent, Las Joyas is located in the heart of the Sierra de Manantlán Biosphere Reserve. Center at 19°35' N, 104°17' W, within the municipalities of Cuautitlán and Autlán.

Physiography: Steep mountainous terrain, at 1540▪2180 m.

Climate: Warm subhumid to temperate subhumid with annual mean rainfall of 1600 mm, and annual mean temperature of 18°C.

Habitat: Pine, pine-oak, cloud forest, and secondary vegetation (Jardel 1991), with 762 species of vascular plants recorded (Cuevas 1994). Of this total, three are endangered, eight are considered vulnerable, and 122 are rare (e.g., *Acer skutchii*, *Juglans major* var. *glabrata*, *Magnolia iltisiana*). The station also holds important patches of *Zea diploperennis*, a perennial teosinte (wild corn) endemic to Manantlán, which was the motive for creation of the Manantlán Reserve (Guzmán and Iltis 1991, Cuevas 1994).

Fauna: Identified thus far have been 45 mammals, 25 reptiles, and 198 bird species (García *et al*. 1994). The latter include 22 hummingbird species, the highest number reported for an area of this size in the world. Other birds present are Singing Quail, Long-tailed Wood-Partridge, Buff-collared Nightjar, Eared Trogon, Gray-crowned Woodpecker, Smoky-brown Woodpecker, White-striped Woodcreeper, Spotted Wren, Russet Nightingale-Thrush, Brown-backed Solitaire, Aztec Thrush, Rufous-backed Robin, Blue Mockingbird, Slaty Vireo, Golden Vireo, Chestnut-sided Shrike-Vireo, Golden-browed Warbler, Fan-tailed Warbler, Red Warbler, Crescent-chested Warbler, Rufous-capped Brushfinch, Green-striped Brushfinch, Collared Towhee, Black-headed Siskin, and Black-vented Oriole.

Research: Since its creation almost ten years ago, Las Joyas has become an important site for research on the ecology of subtropical montane forests, and it has played a significant role in the training and education of technicians and scientists (45 bachelor and graduate theses completed, as well as several workshops and courses).

Land Ownership: The station is owned by the state of Jalisco.

Management: Decreed 8 December 1984, Las Joyas is administered by the IMECBIO (previously known as Laboratorio Natural Las Joyas) of the Univ. de Guadalajara. It is one of the few protected areas in Mexico that has a management plan and effective protection in the field. Full-time personnel work on management, research, and environmental education activities.

Las Joyas' objectives are to (1) offer adequate facilities and resources for conducting research and monitoring of ecosystems under natural conditions; (2) contribute to the education and development of field scientists and technicians knowledgeable in ecology and natural resources management; (3) preserve ecosystem and species diversity in the Sierra de Manantlán; (4) provide opportunities for environmental education and interpretation; and, (5) protect natural populations of *Zea diploperennis*.

Frequent forest fires constitute the principal threat to the area. Control measures include preventive action (supervision of agriculture burnings and cooperative activities with neighboring communities, establishment of fire lines, and prescribed burns) and direct fire fighting. However, a policy on the management of fire based on research results needs to be defined. Cattle grazing was eliminated in 1987▪1988. People from neighboring Indian and ejido communities gather blackberries from around the station. Public visitors are permitted only in organized groups; their growing numbers will eventually necessitate a visitation plan to avoid impact on research activities.

Comments: Las Joyas lies at the heart of one of Mexico's flagship reserves. Both the station and the reserve

benefit considerably from the high number of Univ. de Guadalajara researchers and personnel that work there. High plant and animal diversity underscores the importance of the area for conservation.

Sierra de Manantlán Biosphere Reserve

Location: 52 km north of Manzanillo, southeast of Autlán in southwestern Jalisco and northeastern Colima. Center at 19°34' N, 104°9' W, covering 139,577 ha in the municipalities of Autlán, Tolimán, Cuautitlán, Casimiro Castillo, and Tuxcacuesco in Jalisco, and Comala and Minatitlán in Colima.

Physiography: This area is mountainous, with irregular topography at 400▪2860 m, including an igneous formation that constitutes 75% of the Reserve. Also present is a sedimentary formation to the east, known as Cerro Grande, a calcareous dome with a complex cave system (Lazcano 1988). Thirty-four permanent streams are present, as well as over 2000 ephemeral ones, all part of three major river systems: the Armería, Marabasco, and Purificación.

Climate: Hot subhumid to cool subhumid. A strong orographic shadow effect gives the southern slope more precipitation (1600 mm average) than the northern slope (900 mm average). Annual mean temperatures range from 12°C in the highlands to 27°C in the lowlands.

Habitat: A diverse habitat mosaic exists, with tropical deciduous and semideciduous forests in the lowlands, oak and pine or pine-oak forests at middle elevations, and pine-oak-fir forests at higher elevations (Vázquez *et al.* 1995; Jardel 1992). Cloud forests are found at 1400-2400 m, in areas with high humidity and fertile soils (Santiago and Jardel 1995). Epiphytes, ferns, bromeliads and cacti are abundant. The region is high in plant species diversity, endemism (Hernández López 1995b), and phytogenetic resources, like *Zea diploperennis*, considered an important genetic resource for maize improvement (Iltis *et al.* 1979), and *Populus guzmanantlensis*, a tree that could prove valuable in tropical silviculture (Vázquez and Cuevas 1989). Additional tree species with silvicultural potential include 33 species of oak and 11 of pine. More than 774 plant species from 181 families have been catalogued (Vázquez *et al.* 1995), with 1% restricted to the reserve and 3% endemic to Jalisco (Hernández López 1995a, 1995b). An essential component of the region's biodiversity are the numerous plant varieties used in traditional agriculture, including wild relatives of maize and beans.

Fauna: Wildlife is numerous and diverse, including 304 bird species (30% of Mexico's avifauna, including 36 species endemic to Mexico), 108 mammals (22 endemics), 53 reptiles and amphibians, and 16 fish (Jardel 1992). A sampling of birds includes all those listed for Las Joyas, above, plus Ornate Hawk-Eagle, Stygian Owl, Dusky Hummingbird, San Blas Jay, Dwarf Vireo, Golden-crowned Warbler, Red-breasted Chat, Rosy Thrush-Tanager, and Slate-blue Seedeater.

Research: Numerous projects have been conducted through IMECBIO related to the flora, fauna, ecology, ethnobotany, physiography, and sociology of the reserve, many of which have contributed to the management and conservation of the reserve.

Land Ownership: Land tenure was not modified with the creation of the reserve: 42% belongs to ejidos, 40% is privately owned, and 18% belongs to three Indian communities (Jardel 1992).

Management: The reserve had no formal administration between its decree in 1987 and 1993. During that period, IMECBIO, which promoted its creation, fulfilled the role generally assumed by a managing agency. It arranged the area's administration with local communities and authorities, managed Las Joyas Research

Station, coordinated research, conducted environmental education programs, and provided technical assistance to the local populace through three community centers. In 1993, SEDESOL appointed a director for the reserve; now under SEMARNAP, the directorship has permanent personnel working with IMECBIO in setting administrative policy and direction. Because of its efforts to improve management, it is one of ten Mexican protected areas to receive support from the Global Environmental Facility (Graf *et al.* 1995). Management strategy is based on local participation, integrating conservation and development (Jardel 1992, Jardel *et al.* 1996).

Comments: The Manantlán Reserve is the largest protected area in western Mexico. It conserves significant extents of tropical, tropical subhumid, and cloud forests. In addition, it is important as a provider of water for almost 460,000 people from surrounding agricultural valleys, industries and cities. Manantlán's achievements are recognized internationally, leading to its inclusion in the Man and the Biosphere (MAB)▪UNESCO international network of biosphere reserves.

Chamela▪Cuixmala Biosphere Reserve

Location: Consisting of 13,142 ha, in southwestern Jalisco, along the Barra de Navidad▪Puerto Vallarta highway.

Physiography: Steep hills rising from the ocean, having ephemeral water courses. The area lies within the Cuixmala River basin, and this river forms its southern boundary

Climate: Hot subhumid, with marked wet-dry seasons. Annual mean rainfall is 782 mm, and annual mean temperature is 25°C.

Habitat: Well preserved tropical deciduous and subdeciduous forests, with thornbush, mangrove, grasslands, "manzanillera" (*Hippomane mancinella*), reeds (*Phragmites australis*), and aquatic vegetation (A. García pers. comm.).

Fauna: Recorded are 75 species of mammals, including Jaguar, Mountain Lion, Bobcat, Ocelot, Margay, Jaguarundi, Collared Peccary, White-tailed Deer, and Southern River Otter (Ceballos and Miranda 1994), as well as 271 species of birds (41% migrants), 69 reptiles, and 20 amphibians. The number of west Mexican endemic vertebrates found in the area is high, including *Xenomys nelsoni* (a tree rat endemic to the region), the Lilac-crowned and Yellow-headed Parrots, and 50 reptile species (Ceballos and García 1990). It is also an important area for migatory birds, and one of only two protected areas on the Pacific Slope having crocodiles.

Research: It is located in one of the five better-studied tropical regions in the country (see Chamela Biological Station).

Land Ownership: Chamela▪Cuixmala Biosphere Reserve was created with land from different sources: Chamela's Biological Station (1600 ha), 1700 ha recently donated by SARH to UNAM, an abandoned 700 ha University of Guadalajara research facility, 8000 ha of private land bought by FECU, and 1142 ha of surrounding ejidos.

Management: Decreed in 1993, almost two-thirds of the reserve is in four core areas, while the remaining third constitutes a buffer zone. UNAM manages and administers the two areas it owns, and works jointly with FECU in coordinating scientific research and environmental education. FECU owns the rest, and seeks funding support for the whole area, as well as for purchasing an additional 80,000 ha of adjacent forest. Two sea turtle

nesting beaches, Teopa and Cuixmala, lie within the reserve's boundaries. No management plan yet exists, and SEMARNAP participates little in its administration. Population pressures are low, although illegal hunting increases during the dry season.

Comments: This area holds one of Mexico's most diverse examples of tropical deciduous forest.

Revillagigedo Archipelago Biosphere Reserve

Location: Consisting of four volcanic islands: Socorro, Clarión, San Benedicto, and Roca Partida, 460 km south-southwest of Cabo San Lucas, Baja California Sur, and 580 km west of Cabo Corrientes, on the mainland, between 18°00' and 19°30' N and 110°45' and 115°00' W.

Physiography: Isla Socorro is the largest (21,000 ha) and the highest (1040 m) of the islands.

Climate: Mean monthly temperatures are 19-28°C, with mean annual precipitation of 761 mm (Medina 1978). Most rainfall is between July and October.

Habitat: The vegetation consists of seven physiognomic types: coastal halophytes, *Croton* scrub, guava scrub, fig forest, *Bumelia*/guava forest, *Dodonaea* scrub and summit grassland (Miranda 1960). Rzedowski (1978) observed that these plant communities do not fit most classifications used for continents, perhaps due to the distance from mainland and the volcanic activity on these islands. Levin and Moran (1989) reported 164 plant species, 26% of which are endemic to the islands (Rzedowski 1993).

Fauna: Reports exist for 124 species of birds, of which five are endemic and highly threatened (Socorro Parakeet, Socorro Wren, Clarion Wren, Socorro Mockingbird, and Socorro Towhee). A sixth endemic species (Socorro Dove) is already extinct in the wild (Jehl and Parkes 1983; Santaella and Sada 1991), although the possibility of reintroduction exists. The islands also hold nesting grounds for many marine birds, including the only Mexican breeding population of Townsend's Shearwater (Escalante et al. 1993), and the Pacific Hawksbill Sea Turtle (Ortega 1990). The former population may be recognizable as a separate—endemic—species. A population of at least 700 humpback whales that is often seen is believed to be distinct from those near Hawaii (Campos 1989).

Research: Historically, extensive research has been conducted on these islands, particularly on Socorro. Floristic surveys were reported as early as 1891 by Vasey and Rose; however, the most important floristiic work is by Johnston (1931) and Levin and Moran (1989). Faunistic studies were carried out by Grayson and Lawrence (1871), Cárdenas (1949), and Medina (1957).

Management: This reserve was legally protected recently (1994) and does not yet have a management plan.

Comments: As with most oceanic islands, principal threats are related to introductions of exotic species, as large numbers of feral sheep and cats have reduced dramatically the native flora and fauna of the islands. Lesser impacts have resulted from construction of roads and an airstrip by the local naval garrison.

Las Huertas de Comala Natural Resources Protection Area

Location: South of Comala, Colima, covering 167 ha.

Physiography: Information not available.
Climate: Information not available.

Habitat: Principally orchards containing a diverse mixture of fruit trees, including coffee, banana, plums, walnuts, and "jinicuiles" (*Inga* sp.), with relict patches of tropical semideciduous forest with mahogany (*Swietenia humilis*) and "cuajote" (*Bursera* sp.), among others.

Fauna: This agroforestry system maintains habitat for bird and other wildlife species, but no specific data are available.

Research: None.

Land ownership: Some of the land is private, while the rest is ejidal.

Management: Decreed in 1988, land use is devoted mainly to raising vegetables and fruits. No administration, management plan, or legal framework exists. A civil association promoted the protection of the area, but without clear objectives (Hernández López 1991). Moreover, because the local population, including orchard owners, has not been involved in the decision-making process, conflicts are common, and several petitions have been presented to invalidate it. Urban growth and land value speculation in response to anticipated residential construction menace the orchards' future.

Comments: This area was protected with the objective of maintaining orchards as a traditional agroforestry system, and as an example of sustainable resource use in harmony with nature.

RESERVES FOR SEA TURTLE PROTECTION

Seven of the world's eight species of sea turtles nest on Mexican beaches. Mexican nesting sites rank among the most important in the world for five of these species, owing to the high proportion of global populations found there. Unfortunately, and despite the fact that protection programs have been operating since 1966 (Ortega 1990), overall sea turtle populations have decreased sharply. In 1985, the Inter-institutional Program for the Protection of the Sea Turtle was instituted by the Mexican government, and Jalisco was the first state to participate (Ortega 1990). As a result, in 1986, the federal government decreed 17 reserve zones for sea turtles throughout the country; currently 60 "turtle-camps" exist nationwide, in which numerous organizations are involved in turtle conservation efforts. These camps, the management of the sea turtles, and the protective actions, are all administered and controlled in a similar way. In Jalisco, for instance, 12 camps are under the surveillance of 10 organizations, but only four of the 12 are officially decreed as protected areas.

Jalisco Sea Turtle Reserves

Location: These four beaches, Mismaloya, Teopa, Cuitzmala, and El Tecuán, are distributed along Jalisco's coastline between Puerto Vallarta and Barra de Navidad. Mismaloya extends 69 km from Ipala to Punta Roca Negra with center at 19°57' N, 105°25' W. Teopa covers 6 km between Punta Careyes and Punta Farallón with center at 19°24' N, 105°1' W. Cuitzmala reaches from Punta Farallón 5.9 km to the mouth of the Río Cuitzmala with center at 19°22' N, 105°30' W. El Tecuán extends 5.9 km between Punta El Tecuan and Punta Hermanos with center at 19°17' N, 104°53' W.

Physiography: Beaches backed by narrow plains.

Climate: Warm subhumid, with summer rains. Annual mean temperature is 23°C.
Habitat: The beaches are surrounded by tropical deciduous forest, palms, mangroves, introduced grasslands, and agricultural lands.

Fauna: These beaches were set aside to protect the nesting sites of four species of sea turtle: Pacific Ridley, Leatherback, Black, and Pacific Hawksbill.

Research: A team of researchers from the Univ. de Guadalajara studies the biological and ecological aspects of the Pacific Ridley Sea Turtle. Researchers from FECU are monitoring breeding Least Terns.

Land Ownership: Federal.

Management: Decreed in 1986, the main objective of the reserves is to protect and patrol sea turtle nesting areas. The four beaches are federal land, but no real administration exists. Several governmental and non-governmental institutions are involved in the sea turtle conservation program; each has independent personnel and budget, and the collaboration between them has not been optimal. The former SEPESCA and SEDESOL (now consolidated within SEMARNAP), SEMARINA, and the Secretary of Communications are responsible for the general operative program (i.e., protection, patrolling, infrastructure, and maintenance), while the Univ. de Guadalajara is in charge of research, public use, and environmental education. However, in 1994, SEDESOL was made responsible for Mismaloya; Teopa and Cuitzmala were run by the Cuixmala Ecological Foundation; and El Tecuán by the Hotel El Tecuán. The number of people patrolling the beaches is variable, mostly done by volunteer students; four motorcycles and three jeeps are sometimes assigned to help with this chore. There is no infrastructure. No ecological criteria were used in selecting areas; therefore, some important nesting beaches were left out, and hotels already existed on others that were included. Tourist development and illegal poaching in the area threaten the nesting habitats.

Comments: Casas Andreu (1982) reported a massive nesting of 20,000 Ridleys on Mismaloya in 1970, placing it among the ten most important beaches for this species; unfortunately, these numbers are part of history. The protective camp on this beach is also one of the oldest in the nation, as it was one of the first four turtle camps established in 1968 (Ortega 1990).

Colima Sea Turtle Reserves

Location: Two beaches, Volantín▪Tepalcates and Chupadero▪Boca de Apiza, extending 30 km along the coast of southern Colima east of Manzanillo, Volantín▪Tepalcates is in the municipalities of Armería and Manzanillo, and Chupadero▪Boca de Apiza in the municipality of Tecomán.

Physiography: These beaches are backed by a highly saline lagoon.

Climate: Hot subhumid, with annual mean temperature of 26▪28°C.

Habitat: Mangroves, coastal dunes, halophytic vegetation, and irrigated agricultural lands.

Fauna: No wildlife inventories are available. Two species of sea turtles, Pacific Ridley and Leatherback, are reported from these beaches.

Research: None.

Land Ownership: Federal.

Management: Decreed in 1986, these beaches are not officially recognized by SINAP, and therefore no administration exists. In the past SEDESOL, and occasionally SEPESCA and SEMARINA, undertook protection activities. SEMARNAP now coordinates the protection program, which consists mainly of patrolling the beaches to detect egg-laying turtles. Three guards are permanent, and ten more are hired in peak season. Infrastructure is practically non-existent, consisting of two rustic sheds. The legal status is ambiguous, resulting in no management plan for outlining short-term priorities. SEMARNAP's meager budget is inadequate for providing sufficient patrolling of the area, which, owing to the easy access, results in uncontrolled theft of eggs.

Comments: Increased support for sea turtle camps is needed from within the state of Colima.

POTENTIAL AREAS IN JALISCO

The proportion of territory protected in Jalisco is low (2.5%), and one protected area, the Sierra de Manantlán Biosphere Reserve, represents 66% of the total area conserved. Hernández López (1991) analyzed the extent to which natural landscapes are adequately and proportionally represented in existing protected areas, and to evaluate conservation needs in Jalisco and Colima, including identification of areas of potential importance for protection.

Recognizing vegetation as a good indicator of the variety of landscapes and ecosystems, both states were analyzed using vegetation and land-use maps (scale 1:1,000,000 for Jalisco, and 1:250,000 for Colima; SPP 1980). Comparisons were made using both states' total areas and the portion of each covered by natural vegetation (64% for Jalisco and 63% for Colima), i.e., excluding urban, agricultural areas, and introduced grasslands.

Oak (*Quercus*) forest is the dominant natural vegetation type in Jalisco, covering 18% of the state and constituting 29% of its natural vegetation (Table 7.1). Following in importance are tropical deciduous and pine (*Pinus*) forests. These three vegetation types make-up almost three quarters of the natural vegetation of the state, while the remaining 13 types make up less than 18%. Existing parks and reserves cover 2.5% of the state and include 3% of its natural vegetation.

Only seven of the 16 vegetation types are represented in reserves. Although oak is protected in four areas, and pine forests in three, other ecosystems richer in biological diversity (e.g., tropical deciduous forest), are less well protected. Others with restricted distributions remain completely unprotected, including juniper woodland, thorn scrub, halophytic vegetation, mangroves, mezquital, and fir forests (Table 7.1).

Of Jalisco's 12 protected areas, five are in sierras, six are on the coast, and one is in foothills. As a result, the majority of the state's physiographic landforms are unrepresented, including canyons, plateaus, valleys, plains, and the interior lake and estuarine systems. Considering that no reserves exist in the Central Plateau nor in the Sierra Madre Occidental of the state, establishing protected areas in these physiographic provinces should be a priority (Hernández López 1991).

Following is a list of potential areas in Jalisco that could be set aside to conserve ecosystems requiring protection (Fig. 7.2). Criteria used to select these areas were high ecosystem diversity, ecosystems with restricted distribution, biodiversity, endemism, importance for urban centers due to the services provided, and vegetation types. Detailed information is generally lacking for these areas, and the list is preliminary. Its purpose is to call attention to the need for additional protected areas, more than to specify that these are necessarily the highest priority areas.

El Carricito del Huichol

Description: Located in northern Jalisco, this area holds the only remaining large patches (2400 ha) of primary upland pine-oak forest left in the entire Sierra Madre Occidental (Lammertink *et al.* 1996). Its high elevation (up to 2720 m) and the remoteness of the area cause it to be the Sierra's largest patch of roadless and uninhabited highland forest. Pines (*Pinus michoacana*) up to 1.2 m d.b.h. are found in the old-growth patches, and wildlife include the largest known population of Eared Trogons in the Sierra (Lammertink *et al.* 1996).

Comments: Sawmills have been built by INI and logging of El Carricito, scheduled to begin in 1997, is expected to pay for them. The intent is that the local Huichol Indian community benefit from this logging, although it has been shown that they will gain little (Lammertink *et al.* 1996). El Carricito was declared as Mexico's first Important Bird Area in 1997. CIPAMEX and Conservación Humana have successfully requested that SEMARNAP take an active role in curtailing the logging.

Sierra Huichola and Sierra de Bolaños

Description: Located in northern Jalisco, this area is characterized by irregular topography of high plateaus and sierras interrupted by abrupt canyons. It lies at the southern extreme of the Sierra Madre Occidental, where ecosystems and species reach distributional limits. The vegetation is composed of subtropical shrubs, oak and oak-pine forests, chaparral and natural grasslands.

Comments: In addition to its biological value, this area is extremely important from a cultural perspective, being inhabited by four indigenous communities of Huicholes (Guzmán and Rojas 1996), one of the more traditional cultures remaining in México. The Centro de Ingenieria Ambiental and the Instituto Nacional Indigenista (chapter Guadalajara), coordinated by Guzmán and Rojas respectively, are promoting protection of about 400,000 ha in this area. They have proposed conservation management criteria promoting sustainable development projects, and emphasizing the importance of the local indigenous cultural and the need for strong participation by local communities (Guzmán and Rojas 1996). SEMARNAP considers this area as a top priority for 1995-2000.

Lagos de Moreno–Ojuelos–Jalostotitlán

Description: This area is part of the Los Altos region, which varies topographically from extensive plains and plateaus with canyons to sierras with lobed and step-like plateaus. It contains ecosystems that occur marginally within the state such as the "cardonales" (vegetation dominated by *Opuntia* spp.), columnar cacti, chaparral, scrub, natural grasslands, and juniper forests.

Comments: Intensive research is still needed for this poorly known area, whose importance is just beginning to be appreciated. For instance, two new species, *Mammillaria perezdelarosae* and *Juniperus martinezii*, were only recently described, and the threatened and endangered *J. monosperma* var. *gracilis* and *Pinus cembroides* have been reported (Santana *et al.* 1987).

Barranca del Río Santiago

Description: Located 6 km northeast of Guadalajara, this area is an immense and precipitous canyon 3.5 km wide, about 1.7 km deep, and more than 200 km long. Various names have been given to the canyon, the

largest in the state, which flows northeast from Lake Chapala. Tropical deciduous forest dominates the area, with riparian and oak forest also present (McVaugh 1953). The canyon is of great biological interest, with more than 200 flowering plant topotypes, many of which are endangered (González Villareal and Pérez 1987). Selander and Giller (1959) reported 82 bird species.

Comments: This area is important for Jalisco, as the state's characteristic canyons are unrepresented in its present reserve network. Its preservation is relevant to the protection of the Lerma-Santiago River basin which, besides providing water to Guadalajara, provides habitat for several endemic fishes (66% of this basin's ichthyofauna is endemic, the highest percentage of any basin in Mexico; Espinosa Pérez *et al.* 1993). The canyon is one of the few green areas near the city, and owing to its scenic beauty has become a regularly visited local attraction. However, this closeness to the metropolitan area has also lead to increased threats from urban growth, water diversion, and pollution.

Chapala-Sayula-Atotonilco-Zapotlán Lagoon System

Description: This area holds a series of permanent and intermittent lagoons separated by small mountain ranges, formed as a result of volcanic activity and faulting. The basins have saline and alkaline soils characteristic of basins without outlets. Fertility is low, and drainage is poor. Halophytic vegetation mixed with grasses and succulents is the dominant plant form. Mesquites and aquatic vegetation are present to a lesser degree.

Comments: The lagoons are an important paleontological and archaeological site, as fossils of Pleistocene megafauna and some of the first evidence of human presence in western Mexico were discovered on the shores of Sayula Lagoon. The region is also one of the main wintering grounds for numerous migratory waterfowl (Arellano and Rojas 1956), making it one of the most important areas for conservation in western Mexico. At Sayula alone, 98 bird species have been recorded, including Wood Stork, American White Pelican, Snow Goose, Canvasback, and others (Buenrostro 1992; Buenrostro and Contreras Martínez unpubl.). The Chapala Yellowthroat, a bird potentially recognizable as a separate species, is endemic to the area.

Volcán de Tequila

Description: Reaching 2920 m above sea level, this inactive volcano covers parts of four municipalities in the central part of the state. The topographic complexity of this region gives it special interest, with volcanic plains modified by valleys and alluvial terraces during the evolution of the Río Santiago basin.

Comments: The volcano is important because of its wide elevational gradient with relatively well preserved vegetation, including tropical deciduous, juniper, oak, pine-oak, cloud, and cypress forests. It has attracted the attention of numerous botanical researchers, and therefore is the topotypic area for many species (McVaugh 1972; Rodríguez and Cházaro 1987). Aside from its biological importance, it is a recreational area of scenic beauty.

Nevado de Colima National Park Surroundings

Description: Forested slopes of the Volcán de Colima and Nevado de Colima below Nevado de Colima National Park.

Comments: The vast lower slopes of the volcanoes are not included in Nevado de Colima National Park, and the park boundaries should be extended below their current 3000 m lower elevational limit. As mentioned in the park's description, the area given to the forest concessionaire in 1940 contained important portions of montane cloud, alder, and fir forests. The latter two vegetation types are not included in any other reserve in the state, and have limited distributions in Mexico. The forested mountain slopes and ravines are important for protection of the watershed basins that provide water to nearby towns and cities, among them Ciudad Guzmán and Colima.

Sierra de Tapalpa

Description: This sierra is a major recreational and scenic area southeast of Guadalajara. Conversion of pine forests for livestock and agriculture have severely impacted the area, but pockets of habitat remain intact.

Comments: Tapalpa is important for its floristic endemism, and for its water-holding capacity for adjacent basins, which include the Sayula and Zapotlán lagoons.

Tomatlán-Chalacatepec Region

Description: This coastal area includes the mouths of the rivers San Nicolás and María García and several lagoons and estuaries backed by plateaus, canyons, and hills. This site is the only one in the state in which thorn scrub is well represented. Tropical deciduous forest has its most exuberant and best preserved condition between Tomatlán and El Tuito.

Comments: This ecosystem is highly valued for its biodiversity, including commercially important trees such as mahogany, but is very fragile. Unfortunately, many of its trees have high commercial value, making them especially attractive to lumber companies. If protected, the tropical deciduous forest, tules, and mangroves could act as buffers for important sea turtle nesting beaches nearby.

Tuito-Talpa-Cuale Region

Description: This site is unique in that oak forest, including *Quercus magnolifolia*, grows at 270 m, cloud forest descends to 800 m, and pine forest with *Pinus maximinoi* is found as low as 520 m. These forests can be considered tropical pine-oak forest, but with elements of tropical deciduous and semideciduous forest, oak-pine, and pine-oak woodlands intermixed.

Comments: This area merits protection for its outstanding biological characteristics. Although botanical explorations are lacking, preliminary studies suggest that this region is an important center of plant endemism (Hernández López 1995a). Moreover, this area, which holds the best example of palm forest (*Orbygnya cohune*) in Jalisco, is rapidly being displaced by coconut plantations and cattle pastures (Rzedowski and McVaugh 1966). The area also supplies water for important agricultural valleys before emptying into the ocean.

San Sebastián Region

Description: This region is located in the extreme northwestern part of the state, bordering Nayarit. Its

montane forests were first explored ornithologically by Nelson and Goldman, who there discovered the Mexican Woodnymph, a species new to science endemic to western Mexico (Escalante and Peterson 1992). The region is little known, but potentially fascinating in its biological chacteristics.

Comments: This area is important for protection of hydrographic basins that harbor intact examples of ecosystems such as tropical deciduous, tropical semideciduous, pine-oak, oak-pine, and cloud forests. Although close to Puerto Vallarta, access roads to this area are in poor condition.

OTHER AREAS

Several well-preserved areas of tropical deciduous forest exist that could be set aside for protection. Among these, the **Sierra de Tuxcacuesco** and the **Sierra de Vainilla**, near El Grullo and Autlán, are good examples. In addition, the **Sierra de las Ardillas** and the adjacent **Río Ayuquila Canyon**, deserve attention for their scenic beauty, importance as a hydrographic basin (the third largest in Jalisco), and for their intact stands of tropical deciduous and pine-oak forests. Finally, the area between **La Manzanilla** and **Barra de Navidad** is important given the quality of the existing tropical subhumid forest, mangroves, palm forest, and coastal ecosystems.

POTENTIAL AREAS IN COLIMA

Tropical deciduous forest is the vegetation type best represented in Colima, making up 40% of the state's area and almost 65% of its natural vegetation (Hernández López 1991). Tropical semideciduous and oak forests follow in importance. Thirteen additional ecosystems are present (Table 7.2).

Although with the recent establishment of the Archipelago Revillagigedo Biosphere Reserve the protected territory of Colima increased dramatically (55%), serious gaps in coverage remain on the mainland. Leaving apart the oceanic islands and analyzing only mainland protected areas, we find that not all of the state's ecosystems are represented. The six parks and reserves (including two shared with Jalisco) protect only 2.6% of the whole state. The Colima portion of the Sierra de Manantlán Biosphere Reserve represents 54% of the total area protected on Colima's mainland. Overall, only four vegetation types are represented, and several ecosystems with restricted distributions remain without protection. Landforms such as valleys, plateaus, plains and wetlands are not included in any reserve. Hence, potential areas for improvement of this system are as follows.

Potrero Grande Estuaries

Description: Located approximately 10 km along the road to Manzanillo from the town of Cihuatlán, Jalisco (Fig. 7.2), these marshes are formed when the waters of the Río Marabasco back up before flowing into the Pacific Ocean. The vegetation is composed of cattail (*Typha latifolia* and *Phragmites comunnis*) marsh, tropical deciduous forest, columnar cacti, and coastal dune plants. Wildlife is quite diverse: preliminary reports for the area show that 33 species of mammals, 166 birds, 24 amphibians and reptiles, and 18 fish are present (Jardel and Santana 1990).

Comments: Despite the fact that coastal wetlands are important formations in the state, they lack legal protection. The area contains seven different habitats important for aquatic and terrestrial wildlife, but is threatened by the adjacent Manzanillo airport. The area has good potential for ecotourism.

Amela-Alcozahue-Colorada Lagoon System

Description: These lagoons, and surrounding hills rising to 600 m, are located approximately 15 km east of the city of Tecoman. SEMARNAP-Colima has a small-scale crocodile farm there. Several fishing cooperatives in the area depend on the capture of red carp.

Comments: Aside from the social and economic importance associated with these activities, the lagoons and surrounding tropical deciduous forest deserve conservation attention because they provide important habitat for numerous wildlife species.

Boca de Pascuales

Description: This delta is formed by the outflow of the Río Armería (known as Río Ayuquila in Jalisco). It is located 12 km southwest of the city of Tecomán. Vegetation is comprised of mangroves and cattails.

Comments: The area's importance for breeding crustaceans, fish, and marine birds, as well as for recreation and scenic enjoyment, make it valuable for conservation purposes.

Cerro de Ortega

Description: Plains and low-elevation sierras are the main topographic features of this area, in the southeastern portion of the state, between the cities of Tecomán and Cerro de Ortega. The lagoon system of Amela lies to the north, while the Río Coahuayana, which marks the border with the Michoacán to the east. An estuarine system starts in La Media Luna, 9 km east of Cerro de Ortega, and continues south to Boca de Apiza, where the Río Coahuayana flows into the ocean.

Comments: This area holds Colima's only thorn forest, with a vegetation mosaic also including cattail, coastal dunes, mangroves, and tropical deciduous forest. Its gentle topography facilitates disturbance, so some areas have been converted to agriculture.

Sierra de Perote-El Ocote

Description: Sierra de Perote is located in the state's northeastern corner. It is possibly the area with the most diverse and abrupt topography in the state.

Comments: Within a relatively small area, a wide combination of ecosystems and vegetation types exists, including pine-oak, tropical deciduous forest, and semideciduous forest.

Volcán de Fuego lower slopes

Description: This area is adjacent to the Nevado de Colima and the Volcán de Fuego, between the ejidos La Becerrera and Tonila.

Comments: The boundaries of Nevado de Colima National Park should be extended downslope to preserve

important tracts of fir and cloud forest left out with the 1940 decree. The area also contains surfaces covered by debris and ash flows from the Volcán's activity. Protection of hydrological basins for surrounding cities is another important consideration.

OTHER AREAS

The regions known as **Chavarín-Chandiablo** and **Camotlán** in the municipality of Manzanillo have the most extensive and intact tropical deciduous and semideciduous forests in the state. For the protection of cloud, pine, palm, oak and riparian forests, areas deserving protection include **Minatitlán-Agua Salada**, **Cerro La Nancera** and **Cerro El Barrigón**. In addition, coastal and interior lagoons, such as **Laguna Cuyutlán** and **Laguna Juluapan**, provide water for agricultural irrigation, as well as important habitat for marine, estuarine, and terrestrial wildlife, making them important fishing areas.

ASSESSMENT OF CURRENT SITUATION

In most cases, present management of parks and reserves in western Mexico cannot assure the long-term conservation of valuable natural resources. Here we assess management conditions for protected areas of Jalisco and Colima, ranking areas for the adequacy of their management. A list of recommendations for better ensuring long-term protection of these areas follows.

Table 7.3 presents a general evaluation of the management conditions of each protected area. The evaluation was based on literature review, on-site assessments of protected areas, and interviews with field personnel, government officers, researchers, and local people from surrounding communities. Scores were assigned for each area on eight criteria considered fundamental attributes of any park or reserve. Values for scores from 0 to 4 were as follows: 0 = requirement not met, 1 = incipient actions, 2 = intermediate conditions, 3 = fulfilled sufficiently to maintain *status quo*, and 4 =fulfilled sufficiently to meet long-term objectives for the area. The criteria were:

1. Long-term legal protection
2. Recognition by the government
3. Recognition by local people
4. Existence of management plans
5. Effective protection in the field
6. Existence of a research program
7. Stable funding
8. Basic infrastructure

Most requirements for areas were met to some degree, with average scores of 1-2 (Table 7.3). For legal protection, the highest value could be assigned only to the biosphere reserves and their associated research stations. Overall, national parks and biosphere reserves are well established in national legislation, but forest protection area, wildlife refuges, and marine parks are ambiguous, and not supported legally. Huertas de Comala has a state decree, but a weak legal framework.

Government recognition was considered sufficient in most cases, but no area received the highest rating. Although the existence of protected areas is taken into account, neither specific programs nor government coordination support their development in a long-term sustainable manner. The extreme example is Arcos de Vallarta where federal authorities responsible for its protection were unaware of its formal decree as a protected area, and SINAP does not include it in its system of marine parks.

Recognition by local people is one of the most important conditions to be met, as people living nearby are those who can best contribute to conservation efforts or can have the greatest negative impact. The highest

rank was given to Las Joyas Research Station which, through environmental education activities, technical assistance to neighboring communities and ejidos, employment of local people in management, and permanent institutional presence, has achieved recognition as a site dedicated to conservation, research, and education. Sierra de Manantlán and La Primavera, with active information and environmental education programs, were considered sufficient, but not as fully developed as they could be. On the other hand, Chamela and Cuixmala have done little promotion or environmental education, considering their long existence and high levels of activity.

Most areas lack management plans, and hence received low scores for this criterion. No protected area in Jalisco and Colima has an officially recognized management plan. Las Joyas Research Station has annual operative plans which are undertaken as part of the activities of IMECBIO. It also has directives for the use of the area, and documents that establish the conceptual framework for its management. Chamela has internal regulation, but no management plan. Sierra de Manantlán and La Primavera have published proposals for their management (Jardel 1992, Curiel 1988), which have been used as frameworks for interinstitutional agreements and specific actions. Unfortunately, these plans have not been approved officially, and face serious bureaucratic obstacles and lack of political cooperation. Cuixmala and El Jabalí lack management plans, although several activities have been implemented through a working program.

Overall, site protection is insufficient (Table 7.4). Private lands in El Jabalí and Cuixmala are well-protected for the time being, although private ownership makes for some long-term concerns. Las Joyas Research Station has full-time personnel assigned to protect and patrol the area. Meanwhile, incipient actions with some positive results, such as forest fire-fighting, have been made by local communities in the Sierra de Manantlán.

Research programs are well established at the two research stations, resulting in important scientific contributions. The Sierra de Manantlán has, as a whole, an integrated research program with a well established biological component, and a strong beginning for projects in the social and physical-geographic sciences. Biological research is beginning to be developed at Cuixmala and El Jabalí. Other areas, such as the long-established Nevado de Colima National Park, show sporadic and uncoordinated research.

Funding was also generally insufficient. Areas receiving higher scores had at least some financial resources, and have been maintained for at least 20 years. Infrastructure for management and other activities like research and visitor facilities, was considered adequate only at Chamela, whereas Las Joyas would benefit from improved facilities.

Overall, areas rated highest were the research stations, followed by the biosphere reserves. The most deficient cases were the national park, the marine park, the forest protection area, the Sierra de Quila wildlife refuge, and the turtle nesting beaches. The overall average for protected areas of both states indicated that management conditions were insufficient. Higher scores assigned to research stations resulted primarily from continuous institutional presence; also, less complex issues confront biological stations because of their relatively small size. Finally, their inclusion within biosphere reserves confers a favorable environment for conservation and buffering from external presures.

This evaluation is preliminary, with all criteria weighted equally, and without regard for size and complexity of areas. However, we believe that its results reflect real characteristics of areas, for example, the Sierra de Manantlán Biosphere Reserve is the largest protected area, and has complex management conditions, considering its location in parts of 27 agrarian communities in seven municipalities of two states. Nevertheless, it obtained an above average score of 2.5, higher than many smaller areas that could potentially be managed more easily.

RECOMMENDATIONS

Table 7.5 presents a classification of the protected areas in Jalisco and Colima according to current management conditions and threats. This evaluation is rather general, but readily identifies the issues critical to

the management of each area. Again, areas with better conditions are those with permanent institutional presence and specific management objectives. The two research stations, the protected areas that best meet the management criteria, face the fewest threats. However, the evaluation should take into account the contrast between the magnitude and complexity of the management problems confronting the bigger areas like La Primavera and Sierra de Manantlán versus those facing smaller areas.

In general, the status of Jalisco and Colima's protected areas indicates that long-term conservation is not assured, owing to insufficient management, limited representation, and numerous threats. We therefore recommend the following steps:

- X Revise the legal framework and management categories for the region's protected areas, emphasizing institutional design for adequate management
- X Incorporate protected areas explicitly into the government's development planning
- X Develop detailed management plans for existing reserves with the participation of those involved in implementation
- X Supply current reserves and parks with staff and basic infrastructure for their management, and design appropriate mechanisms to finance operations
- X Support participation of local academic institutions in developing research, teaching, and technical assistance activities within protected areas
- X Promote education and public awareness programs regarding the value and function of protected areas
- X Regulate harvest, exploitation, and production of resources within the protected areas and their surroundings with a multiple and sustainable use approach
- X Increase the size and number of protected areas in the region to protect more threatened environments, such as lake and estuarine systems, wetlands, semi-arid vegetation relicts, and the tropical deciduous and semideciduous forests

These tasks require active, local participation, and such will be obtained when the population acknowledges and recognizes the value and importance of protected wildlands for achieving a sustainable society.

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Chapter 8. PROTECTED AREAS OF MICHOACÁN - J. Fernando Villaseñor Gómez, Laura E. Villaseñor Gómez, Arturo E. Villaseñor Gómez, Neyra Sosa Gutiérrez, and Adriana M. Guzmán Pérez (translation by J. Fernando Villaseñor Gómez)

INTRODUCTION

Michoacán is one of the most rugged and physiographically diverse states in Mexico. It has roughly 7000 species of vascular plants in a wide variety of habitats (Rzedowski 1978). Principal habitat divisions include temperate coniferous and oak forests (26%), tropical forests (14%), subtropical scrub (8%), lakes and wetlands (2%), and agricultural and secondary growth (49%). Its diverse avifauna (492 species of 63 families) comprises 156 migrants, 116 Mesoamerican endemics, and 220 widely-occurring residents (L. Villaseñor Gómez and J. F. Villaseñor Gómez 1994), almost half of Mexico's approximately 1030 bird species. In other vertebrate taxa, 353 Mesoamerican endemic species occur in the state (Flores Villela and Gerez 1994). Of the 38 vertebrate species endemic to the state, 15 are endangered.

Five physiographic regions are represented in the state. The Transvolcanic Belt (27,500 km^2) extends across the northern part of the state, containing the principal summits of Tancítaro (3845 m), Patamban (3740 m), San Andrés (3690 m), and Paricutín (2575 m), with numerous lakes occuring in the intermountain valleys, including Cuitzeo (3618 km^2), Pátzcuaro (1525 km^2), and Zirahuén (615 km^2), and a 125 km^2 portion of Chapala, the largest lake in Mexico. The southern sierras (16,000 km^2), in the southwestern part of the state, is a mountainous region susceptible to earthquakes with a principal summit called Cerro El Cantador (2764 m). The Pacific coastal plain extends 208 km from the mouth of the Río Coahuayana on the north to the Río Balsas in the south, narrowly constricted between the southern sierras and the Pacific Ocean. It has a mean width of 3 km, and is broken into smaller portions by numerous ridges running out of the sierras to end in steep ocean-side escarpments. Numerous arable alluvial plains are present, which, in conjunction with the lower slopes of the southern sierras, constitute what is known as "La Costa." The Balsas Basin (14,466 km^2) is located in the state's center with important summits including the Volcan Jorullo and the peaks of Cucho and Condémbaro. The Central Mexican Plateau constitutes 4087 km^2 in Michoacán, and is known as the Lerma Depression, after the Río Lerma which forms part of Michoacán's northern border. This is a high, flat plain with numerous broad valleys that historically contained lakes similar to the marshes of Chapala and Zacapu. These valleys form part of the agricultural zone known as "El Bajío," which extends into the states of Guanajuato and Jalisco.

For all of its biological diversity, only 1% of Michoacán is under any protection (Fig. 8.1). Although increased protection is needed for many areas, conservation success in Mexico relies heavily on support from local communities. They must be made aware of the benefits of conservation to their own lives, a daunting task when 60% of Michoacán's families exist in economic marginality. Pressures on Michoacán's natural resources are growing, making for an urgent need to increase conservation efforts substantially before additional areas are irreparably harmed.

PROTECTED AREAS

Pico de Tancítaro National Park

Location: Comprising 19,000 ha, Tancítaro lies approximately 27 km west of Uruapan, with center at 19°24' N, 102°18' W. Villages within the park are La Escondida, San Nicolás, Tiscato, Tzirimóndiro, El Jasmín, and Parastaco.

Physiography: Located in the Transvolcanic Belt (2064–3845 m), Tancítaro is the highest point in Michoacán, with its summit in clouds for most of the year. It is a remnant of the cone of an ancient volcano, and is surrounded by steep slopes and deep canyons. Several tributaries of the Río Tepalcatepec originate on its

southern slopes, as well as numerous ephemeral streams. Two springs provide water for the towns of Tancítaro and Apo.

Climate: At 2000 m, it is warm humid, with annual mean rainfall of 910 mm and annual mean temperature of 18°C. At 3845 m, it is temperate subhumid with annual mean rainfall of 1300 mm and annual mean temperature of 9°C.

Habitat: Pine-oak (below 2400 m), pine, pine-fir (above 3100 m), montane cloud forest (confined to protected canyons above 2000 m), and high elevation clumped grasses (2600▪3100 m).

Fauna: Birds of special note known from the area include Imperial Woodpecker (last recorded in 1951), Long-tailed Wood-Partridge, Banded Quail, the endangered Thick-billed Parrot, Dusky Hummingbird, Eared Trogon, Scaled Antpitta, Gray-barred Wren, Spotted Wren, Dwarf Vireo, Chestnut-sided Shrike-Vireo, Red Warbler, Green-striped Brushfinch, and Collared Towhee. To date, 14 species of amphibians, 35 reptiles, 196 birds, and 105 mammals have been recorded from the area.

Research: Vertebrates were first studied in the area in the last century by Nelson and Goldman, followed by Blake and Hanson (1942). Leavenworth (1946) described plant communities, and Duellman (1965) reviewed amphibians and reptiles. The most recent data on the fauna of the area have been obtained by Salas (1986), Villalón (1990), and L. Villaseñor Gómez (1992).

Land ownership: 7600 ha (40%) belong to ejidos, 950 ha (5%) to communal ownership, and 10,450 ha (55%) are privately owned. The portion of the park within the municipality of San Juan Nuevo Parangaricutiro is owned by an ejido. Documents regarding land ownership are generally respected; however, owing to vague boundary definitions, some legal problems exist.

Management: Pico de Tancítaro National Park was created in 1941 for the conservation of its habitats, and to guarantee the recharge of streams and springs. It was initially assigned to the Departamento Forestal de Caza y Pesca; later, its responsibility was transferred to the Dirección Forestal y de Caza of the Secretaría de Agricultura y Ganadería, which was delegated to cover the required expenses for restoration and conservation (which never happened). In 1982, the park was assigned to SEDUE. Although a park administration building existed at one time, no buildings presently exist. In 1992, SARH funded two guards and two workers. A road to the summit is maintained by the electric company.

Of the total 19,000 ha, 7500 have been converted from forest. Extensive avocado plantations near the towns of Tancítaro and Peribán cover nearly 35% of the total area. In addition, much cattle raising, short-lived farming, logging, resin extraction, and unregulated sawmills affect the park's natural habitats negatively.

Comments: Tancítaro is a spectacular forest-covered volcano. Between 2400 and 3000 m, several boreal plants endemic to the Transvolcanic Belt have been identified, including *Achaenopodium, Hintonella, Microspermum,* and *Salvia* (A. Villaseñor Gómez unpubl.). The vertebrate life is rich, and high montane islands in the region are few. Already, summits closer to Mexico City (e.g., Nevado de Toluca) are suffering severe degradation. Tancítaro is located near the junction of the Transvolcanic Belt and the Sierra Madre Occidental, both of which hold high levels of endemism (Escalante Pliego *et al.* 1993). It is also adjacent to the Balsas Basin, well known as a refuge during glaciations and as a source for subsequent speciation.

The problems facing Tancítaro are complex. Social problems related to low per capita income have contributed to the degradation of local resources. Without sufficient guards to monitor the area, unauthorized activities are common. Recently, several cases of illegal clear-cutting and intentional burning having occurred, as local residents, spurred by the need for land and frustrated by inability to obtain required permits, have moved farther into the park. Furthermore, many private landowners allow continued logging with or without

federal authorization. A management plan and qualified personnel to coordinate it are urgently needed. Alternatives need to be offered to the inhabitants of the region to show how they could benefit from incorporation of sustainable practices in agriculture, logging, and other activities.

Cerro de Garnica National Park

Location: The area is located 58 km east of Morelia and 48 km west of Ciudad Hidalgo. Its center is at 19°42' N, 100°51' W, totalling 968 ha in the municipalities of Hidalgo and Queréndaro.

Physiography: Cerro de Garnica is located in the part of the Transvolcanic Belt known as the Sierra de Mil Cumbres or Sierra de Otzumatlán. Climbing from 1840 to 3000 m, it is one of the highest summits in Michoacán; with extremely complex topography, and numerous peaks and intermountain valleys. Important aquifers underlie the region, but surface streams are small, the most important being El Venado, that flows into the Río Chinapa.

Climate: Temperate subhumid, with annual mean rainfall of 1200▪1400 mm, and annual mean temperature of 15°C.

Habitat: Pine, oak, pine-oak, and fir forests.

Fauna: Monarch butterflies establish temporary colonies in this area during the winter. Other classes of animals include nine species of amphibians, 18 reptiles, 172 birds, and 38 mammals, including 22 bat species. Birds included Dusky Hummingbird, Bumblebee Hummingbid, White-striped Woodcreeper, Pine Flycatcher, Gray-collared Becard, Gray-barred Wren, Spotted Wren, Russet Nightingale-Thrush, Chestnut-sided Shrike-Vireo, Golden-browed Warbler, Green-striped Brushfinch, and Rusty-crowned Ground-Sparrow.

Research: The Univ. Michoacana has conducted a variety of biological research projects, mostly in unpublished theses (e.g. Barajas 1994). Formerly, several naturalists worked in the area, including H. O. Wagner, R. K. Selander (1955), and J. Davis (1962), all of whom collected bird specimens now deposited in museums of the United States (Méndez and Rodríguez 1990). Recent bird research has been published by Barajas and Phillips (1994).

Land ownership: Most of the park is private property (875 ha, 90%), with 58 ha (6%) and 35 ha (4%) in ejidal and communal ownership, respectively. Presently, legal problems exist between the Ejido Otzumatlán and the private property named "Ojo de Agua de las Palomas."

Management: Decreed in 1936, this park was originally established because of its scenic beauty and location on a watershed. However, problems include boundary definitions, which were not specified in the decree, and size, which was indicated in the decree as "1936 ha," instead of the actual 968 ha. The park has an administration cabin, bunk house, storage room, kitchen, outhouses, and some fencing, but because management or staff are not assigned to the area, these buildings are in serious disrepair. A fire lookout and SARH foresters' camp with radios are on the summit. Presently, the park has no protection or management plan. The guards at Parque Nacional José Morelos apparently drive to Cerro de Garnica once a month to look for fires and other problems.

In the 55 years since the park's creation, no attempt has been made to require land owners to protect the area. The former state Forestry Commission allowed the owners to sell lumber from the park, the only stipulation being a restriction to the taking of dead trees only. As a result of the authorized logging and other ventures, including conversion to agriculture, livestock grazing, unauthorized logging, and activities of local

people, the natural landscape of the park is gradually being lost. Fortunately, the owners apparently take some interest in conservation of the forest, and because of them the park is not in worse shape. Currently, 80% of the area is forested, and 20% holds shrubby secondary vegetation and grass.

Comments: The area is important for recharging aquifers and conservation of important forested habitats. An immediate need is the development of a management plan, especially regarding the extensive cattle ranching in the area. Considering various aspects of local development could help in assigning parts of the park to different purposes. Despite its small size, the park remains attractive, with good potential. Hence, one part could be devoted to conservation and a second to recreation. Finally, a buffer zone should be defined, in which restricted agriculture and livestock activities would be allowed.

Lago de Camécuaro National Park

Location: Located 14 km west of Zamora, 2 km south of Tangancícuaro, in the municipality of Tangancícuaro; center at 19°56' N, 102°15' W, and total area 9.65 ha, most of which is water.

Physiography: Located in a large intermountain valley at 1700 m, Lago de Camécuaro belongs hydrologically to the Lerma▪Chapala Basin. Within the park, numerous streams emerge and flow into the Río Duero, and pass the hydroelectric plant of El Platanal to the Río Lerma.

Climate: Warm humid, with annual mean rainfall up to 790 mm, and annual mean temperature of 20°C.

Habitat: Cypress forest and freshwater lake. Surrounding vegetation is disturbed subtropical scrub and agricultural.

Fauna: The fish are all exotic species introduced some decades ago. They include carp, tilapia, and some rainbow trout (A. Villaseñor Gómez unpubl.); some decapod crabs are also present. Inhabitants mention that until some ten years ago, populations of Canada Geese overwintered in the area, and Mourning Doves were abundant.

Research: None.

Land ownership: Federal lands constitute 8.6 ha (89%), and 1.05 ha (11%) are private.

Management: From its 1941 decree until 1976, SARH managed the park; from 1976 to 1983 management was by SAHOP; and from 1983 to 1992 by SEDUE. Internal regulations for the park were published in 1991. The park is managed by a committee appointed by the council of Tangancícuaro municipality. An administrator and a ticket seller are paid by municipal authorities. Park guards supervise visitors and take care of the gate. However, no management plan exists, and the lack of regulations on water use within and around the park has allowed it to be pumped out for hotel and agricultural purposes.

The present use of the land is 80% recreational and 20% urban. Although a national park, it is basically a recreation area, with concession stands selling food, clothing and souvenirs. Facilities include an admission stand, administration lodge, restaurant, storage room, rest rooms, dressing rooms, boat service, two pools, trash containers, and a fence. A hotel has been built adjacent to the park.

Comments: The only important biological aspect of this area is the preservation of its springs. In this small park, tourism stresses the ecosystem most seriously. The food stands surrounding the lake in semi-permanent booths promote soil compression, affecting the natural flow of water. Pollution of the water is increased by

washing of cooking utensils directly in the lake. Although some of these activities have been reduced, food stands need to be assigned to special areas, an action that the Tangancícuaro city council has been promoting. Recently a cement trail encircling the lake was completed, and train rails were installed. We suggest that, owing to its small size and its vocation, this area should be considered a national monument instead of as a national park.

Insurgente José María Morelos y Pavón National Park

Location: This area is located 23 km east of Morelia, with center at 19°36' N, 100°31' W. It totals 13,730 ha, of which 8864 ha is a forest protection area, and 1813 ha is for recreation. It includes portions of the municipalities of Charo and Tzitzio.

Physiography: The park is located in the Sierra de Mil Cumbres, or Sierra de Otzumatlán, at 1340▪2640 m, and includes parts of the Balsas Basin and the Lerma▪Santiago watershed. Mountains and hills intermingle with valleys and a few permanent streams. Springs maintain the El Salto stream and waterfall, the most important being El Puerto de la Conveniencia, Ojo de Agua La Laja, and Ojo de Agua de Los Tepetates, all located in the northern part of the park.

Climate: Warm subhumid at lower elevations and temperate subhumid at higher elevations, with mean annual rainfall of 1692 mm, and annual mean temperature of 18°C.

Habitat: Oak, pine, pine-oak, and riparian forest, as well as second growth.

Fauna: Four salamander species, five frogs, and one agnatha (*Tetrapleurodon* sp.) have been found in the streams that flow to Lago de Cuitzeo. The rare Slaty Finch has been recorded here (Barajas 1994, Barajas and Phillips 1994), but probably does not represent a resident population (A. T. Peterson, pers. comm). Other birds present include Banded Quail, Buff-collared Nightjar, Dusky Hummingbird, Gray-barred Wren, Spotted Wren, Ruddy-capped Nightingale-Thrush, Rufous-backed Robin, Golden Vireo, Chestnut-sided Shrike-Vireo, Red-headed Tanager, Rusty-crowned Ground-Sparrow, and Black-headed Siskin. To date, 18 reptile, 172 bird and 38 mammal species are known to inhabit the area (A. Villaseñor Gómez unpubl.).

Research: Unpublished studies by the Facultad de Biología of the Univ. Michoacana have examined vegetation, fungi, and lampreys. An analysis of the litter in the recreational area has also been carried out. Bird-related work has focused on censuses (Davis 1953, L. Villaseñor Gómez unpubl., J. F. Villaseñor Gómez 1995) and elevational distributions in the region (Barajas 1994).

Land ownership: Mostly privately owned, and partly under ejidal control, exact proportions for the area are unknown. The area designated as a national park was never purchased, and remains subject to whims of the private landowners. Part of the land within the park is being claimed by the Indigenous Community of Charo, the Community of Zurumbeneo, and small landowners of El Vaquerito, with no legal resolution.

Management: Decreed in 1939, this park was originally intended to mantain the integrity of the forest on both sides of the highway, as well as to preserve the springs and scenic landscapes. The area was initially the responsibility of the Oficina de Bosques y Parques Nacionales, and subsequently of the Departamento de Parques Nacionales e Internacionales. From 1976 to 1982 it was under the direction of SARH. With the creation of SEDUE, most national parks were transferred to this agency, and the Michoacán Delegation became responsible for protecting and maintaining the recreational portion of the park, as well as taking care of an acclimation greenhouse for forest tree species. An administrator and two guards are in charge of the

recreation area. Infrastructure includes a ticket booth, cabin-office, restaurant, 12 food booths, playground, amphitheater (unused), restrooms, and a small parking lot. The recreational portion of the park is a popular destination for people from nearby Morelia, averaging 200▪300 visitors each weekend. Activities appear to include gathering of firewood and discharging of firearms. The remainder of the park lacks any management, primarily because most of the land is private property.

Comments: The park lies in the transition zone between tropical lowland habitats and temperate coniferous highland forests. As a result its fauna and flora are very diverse. Complex problems face the park, beginning with uncertain boundary definitions making implemention and enforcement of regulations difficult. A special problem regards logging, much of which is not authorized by agencies, though approved by landowners. Additional problems result from wastewater pollution of streams by communities within the park.

Barranca de Cupatitzio National Park

Location: This 527 ha area is located 3 km northwest of central Uruapan, with center at 19°25' N, 102°04' W.

Physiography: The park is on the southern slope of the Transvolcanic Belt at 1700▪2114 m, in the region called "Meseta Tarasca" or "Sierra Purhépecha." The area is characterized by numerous volcanic extrusions and cinder cones, with basaltic flows and small valleys. Principal summits are Cerro Sapién (2100 m) and Cerro Jabalí (2114 m). The area is in the basin of the Río Tepalcatepec▪Infiernillo, in the Balsas Basin. Among the most important springs is the famous "Rodilla del Diablo," the principal source of the Río Cupatítzio.

Climate: Warm temperate, with annual mean rainfall of 1600 mm and annual mean temperature of 17°C.

Habitat: Pine, pine-oak, and cloud forests, plus introduced ornamentals that comprise 30▪40% of total.

Fauna: Poorly known. Birds present include Lesser Roadrunner, White-naped Swift, Blue-throated Hummingbird, Gray-barred Wren, Spotted Wren, Happy Wren, Brown-backed Soiltaire, Blue Mockingbird, Gray Silky-Flycatcher, Chestnut-sided Shrike-Vireo, Red-headed Tanager, and Green-striped Brushfinch.

Research: Studies done in the area have focused on spiders, butterflies, and scorpions. Among vertebrates, mammal and bird species of the Campo Experimental Forestal Barranca de Cupatitzio are listed by Orduña *et al*. (1993), and some observations on birds have been gathered by the Laboratorio de Ornitología of the Univ. Michoacana.

Land Ownership: Federal lands constitute 471 ha (the Campo Experimental Forestal Barranca de Cupatitzio of INIFAP); 19 ha are municipal property (the recreational park "Eduardo Ruíz"), and 37 ha are federal lands occupied by squatters.

Management: Decreed in 1938, this park was established to conserve and restore the beautiful area surrounding the "Rodilla del Diablo" springs. Presently, however, it receives almost no recognition as a national park. In February 1963, 471 ha were assigned to INIFAP to create a research station (Campo Experimental Forestal Barranca de Cupatitzio), emphasizing forestry and faunal studies. In 1979, the rest of the area (56 ha) became a municipal park (Parque Eduardo Ruíz), managed by a board appointed by the Uruapan city council and administered by SARH through the Departamento Forestal. This part once held a coffee plantation that left the overstory largely intact. Owing to problems within the board, the Movimiento Ciudadano Ecologista Defensa del Parque Nacional Barranca del Río Cupatitzio was established in the city of Uruapan to work for its conservation. After a series of actions, the Uruapan City Council disbanded the board

in 1993, and assumed direct responsibility for the park's administration. Parque Eduardo Ruíz has since been reduced to 19 ha.

Income to support the park is drawn primarily from entrance fees collected from 360,000 yearly visitors, covering salaries of the administrative and maintenance personnel. The park receives no federal or state support, with the exception of four SARH guards. The park has benches, fencing, sidewalks, an administration building, restrooms, food booths, and bridges. Food vendors within the park do not pay for the privilege because they were there before the park was developed; their descendants are "grandfathered" into their stall spaces. The park has running water, electricity, sewers, telephones, a hotel, and a greenhouse for reforestation activities that produces approximately 20,000 plants a year.

The Campo Forestal Barranca de Cupatitzio consists mostly of pine and pine/oak forest with orchards (avocado) and small agricultural in-holdings (cornfields) interspersed. Along roads, the forest is heavily managed, and the understory removed. Moving away from the roads, a pine-oak forest remains undisturbed, although much of this forest burned in 1991 from a fire originating outside the management area. Facilities within the camp include a weather station, dorms, offices, and labs. The field station is guarded, mostly for fire prevention. An ejido west of the station is managed by Indians for lumber, and other uses such as turpentine extraction are being developed. This block of forest is part of continuous forest extending from the outskirts of Uruapan to Parque Nacional Tancítaro.

Comments: Presently, 418 of the total 527 ha are forested; the rest is occupied by installations, irregular settlements, and avocado plantations. The settlement in the park called "28 de Octubre" has increased pollution and discharge of wastewater into the Río Cupatitzio. The springs at the recreational park have been negatively impacted as the surrounding forests have been converted to agriculture and cattle raising, and as the demands of a growing city have increased. This pressure has also decreased soil moisture and water volume in the river. No group is presently interested in administrating the park, although the Facultad de Biología, UMSNH, with support from local government, is proposing an environmental restoration project for the Parque Eduardo Ruíz.

Rayón National Park

Location: Located near the town of Tlalpujahua, the park has its center at 19°48' N, 100°11' W. Originally having 34 ha, but reduced to 27 ha in 1954.

Physiography: An irregular and physiographically complex area of volcanic origin at 2450▪2600 m. No permanent streams or springs exist within the area.

Climate: Cool subhumid, with annual mean rainfall of 800 mm and annual mean temperature of 10°C.

Habitat: Introduced white cedar, oak, juniper.

Fauna: The fauna is almost unknown. Except for an incomplete list of bird species, vertebrate communities of the area have not been characterized.

Research: None.

Land ownership: Private.

Management: Decreed in 1952, this site was an operation center for the Rayón brothers during the Mexican war for independence, and was established in tribute to them. Since that time, however, the vegetation has been completely modified. The Tlalpujahua city council administrates the park, to which they refer as Campo del

Gallo, focusing primarily on fire prevention and reforestation. Within the park, a guard station, restrooms with septic system, water tank, monuments, and picnic tables are present. This park is a recreational area, and no management plan exists.

Comments: The inhabitants of Tlalpujahua and neighboring areas use the park for recreational purposes. Because of its popularity, a management plan addressing tourist development in conjunction with improvement and restoration of habitat should be developed. Some older trees have been attacked by the bark beetle *Phloesinus* sp. The neighboring town of Los Remedios is slowly taking over a portion of the park. Overall, this area is not important; its small size and non-native vegetation make it a low conservation priority. A more appropriate status may be as a national monument, instead of as a national park.

Monarch Butterfly Special Biosphere Reserve

Location: Situated northeast of Zitácuaro in the five sierras bordering the state of Mexico: Cerro Altamirano, Sierra Chincua, Sierra El Campanario, Huacal▪Chivati, and Cerro Pelón. The protected areas are found in the Michoacán municipalities of Ocampo, Angangueo, Senguio, Zitácuaro, and Contepec, and the Mexico municipalities of Donato Guerra, Villa de Allende, and Temascalzingo. Center at 19°32' N, 100°16' W, with a total for the five areas of 16,110 ha (4490 ha as core zones, and 11,620 ha as buffering zones).

Physiography: The five protected areas are located within the Transvolcanic Belt at 2500▪3500 m. Permanent streams are found in the Sierra Chincua and Sierra El Campanario, and ephemeral streams are numerous in all five areas.

Climate: Temperate subhumid, with annual mean rainfall of 1300▪1600 mm, and annual mean temperature of 10°C.

Habitat: Fir and pine-oak forest, pastureland.

Fauna: Besides Monarch Butterflies, two salamander species (*Ambystoma* and *Pseudoeurycea*), and the snakes *Pituophis* sp. and *Crotalus triseriatus* occur. Twenty-four mammal species and 204 species of birds have been recorded, but complete inventories are not available. Birds include Lesser Roadrunner, Dusky Hummingbird, Gray-barred Wren, Spotted Wren, Aztec Thrush, Chestnut-sided Shrike-Vireo, Green-striped Brushfinch, Cinnamon Flowerpiercer, and Striped Sparrow.

Research: Research has focused on migratory movements, habitat selection, behavior, ecology, breeding physiology, hormonal regulation, temperature control, and other characteristics of Monarch Butterflies. INE is presently developing a general management plan with a biological research component.

Land ownership: Most of the land belongs to ejidos, with one portion held communally, and only a small portion owned by the government. Exact figures are not available.

Management: Decreed in 1980, and expanded in 1986. In 1985, the property known as Hacienda de Jesús Nazareno and other small areas were donated to the state government as a first step towards creating a Monarch Butterfly preserve. Of the five sites, the Sierra del Campanario site has an entrance station, a place for permanent exhibits, a handcrafts stand, audiovisual hall, restrooms, and two nature trails. During winter, tourist services such as transportation, guides, and food are available. At Sierra Chincua are installations devoted to research and monitoring of the butterflies; presently, INE is in charge of these activities, with a staff of six biologists, two technicians, one sociologist, three guards, and other personnel, who work with specialists from

the U.S. and Canada. PROFEPA supports the administration by providing regular inspections of the areas.

These areas are mostly forested, with harvesting of natural resources in buffer zones subject to SEMARNAP regulations. Presently, these areas are under the supervision of INE, and recently were included as part of the Model Forest Program, which is implementing a plan for conservation and sustainable use of natural resources. Other monarch overwintering areas have not been included in this system. After an assessment of the importance of additional areas, they could be included in a modification of the present decree.

Comments: The reserve is of great importance as the principal wintering area for Monarch Butterflies. In addition, the two genera of salamanders known from the area are endemic to the Río Lerma Basin. The region's forestry resources have been overexploited by both legal and illegal activities. Forest fires set for agricultural and livestock conversion is a common and detrimental practice, done to obtain permission to harvest dead trees. These actions have increased in response to social problems. An unsuccessful attempt has been made to diversify productive activities to benefit local inhabitants.

Colola and Maruata Sea Turtle Reserve

Location: Five beaches, Colola, Maruata, Careycillos, Caretila, and Chicuasa, located 80 km southwest of the Colima-Michoacán border, with center at 18°16' N, 103°23' W. The length of the reserve is 12.5 km. Colola is 4.8 km long and 150 m wide. Maruata is 2.3 km long and 40 m wide.

Physiography: Although located on the coastal plain, this area is strongly influenced by the proximity of the Sierra de Coalcomán. The influence of the sierra on the coastal lowlands results in cliffs, crags, narrow beaches, and constricted plains (Correa 1974). The rivers and streams of the area are part of the coastal river system, with numerous ephemeral streams flowing to the Pacific Ocean. Important rivers in the area are the Coire (or Maruata), that runs to the Maruata Beach, and the Colola that flows to the middle of the Colola beach.

Climate: Hot subhumid, with annual mean temperature in excess of 26°C.

Habitat: Halophytic vegetation and coastal dunes, backed by tropical deciduous and semideciduous forests, and mixed with second growth in small areas converted for agriculture and livestock (Rodríguez *et al*. 1992).

Fauna: Three species of sea turtles nest on the Michoacán coast. Colola and Maruata are the most important breeding sites known for the Black Turtle. Species counts for other vertebrate groups include 19 amphibians, 79 reptiles, 216 birds, and 88 mammals. Birds include West Mexican Chachalaca, Lilac-crowned Parrot, Balsas Screech-Owl, Eared Poorwill, Citreolene Trogon, Flammulated Flycatcher, Black-throated Magpie-Jay, Rufous-naped Wren, Sinaloa Wren, White-bellied Wren, White-lored Gnatcatcher, Rufous-backed Robin, Golden Vireo, Red-breasted Chat, Scrub Euphonia, Blue Bunting, Orange-breasted Bunting, Olive Sparrow, and Yellow-winged Cacique.

Research: Numerous research projects have been conducted in this area, most having to do with the ecology, population biology, and conservation of marine turtles (Alvarado and Figueroa 1990a, 1990b, 1992a, 1992b; Alvarado *et al.* 1991, 1994). General studies of terrestrial and aquatic communities (phytoplankton and zooplankton) have been developed (Ceballos 1988; González 1987). A description of the surrounding vegetation types (Guerrero 1985), and an assessment of the status and use of the tropical forest have been made (Rodríguez *et al.* 1992). Relative abundances and preferred habitats of birds were studied by J. F. Villaseñor Gómez (1990) and L. Villaseñor Gómez (1994). Other research activities have addressed economic and

educational alternatives for the Náhuatl Indians, including conservation and use of iguanas (Suazo and Ibarra 1992), ecotourism (Sánchez and Zubieta 1992), and environmental education (Hernández and Villaseñor 1996).

Land Ownership: The sea turtle beaches are federally owned. Adjacent inland areas are communally owned by the Náhuatl Indian communities of Pomaro and Coíre, but property boundaries are poorly defined.

Management: These areas were decreed in 1986 to establish favorable conditions for conservation and increased production of threatened sea turtle populations. Federal support was improved in 1990, when SEPESCA banned exploitation of sea turtles in Mexico. No formal administration exists for these beaches, with conservation activities coordinated through the sea turtle protection program established in 1982 by the Facultad de Biología, UMSNH. During the turtle breeding season, September-January, eggs are collected and placed in protected incubation areas. Mexican Marines assist with protection activities. In addition, the non-governmental organization, Ecotonia A.C., was created specifically to develop projects that would both improve the quality of life for local people, and help conserve the turtles. The decree creating these areas states that, in accord with conservation goals for these beaches, SEDUE (now INE) is required to promote suitable use of the areas adjacent to them, including avoidance of the deterioration of ecological conditions and banning the discharge of sewage and other contaminants.

Comments: The Michoacán coast holds breeding sites for three species of sea turtle: Pacific Ridley, Leatherback, and Black. The beaches of Colola and Maruata are the most important sites known for Black Turtles. Numbers of this species were far greater at the beginning of this century, with reports of massive arrivals of up to 10,000 turtles in one night. Presently, only 800-1000 females lay eggs each breeding season, placing this species in severe jeopardy. This decline in numbers results primarily from excessive exploitation of adults and eggs.

The recent construction of the coastal highway has disclosed the great biological, economic, and social importance of the Michoacán coast. The area promises a diverse productive potential in fisheries, timber, agriculture, livestock, mining, and tourism. If these activities continue without control, severe environmental disturbance could result. On the other hand, activities could be diversified and intensified within a rational framework, taking into account the development of research programs to determine, propose, and evaluate strategies for sustainable use of resources.

In 1971, the community of Maruata and members of the fishing cooperative "Pomaro" initiated protective activities on the beaches of Maruata, Paso de Noria, and Cachán, seeding turtle nests in hatcheries, and releasing the hatchlings on various beaches. Since 1982, the Facultad de Biología, UMSNH, in coordination with the Náhuatl Cooperative Societies of Pomaro, Maruata, Colola and Motín del Oro, SEMARINA, SEPESCA, the state government, and SEDUE, with financial support from international organizations such as World Wildlife Fund and U.S. Fish and Wildlife Service, has continued the protection and research actions. This "Programa de Protección y Recuperación de Tortugas Marinas en el Estado de Michoacán, con especial atención a la tortuga prieta, *Chelonia agassizii*." has been implemented principally by professors and students from the UMSNH.

In addition to biological research, social, economic, and cultural aspects are also under study, to determine the human relation with local resources. In this regard, the Facultad de Biología began an environmental education program in 1984, directed principally at the indigenous communities surrounding the Black Turtle breeding beaches. Additional research has focused on development of alternative uses of natural resources to increase quality of life for the local populace, and to diminish pressures on the turtle population.

Playón de Mexiquillo Sea Turtle Reserve

Location: Approximately 125 km southwest of the Colima border, with center at 18°07' N, 102°52' W, length 12.5 km, and average width of 35 m.

Physiography: This area is characterized by long, constricted coastal plains, with the sierra coming down to the ocean in some places. The Mexiquillo Plain, approximately 42 km long, extends from northwest of the town of La Huahua to La Manzanilla (J. F. Villaseñor Gómez 1990). Most of the streams descending from the coastal sierra are ephemeral. The rivers Tupitina and Nexpa are the most important permanent streams.

Climate: Hot subhumid, with annual mean temperature in excess of 26°C. No precipitation measurements are available.

Habitat: Beach, backed by tropical deciduous and tropical subdeciduous forest, with some conversion to use for agriculture (papaya, banana, mango and coconut palm) and grazing on introduced grasses (Guevara and Zamudio 1981).

Fauna: See Colola and Maruata above.

Land ownership: The protected area is federal; the surrounding land is private.

Research: Research activities have included studies of gastropods (Alarcón 1993), reptiles, medicinal plants (Ruíz 1989), birds (J. F. Villaseñor Gómez 1990), and sea turtles, including ecological aspects of bird predation on hatchlings (Mejía *et al*. 1989).

Management: Decreed jointly in 1986 with the beaches of Maruata and Colola. When SEDUE was created in 1982, a research station was established at El Farito. Since then, SEDUE and UNAM have conducted various research and protection programs. In 1984, UMSNH began a similar operation in the neighboring area of "El Salado." The program established by SEDUE (later SEDESOL, INE, and UNAM) continues to the present.

Comments: Playón de Mexiquillo is considered one of the most important breeding beaches in the world for Leatherback Turtles, both in number of breeding females and in hatchling productivity. Pacific Ridley and Black Turtles also breed there (A. Villaseñor Gómez unpubl.).

Los Azufres Forest Protection Area

Location: Approximately 10 km northwest of Ciudad Hidalgo and north of the town of San Pedro Jácuaro. The area encompasses parts of the municipalities of Zinapécuaro, Hidalgo, and Maravatío, and consists of 8681 ha.

Physiography: This part of the Transvolcanic Belt is known as the Sierra de San Andrés, with Cerro de San Andrés (3690 m) as the highest point. The Río Tejamaniles is the principal river of the area, and many ephemeral streams are also present. Important bodies of water are Laguna Verde and Laguna de La Alhajita, and the hot springs of Los Azufres and Laguna Larga.

Climate: Cool subhumid, with annual mean rainfall of 1400 mm and annual mean temperature of 15°C.

Habitat: Pine-oak and fir forest.

Fauna: Vertebrate species recorded thus far include 2 amphibians, 6 reptiles, 74 birds, and 29 mammals.

Birds include White-striped Woodcreeper, Gray-barred Wren, White-throated Robin, Blue Mockingbird, Colima Warbler, Red Warbler, Golden-browed Warbler, Rufous-capped Brush-finch, Green-striped Brush-finch and Collared Towhee.

Research: Work has been conducted by Alba Pérez (1986) and the Facultad de Biología, UMSNH, for CFE.

Land ownership: Within the area, ejidal property comprises 3421 ha, communal property 1851 ha, private property 3247 ha, and invaded areas 163 ha. Land ownership disputes exist in the town of Agua Fría, in the municipality of Hidalgo.

Management: Decreed in 1979, this area was established for its extensive forests, scenic beauty, and hot springs and lakes. In 1975, exploratory activities were begun by CFE for establishment of a geothermal field, of great potential importance for regional production of electricity. A management plan exists for conserving the area and preventing negative impacts, including elements of reforestation, noise reduction, and water treatment. Some small land owners around Laguna Larga have resorts with cabins, and a tourist camp has been established by the state government in coordination with the local ejidos.

Comments: The forested area has been affected seriously by geothermal energy exploration. Weakened fir and pine trees are subject to insect invasion and parasitic plants (e.g., *Arceuthobium globosum*). Clandestine logging has increased, primarily for shingles, beams, and Christmas trees. A more comprehensive management plan, with participation by all government agencies working in the area, is badly needed.

City of Ario de Rosales Forest Protection Area

Location: Surrounding the city of Ario de Rosales, 110 km southwest of Morelia, with center at 19°12' N, 101°42' W, consisting of 13,800 ha.

Physiography: This area is located in the Transvolcanic Belt as it begins to slope towards the Balsas Basin. The highest point is Cerro La Barra at 2620 m, and the lowest at 1800 m. Additional important summits are Las Vigas, Cerro Colorado, Cerro Capulín, and Cerro Ciprés. The area lies in the Tepalcatepec-Infiernillo watershed of the Río Balsas drainage. Many temporary streams flow into the most important river of the area, the Río Guariméo. Major streams include Aparícuaro, Contembo, La Laja, and Tzintzango; the spring of Ario de Rosales provides the city with water.

Climate: Warm subhumid, with annual mean rainfall of 1198 mm and annual mean temperature of 19°C.

Habitat: Pine-oak and secondary vegetation. Much of the vicinity of Ario de Rosales has been converted to agriculture.

Fauna: Vertebrate species recorded thus far for the area include 58 birds and 20 mammals. Birds include Dusky Hummingbird, Russet Nightingale-Thrush, Gray Silky-Flycatcher, and Rusty Sparrow.

Research: None.

Land Ownership: Ejidal ownership comprises 8260 ha, and communal lands 5520 ha.

Management: Decreed in 1937, this area was established in recognition of Ario de Rosales' reliance on the surrounding forests for many purposes, and to help preserve those forests. It is not known if a resource use or

management plan has been developed for the area.

Comments: This area is located west of the City of Tacámbaro Forest Protection Area, which has similar flora and fauna, as well as many of the same problems.

City of Tacámbaro Forest Protection Area

Location: Within the municipality of Tacámbaro. Center at 19°15' N, 101°31' W, consisting of 36,000 ha.

Physiography: This area is located in the Transvolcanic Belt as it slopes towards the Balsas Basin. Its territory is mountainous (1200▪2100 m), though without high elevations. Principal hills are Caramécuaro, Agua Fría, El Tlacuache, El Jasmín, El Pedregoso, Colorado, Cerro Hueco, Cerro Partido, El Puerto and El Mayorazgo. Mountain streams help recharge several reservoirs for irrigation. The Río Tacámbaro, or Río Frío, originates in the Sierra de Curucupaseo and is the principal river of the area, being joined eventually by the Río Turicato and Río Carácuaro. Some natural bodies of water in the surroundings of Tacámbaro are La Alberca de Chupio (an inactive volcanic crater), Laguna de La Magdalena, and the waterfalls of Santa Paula (formed by the Río San Miguel), Santa Rosa, and Caricho. Some creeks of the area are San Juan de Viña, Agua Tibia, Arroyo Frío, Caramécuaro, and El Salitrillo.

Climate: Warm subhumid, with annual mean rainfall of 1130 mm, and annual mean temperature of 18°C.

Habitat: Pine-oak and oak forests, and transitions to lowland tropical deciduous forest.

Fauna: Poorly known. The recently descibed bird species, White-fronted Swift, is known to be present, probably nesting behind several of the high waterfalls in the vicinity (Navarro Sigüenza *et al*. 1992), making this area the only identified nesting area for the species.

Research: Work was done by Ferrer (1989) and Navarro Sigüenza *et al.* (1992) on swifts.

Land ownership: Unknown.

Management: Decreed in 1936, and extended in 1939, this area was created to protect the forested areas surrounding Tacámbaro to help preserve local climatic conditions and to ensure the recharging of aquifers. No management plan has been created, and conflicts exist among local land owners.

Comments: The main problem for this area is excessive exploitation of forest resources. SARH has recommended that the area be abolished, and that the management and protection of the area be turned over to the municipality of Tacámbaro.

City of Jiquilpan Forest Protection Area

Location: Within the municipality of Jiquilpan de Juárez in far western Michoacán, this area consists of 7000 ha. Settlements within the area include Jiquilpan, Los Remedios, San Martín Totolán, Santa Bárbara, and Las Animas.

Physiography: This area is located in the northern part of the Transvolcanic Belt at 1700▪2500 m, including plains and some hills, such as Cerro San Francisco. The most important rivers are Paredones and Jiquilpan;

principal bodies of water are La Lagunita, Lagunita de la Puerta, and Presa de los Paredones.

Climate: Temperate, with annual mean rainfall of 826 mm, and annual mean temperature varying by elevation from 10° to 25°C.

Habitat: Patches of oak forests and subtropical scrub, but mostly agricultural land, eucalyptus plantations, and secondary vegetation.

Fauna: Little information available.

Research: Unknown.

Land Ownership: Includes ejidal (630 ha), private (320 ha), municipal (30 ha), and federal (20 ha) lands.

Management: Decreed in 1938, this area was created to protect forest, reduce soil degradation, and allow recharge of aquifers.

Comments: Deforestation has been extensive, and forest recovery conservation actions have been ineffective. Less water is available for the inhabitants of Jiquilpan, and other serious problems are appearing.

City of Uruapan Forest Protection Area

Location: Surrounding the city of Uruapan (19°24' N, 102°03' W), and consisting of 13,661 ha

Physiography: This area is located on the southern slopes of the Sierra de Uruapan, where the Transvolcanic Belt slopes toward the Balsas Basin. Principal summits include Cerro de la Cruz, Cerro de la Charanda, El Cajete, Cerro Jicalmi, and Cerro Colorado. The area is located within the Río Tepalcatepec-Infiernillo Hydrological Region, Río Cupatitzio Watershed. The most important rivers are the Cupatitzio and San Antonio.

Climate: Temperate subhumid and warm subhumid, with annual mean rainfall of 1604 mm and annual mean temperature of 17°C.

Habitat: Pine and pine-oak forest, with patches of montane cloud forest in sheltered areas.

Fauna: Vertebrate species recorded from the area include 5 amphibians, 122 birds, and 37 mammals.

Land ownership: Undetermined.

Research: None.

Management: Decreed in 1937, this area was established to conserve springs necessary to provide water to Uruapan and smaller towns at lower elevations. Its primary objective was the protection of the forest surrounding Uruapan. It is administered by the municipality through the Centro de Formación y Capacitación No. 1.

Comments: In recent years, in the process of converting lands to agricultural purposes, several forest fires have started in the area, resulting in subsequent insect infestations. However, protective actions have been

supported by environmental groups and civil associations.

Lake Pátzcuaro Basin Forest Protection Area

Location: 64 km west of Morelia, consisting of 96,800 ha, with center at 19°35' N, 101°39' W. The area includes parts of the municipalities of Pátzcuaro, Huiramba, Tzintzuntzan, Quiroga, and Erongarícuaro.

Physiography: Located between the sierras of Pátzcuaro, Nahuatzen, Comanja, and San Andrés, this basin rises from 2040 to 3000 m, and can be divided into three portions, based on elevation, vegetation, and physiography. The High Basin is a forested zone on volcanic soils, such as on the hills of El Tzirate (2700 m) and San Isidro (3000 m); the Middle Basin comprises the high grassland valleys and hillsides between 2100 and 2400 m, and the Low Basin contains the lake and its shore (Macías 1978).

Climate: Temperate subhumid, with annual mean rainfall of 996▪1043 mm and annual mean temperature of 16°C.

Habitat: Pine-oak and oak forests, as well as shrubby secondary vegetation, grasslands, and some cloud forest.

Fauna: Fish represented in the lake include silversides, carp, cichlids, and sunfish, with some species endemic to the watershed. An endemic amphibian of the Ambystomidae family, (*Ambystoma dumerilii*) occurs, as well as 170 bird and 37 mammal species. Birds include Long-tailed Wood-Partridge, Berylline Hummingbird, Happy Wren, Brown-backed Solitaire, Blue Mockingbird, Black-polled Yellowthroat, Green-striped Brushfinch, and Black-headed Siskin.

Research: A vertebrate inventory was conducted by Martín del Campo (1940), and several bird studies have been completed (Edwards 1949, Edwards and Martin 1955, Lea and Edwards 1950).

Land ownership: Divided among ejidos (34,230 ha), communal land (24,450 ha), and private land (38,120 ha).

Management: Decreed in 1936, the Pátzcuaro area is one of the most important in Michoacán. Programs have been implemented by Unidades de Conservacion Forestal of Pátzcuaro to conserve soil and prevent erosion, conserve aquatic resources of the lake, and develop new economic alternatives for the inhabitants of the region. Culturally, this area is of utmost importance to the Purhépecha ethnic group.

Comments: Since Prehispanic times, the natural resources of this area have been overtaxed, particularly in regard to deforestation. Erosion has resulted in sedimentation and reduced storage capacity of the lake. In addition, use of agrochemicals and discharge of sewage have caused increases in primary productivity, accelerating the lake's aging process.

Río Chiquito Basin Forest Protection Area

Location: Southeast of Morelia, within the Morelia municipality and consisting of 7375 ha. Center at 19°19' N, 101°08' W.

Physiography: Thirty percent of the basin is high hill country between 2400 and 2625 m, which slopes into prairies and flatlands at around 2100 m. The area forms part of the Río Grande de Morelia watershed. Río

Chiquito crosses the southern side of the city of Morelia, and joins the Río Grande de Morelia west of the city.

Climate: Temperate, with annual mean rainfall of 750▪1100 mm; annual mean temperature 16▪18°C at 1950▪2150 m, and 2▪3°C lower at elevations up to 2600 m.

Habitat: Pine and oak forests, subtropical scrub, cloud forest, grassland, and riparian communities.

Fauna: 97 bird species have been recorded for the area, including Lesser Roadrunner, Spotted Wren, and Blue Mockingbird.

Research: Medina and Rodríguez (1993) conducted a thorough floristic study of the basin.

Land Ownership: Mostly private, with some ejidal land. Exact proportions are undetermined.

Management: Decreed in 1936, with no current management.

Comments: The area holds many rare and endangered plant species, including *Liabum angustissimum, Vernonia tequilana, Dalea abietifolia, Agnistus arborescens*, and *Phoebe arsenei* (Rzedowski and Calderón de Rzedowski 1987; Medina and Rodríguez 1993). Although details of management and land use are not known, exploitation for wood and resin production have reduced and fragmented the forest. The growth of Morelia, particularly on unsuitably steep slopes, has caused serious erosion. The volume of the Río Chiquito, formerly the main source of water for the city, has diminished considerably, and recharge of Morelia's water supply is dependent on protection of this area. As strong interest in urbanization exists, an ecological assessment and management plan are urgently needed to control and prevent potential problems.

POTENTIAL AREAS

Sierras of Coalcomán and Aguililla

Description: These sierras (1200▪2700 m) are in southwestern Michoacán, at 18°40' N, 103°00' W, in the municipalities of Coalcomán, Aguililla, and a small portion of Tepalcatepec (Fig. 8.2). Within this area are found the towns of Dos Aguas, Puerto Hondo, El Izate, Varaloso, Las Cruces, La Nieve, Salsipuedes, and Barranca Seca.

This remote mountainous area slopes towards the Pacific Ocean, with few major valleys. Habitats include pine-oak, oak, pine, fir, tropical deciduous forest, and secondary growth. The climatic regime varies from warm to temperate with elevation, with the lower portions more humid. Streams originating in this area flow south to the Pacific Ocean. The principal rivers are not very large, including the Ixtala, Del Aguaje, and Chapula, and the stream of La Nieve. To the south, the Río Cachán (or Coalcomán) reaches the ocean at Maruata Bay. Birds present include Bumblebee Hummingbird, Mountain Trogon, Russet-crowned Motmot, Nutting's Flycatcher, Gray-barred Wren, Spotted Wren, Sinaloa Wren, Happy Wren, Rufous-backed Wren, Golden Vireo, Chestnut-sided Shrike-Vireo, Red Warbler, Blue-hooded Euphonia, Flame-colored Tanager, Red-headed Tanager, Green-striped Brushfinch, and Audubon's Oriole.

Comments: This unique, largely pristine area holds a wide diversity of habitats within a narrow range. Its location at the southern extreme of the Transvolcanic Belt, close to the Sierra Madre del Sur, makes it fascinating, but the area has not been inventoried faunistically.

Region of Zamora - Yurécuaro - Ixtlán de los Herbores

Description: This area is in "El Bajío," in northwestern Michoacán, refering to its proximity to the confluence of the Río Lerma and the Lago de Chapala. Situated at 20°6'N, 102°6' W, it includes parts of the municipalities of Ecuandureo, Zináparo, La Piedad, Zamora, Tanhuato, Yurécuaro, Tangancicuaro, and Tlazazalca. The most important towns are Zamora, Ecuandureo, San José de Vargas, El Refugio, La Soledad, La Rinconada, Atacheo, and Tierras Blancas.

The Central Mexican Plateau reaches its southernmost limit in this area. High, broad valleys are separated by rolling hills descending from the surrounding sierras (1550▪2400 m). The climate is warm, with annual mean rainfall of 800▪1000 mm and annual mean temperature of 19°C. The area is part of the Lerma▪Chapala watershed and has numerous lakes and ponds (the majority of which are dry), used extensively for irrigation. The most important agricultural valleys are those of Yurécuaro, Tanhuato, and Zamora. Many streams, including El Moreno, El Convento, Quiringuícharo, Loreno, and Guacamalate, flow into the Río Lerma and the Colesio Reservoir, and provide water to La Piedad, Yurécuaro, and Vista Hermosa. In the Zamora area are the Río Duero, the Chaparaco Reservoir, and the Río Chavinda.

Habitats include subtropical scrub, often dominated by *Opuntia* thickets, with arboreal or shrubby second growth. In general, it is a dense perennial vegetation 3▪5 m tall, best represented between Cotija, Ixtlán de los Herbores, and Pajacuarán. Native halophilic vegetation and grasslands are also well represented in the nearby valleys of Jiquilpan, Tangamandapio, Tocumbo, El Sabino, and El Jarro. Oak forests are restricted to the sierras (1700▪2400 m). Birds present include Long-tailed Wood-Partridge, Blue Mockingbird, and Blue-hooded Euphonia.

Comments: El Bajío is the most important agricultural area of central Mexico. However, the portion treated here is not favorable for agriculture, used only to a small extent for livestock and fuelwood. This habitat is unprotected in Michoacán, and yet has not been excessively impacted in this area. Because it is less highly regarded for production than elsewhere in El Bajío, reserve status could be acheived without great opposition.

Coastal Náhuatl Region

Description: This area, also called the Coíre▪Pómaro Region, lies at 18°22' N, 103°22' W, at sea level to 1200 m, within the municipalities of Aquila and Coalcomán, and containing the towns of Pómaro, Coíre, La Vainilla, and Ostula. It is part of the Pacific coastal plain, within the Río Cachán watershed, with numerous ephemeral streams and primary rivers including the Maruata, Motines del Oro, Cachán, and Coyutlán. The climate is warm, with annual mean rainfall of 1000▪1200 mm, and annual mean temperature of 22°C. This area is outstanding for its extensive tropical deciduous forest. In higher and steeper parts, the forest is in more or less pristine condition. In the dryer parts, large cacti are a noticeable component, with many leguminous and grass species in the understory. In more humid and protected sites, the forest develops a closed canopy, with thicker uniform foliage. In restricted areas, tropical semideciduous forest is found; this habitat, in some areas, has been extensively disturbed, with the subsequent development of shrub-dominated successional stages.

Comments: Clearings in this area are growing as forest patches are converted to agriculture. Unfortunately, newly opened areas are used inefficiently, and are often abandoned after a year in favor of other openings; abandoned land is left fallow for several years to recover on its own. As a result, the surroundings of towns present a mosaic of different successional stages.

Northern Region of the Infiernillo Reservoir

Description: This area of tropical deciduous forest is in the westernmost extreme of the Balsas Basin, at the confluence of the Río Balsas and Río Tepalcatepec, the two main arms of the Presa de Infiernillo, at 18°36' N, 101°50' W, 160–600 m. It includes portions of the municipalities of La Huacana, Churumuco, and Arteaga. Towns include El Reparito, Las Cañas, Descansadero, Cueramo, Hacienda Vieja, and Guayacán. The climate is hot and dry, with annual mean rainfall of 511 mm, and annual mean temperature of 28°C. The topography is characterized by rolling hills with occasional small intermountain valleys. The major rivers are the Cutzamala, Carácuaro, and Tepalcatepec. Birds include West Mexican Chachalaca, Banded Quail, Buff-collared Nightjar, Russet-crowned Motmot, Golden-cheeked Woodpecker, Black-throated Magpie-Jay, Banded Wren, Orange-breasted Bunting, and Black-chested Sparrow.

Comments: During Pleistocene glaciations, the Balsas Basin provided an important isolated refuge for many species. Afterwards, it constituted a barrier to the expansion of tropical highland species north along the Pacific Slope. The region is rich in restricted-range endemics (e.g. Balsas Screech-Owl), as well as being the northernmost limit for many tropical species.

ASSESSMENT OF CURRENT SITUATION; CONCLUSIONS

Most Mexican protected areas are confronted with a similar array of problems, including uncertain land ownership, overgrazing, clandestine logging, surreptitious hunting, and extensive erosion. The most important step towards resolving these problems is to define and establish management plans integrating reserve activities with needs of local communities. These management plans must involve not only biological considerations, but economic and social ones as well. Additional critical steps include addressing problems of soil erosion, and promoting implementation of ecological recovery programs. Specific requirements include the following:

- Integration of local communities in conservation of important natural areas through programs and economic activities, in accord with the natural well-being of these areas. Ecotourism and development of small-scale local industries are important possibilities. These activities imply the need for establishing a variety of programs and for the development of visitor services; most importantly, the inhabitants of the zone will have to be incorporated into conservation, administration, maintenance, and management activities.

- Implementation of scientific studies to determine species diversity of areas, and to help direct priorities with regard to vigilance, protection, and management. In this regard, important needs include research equipment, technical support, and staff training programs to improve monitoring of flora and fauna.

- Implementation of activities related to environmental education, to inform and encourage the development of conservation ethics and caring ideas and attitudes in the local inhabitants, residents of surrounding communities, and visitors to the different natural areas.

- Development of infrastructure that includes administrative facilities, tourist installations, etc., as well as trained personnel, vehicles, computers, radios, telephones, and logistic material to improve administration, vigilance, and supervision of the reserves.

On one hand, it is important for conservation efforts to include participation by institutions related to management and conservation of natural areas, as well as national and international academic and research institutions. On the other hand, these activities must be predicated on the understanding that long-term management of natural protected areas must rest in large part with a local populace that discerns the area's importance to its own well being. Local residents assume responsibility for the protection and conservation of natural areas, making their long-term preservation more feasible.

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CHAPTER 9. PROTECTED AREAS OF MORELOS - Fernando Urbina Torres, Aquiles Argote Cortés, César D. Jiménez Piedragil

INTRODUCTION

Morelos is a small state in central Mexico (495,000 ha, slightly smaller than Connecticut), at the intersection of the Transvolcanic Belt, the Mexican Plateau, and the Río Balsas Basin. From the volcano Popocatépetl (5650 m) and the high pine-oak forest region of Zempoala in the north and east, the state slopes down to tropical deciduous forest near the Río Amacuzac (750 m) in the south.

Principal mountain ranges include the Serranías de Chalma y Ocuila, extending from the Transvolcanic Belt south to the Sierra de Taxco in Guerrero. The Sierra de Huitzilac lies in the western part of the state and includes the summits of Ocotlán and San Gabriel. In central Morelos, two main valleys lie between the Sierras of Santo Domingo and Tepoztlán: the valley to the west holds the cities of Cuernavaca and Jojutla, and the Plains of Michapa, whereas that to the east holds Cuautla and the Plains of Plan de Amilpas. A large mesa dominates the southwestern part of the state. Apart from Popocatépetl, principal Morelos summits include Chichinautzin (3420 m), Ocolique (3280 m), and Ajusco (3250 m). Fifty-two natural springs are present in the state, the most important being Las Estacas in the municiplity of Tlaltizapán. The state's twelve rivers all lead to the Río Amacuzac, which in turn leads to the Río Balsas. Annual mean precipitation varies from 800 mm in the warm lowlands, to 1500 mm in the highest parts.

Within this small state, 3000+ vascular plant species are found (Martínez Alvarado and Flores Castorena 1992). Dominant vegetation (53%), however, is related to agricultural activities. Of Morelos♠546 vertebrates, 242 are Mesoamerican endemics, and five (3 fish and 2 amphibians) are endemic to the state. Birds number 362 species, with 103 Mesoamerican endemics and thirteen restricted-range Mexican endemics.

The amount of area currently protected in Morelos is proportionally one of the largest in Mexico (20%), with a combined area of state and federal reserves of 98,665 ha. However, the usual Mexico problems of population growth, poverty, unsupervised land use, and inadequate land management contribute to an urgent need to forestall actions that may cause, or have already caused, irreparable harm. In this regard the state government has implemented a System of Protected Areas of Morelos as part of a regional conservation stategy, and this plan has formed the foundation of the Law of Ecological Balance and Environmental Protection of the State of Morelos (Figueroa *et al.* 1993). We describe seven currently protected areas, and three potential areas for conservation attention.

PROTECTED AREAS

Lagunas de Zempoala National Park

Location: Consisting of 4790 ha, 3965 ha in northeastern Morelos and 825 ha in adjacent México, in the municipalities of Huitzilac and Ocuilán, with center at 19°15' N, 99°20' W.

Physiography: Zempoala constitutes a mountain valley surrounded by steep sierras in the Transvolcanic Belt. The lower portion of the park (2400-2800 m) forms a small basin containing the lakes of Zempoala, Compila, Tonatiahua, Seca, Prieta, and Atexpa. The higher and larger portion of the park rises to above 4000 m.

Climate: Temperate subhumid, with average temperature of 12-18° C, and annual mean precipitation of 1200-1500 mm.

Habitat: Pine, oak, pine-oak, fir and pine-fir forests, as well as deforested portions with pastures and secondary vegetation. In addition, the system of seven lakes and a spring contain a rich aquatic flora of 66 species in 27 families (Bonilla Barbosa and Novelo 1995).

Fauna: Four species of fish occur in Lago de Zempoala, one of which is endemic to the park and considered endangered (IUCN 1994). Of the ten known amphibians, eight are endemic to Mexico, and six are threatened; of these, one salamander is restricted to the Transvolcanic Belt, and a second is endemic to the park. Of the 18 known reptiles, 14 are endemic, two threatened, and one endangered. The rattlesnake *Crotalus transversus*, present in the park, is endemic to the Transvolcanic Belt. Among birds, 63 species have been identified, 15 of which are endemic, and six of which are threatened. Range-restricted endemics include Long-tailed Wood-partridge, Gray-barred Wren, Dwarf Vireo, and Green-striped Brushfinch. Threatened species include Merlin, Montezuma Quail, and Dwarf Vireo. In the case of mammals, 34 species have been recorded, of which six are endemic; two of these species are endemic to the Transvolcanic Belt. The endangered Volcano Rabbit, restricted to the higher elevations of the Transvolcanic Belt, has already been extirpated from some summits.

Research: Vertebrates of the area were first documented by Martín del Campo (1940). Detailed ichthyological studies were reported by Viana (1991) and Contreras (1995). Amphibians and reptiles research have been detailed by Taylor and Smith (1945), Smith and Taylor (1966), Martín del Campo (1977), and Castro Franco and Bustos (1992, 1994, 1995). Birds were studied by Davis and Russell (1953) and Urbina (in prep.). Ramírez Pulido (1969) presented extensive studies of mammals; and Cervantes *et al.* (1990) studied the Volcano Rabbit.

Land Ownership: Federal, with some expropriation from original local ownership without compensation.

Management: Decreed in 1936, the park is currently managed by SEMARNAP and INE. The present management plan (SEMARNAP 1995) calls for identification of a protected core area around the lakes, a limited-use buffer zone including all intact forest, and a high-use area northeast of Lago Zempoala where food stalls, restrooms, administrative offices, a playground, and parking are located. The plan calls for a park manager and 18 guards. The Huitzilac municipal police do some surveillance, but only in the vicinity of Lago Zempoala. Currently, residents of Huitzilac and Santa Martha come to the lake area to sell food and other items, as well as to rent horses to tourists. Information booths are located at the main park entrances.

Comments: Many problems confront the rehabilitation and conservation of the water, soil, and wildlife resources, including solid waste contamination, illegal harvest of trees, and illegal hunting in remote parts of the park. Limits on land use within the park have not been established. Road signs and information signs are lacking, or do not function correctly. No cultural or environmental education programs exist. Border problems between the states of Morelos and México create problems for the management and care of the park. A property rights dispute exists between the communities of Huitzilac, Morelos, and Ocuilán de Arteaga, México.

Chichinautzin Biological Corridor Wildlife Sanctuary *(Área de Protección de Flora y Fauna Silvestre y Acuática)*

Location: Consisting of 37,302 ha in northeastern Morelos, in the municipalities of Cuernavaca, Huitzilac, Jiutepec, Tepoztlán, Tlalnepantla, Tlayacapan, and Yautepec, and part of neighboring Distrito Federal, with center at 18°58' N, 99°6' W.

Physiography: The Chichinautzin Biological Corridor is in a part of the Transvolcanic Belt varying dramatically from low hills at 1250 m, to complex and rugged mountains reaching 3480 m in the extensive

massif of Chichinautzin.

Climate: Warm (18-22° C) at lower elevations, and cool (5-12° C) at upper elevations, with annual mean precipitation of 1000-1500 mm.

Habitat: Tropical deciduous, pine, pine-oak, fir, and montane cloud forest, as well as scrub, subalpine grasses, and meadows. Portugal (1995) identified 190 mushroom species for the area. Overall, the combined Nearctic and Neotropical floristic elements confer a great diversity of biotic communities on the area.

Fauna: Seven amphibian species have been identified, six of which are endemic to Mexico, and three threatened. Of the 18 reptiles species present, 13 are endemic to Mexico and two endangered; one (*Crotalus transversus*) is endemic to the Transvolcanic Belt. In all, 180 bird species have been recorded, of which 51 are Mexican endemics, and eight threatened. Range-restricted endemics include Slaty Vireo, Green-striped Brushfinch, and the endangered Sierra Madre Sparrow. Threatened species include Aplomado Falcon, Montezuma Quail, and Slaty Vireo. In the case of mammals, 11 species have been recorded, of which two are endemic to the Transvolcanic Belt.

Research: Palacios Vargas (1981) and Murillo *et al.* (1983) studied insect faunas associated with bromeliads of the genus *Tillandsia*. Castro and Aranda (1984) and Castro and Bustros (1995) studied the area's herpetofauna. Davis and Russell (1953) reported on mammals and birds. Cruz (1983), Márquez (1986), and Urbina (1990) detailed the avifauna of the region. López Paniagua *et al.* (1990) analyzed the area's rich biotic diversity, and extensive work by the Centro Investigaciones Biológicas, UAEM, resulted in a natural history monograph (Contreras and Urbina 1995).

Land Ownership: Ejidal and communal (43%), with the rest private and federal.

Management: Decreed in 1988, management responsibilities have been given to SEMARNAP, SRA, and INE. In 1990, the Univ. Autónoma Metropolitana-Xochimilco and UAEM developed a management plan identifying three core areas within the reserve: Chalchihuites, Chichinautzin-Quiahuistepec, and Las Mariposas. As the corridor has been established so recently, no infrastructure exists; however, the neighboring national parks of Lagunas de Zempoala and El Tepozteco provide some infrastructure.

Comments: The Chichinautzin Biological Corridor was the first reserve created under the category of Área de Protección de Flora y Fauna Silvestre y Acuática. The area is subject to the continued effects of deforestation, illegal mining, encroaching agriculture, illegal hunting, unsupervised tourism, and increased ranching. These combined factors contribute ultimately to the area's destruction via occupation and even urbanization.

El Tepozteco National Park

Location: Consisting of 24,000 ha in northern Morelos, in the municipality of Tepoztlán, and the delegation of Milpa Alta, Distrito Federal. Center is at 18°58' N, 99°07' W.

Physiography: The steep mountainous terrain (1200-3480 m) of El Tepozteco National Park is dominated by the Sierra de Tepoztlán. The area has an extraordinary eroded landscape giving it incomparable scenic beauty.

Climate: Warm to temperate subhumid. Annual mean temperature is over 18° C at lower elevations, 12-18° C at middle elevations (2400-2800 m), and 5-12° C at upper elevations. Annual mean precipitation is 800-1200 mm, increasing with elevation.

Habitat: Pine, pine-fir, fir, pine-oak, juniper, montane cloud, and tropical deciduous forest. The broad altitudinal gradient provides for a variety of vegetation types. Pine-fir is found above 3000 m, with pine predominating above 2800 m. Pine-oak with juniper dominates at 1600-2800 m, giving way to tropical deciduous forest below 1600 m. Cloud forest is found predominantly on steep slopes of humid barrancas.

Fauna: Twenty-seven species of reptiles, including 19 Mexican endemics, have been found, including a venemous species of Gila Monster. Among birds, 126 species have been identified, including 42 Mexican endemics. Range-restricted endemics include Banded Quail, Dusky Hummingbird, Boucard's Wren, and Black-chested Sparrow. Mammals reported include 35 species, with three Mexican endemics.

Research: Reptile ecology was studied by Castro and Aranda (1984). Avian studies include Davis and Russell (1953), Bueno and Espinosa (1988), and Urbina (in prep.). Mammal studies are limited to those of Davis and Russell (1953) and Vargas *et al*. (1987).

Land Ownership: Ejidal and communal (80%), private (15%), and federal (5%) (SEMARNAP 1995).

Management: Decreed in 1937, the park forms part of the SINAP. The management plan presented by SEMARNAP (1995) divides the park into "extensive use" and "special use" areas. The first is composed primarily of temperate and tropical deciduous forest. The second includes the town of Tepoztlán, the Tepoztlán Dominican convent, and the Cerro del Tepozteco, which has a road to the top. According to the decree, administration is the responsibility of SARH; however, SEMARNAP and INE are presently in charge, as well as the INAH, which is responsible for an archeological zone and the convent. Even so, no administrative infrastructure, surveillance, or conservation measures have been implemented. Increasing human population and deforestation are having particular impact at lower elevations.

Comments: The SEMARNAP management plan's definition of core zones is indefinite, and inadequate in protecting natural resources. The approach by federal and state authorities lacks a positive, cohesive attitude. On the other hand, local residents are coming to realize the value of safeguarding their natural resources, and in some cases are even experimenting with self-government.

Iztaccíhuatl-Popocatépetl National Park

Location: Consisting of 25,679 ha at the intersection of the states of México, Puebla, and Morelos, with only 700 ha in Morelos in the municipality of Tetela del Volcán.

Physiography: Iztaccíhuatl-Popocatépetl National Park is in a portion of the Transvolcanic Belt in which principal features are the hills of Tláloc and Telapón and the mountains of Iztaccíhuatl and Popocatépetl. Elevational range within Morelos is 3600 to 5650 m.

Climate: Cold, with mean annual temperature of 4-8° C and precipitation of 800-1000 mm.

Habitat: Alpine tundra up to 4500 m.

Fauna: The Volcano Rabbit is likely found in the park.

Research: No work has been done in the Morelos portion of the park. Leopold (1977) mentioned the presence of the Volcano Rabbit on the slopes of Iztaccíhuatl and Popocatépetl.

Land Ownership: Uncertain, although communal lands previously surrounded the park.

Management: Decreed in 1935, this area is the responsibility of SEMARNAP and INE. Within the park are lodgings at Tlamacas, Estado de México, which are used as a base for climbing, camping, and general enjoyment of the natural landscape.

Comments: Sánchez (1987) reported that the conservation status of the area is "acceptable." Recent elevated volcanic activity on the part of Popocatépetl makes for an uncertain future for the forests of this area.

El Texcal State Ecological Conservation Area *(Área Sujeta a Conservación Ecológica)*

Location: Consisting of 408 ha in northeastern Morelos, in the municipality of Juitepec, with center at 18° 53' N, 99°10' W.

Physiography: El Texcal is a high plain at 1355 m in the Transvolcanic Belt.

Climate: semi-warm subhumid, with annual mean precipitation of 800-1000 mm, and annual mean temperature of 20° C.

Habitat: Tropical deciduous forest, with 94 plant species of 21 families identified thus far. Dominant genera include *Bursera*, *Lysiloma*, *Hipomoea*, *Pileus*, and *Opuntia*. Also, 65 species of mushrooms have been identified.

Fauna: Little information is available for most vertebrate groups. Three species of fish have been identified at the Hueyapan Spring, two introduced and one endemic to Mexico. Amphibians are represented by nine species, five of which are Mexican endemics. Among birds, 44 species have been identified; 12 are Mexican endemics, including the range-restricted Dusky Hummingbird. Although the initial report establishing El Texcal as an area of ecological conservation mentions the presence of the Volcano Rabbit, the habitat is incorrect, and little reason exists to expect this species here.

Research: Portugal *et al.* (1985) investigated the mushrooms of the area. Chávez Martínez and Lara López (in prep.) included this area in their studies of the amphibians of Morelos. Urbina (1985) investigated the ecology of the squirrels of the area. Urbina (in prep.) included El Texcal in his study of Morelos birds.

Land Ownership: Communal; the northern portion belonging to the community of Santa Catarina and the southern to the community of Tejalpa.

Management: Proclaimed in 1992 as a state reserve. In 1994 the Ecology Undersecretary for Morelos presented a management plan designating two areas, a core ecology protection zone of 294 ha and a restricted-use buffer zone of 113 ha.

Comments: El Texcal is under continuous pressure, primarily from the impinging effects of industrialization and urbanization from Cuernavaca. The residents of Tejalpa are interested in conserving the area.

Los Sabinos-Santa Rosa-San Cristóbal State Ecological Conservation Area *(Área Sujeta a Conservación Ecológica)*

Location: Consisting of 152 ha in western Morelos, in the municipality of Cuautla and near the city of the same name.

Physiography: An area of springs on a plain at 1300 m in the Transvolcanic Belt.

Climate: Warm subhumid, with mean annual temperature of 20-22° C, and mean annual precipitation of 800-1000 mm.

Habitat: Riparian gallery forest of the conifer *Taxodium mucronatum*, with *Ficus* and *Salix* spp., surrounded by irrigated farmlands.

Fauna: No information available.

Research: None.

Land Ownership: Federal.

Management: Decreed in 1993. The state government, in coordination with the Instituto de Cuautla, designated two types of areas: core zones in the areas immediately adjacent to the springs and surrounding buffer zones. The two core zones are Los Sabinos-Santa Rosa (5 ha) and San Cristobal (12 ha). The Secretaría de Desarrollo Ambiental (Department of Environmental Development) has management responsibilities, except for those pertaining to the water from the springs, which lie with the Comisión Nacional del Agua.

Comments: Mention has been made in the official journal *Tierra y Libertad* that this area should be conserved because of its important springs.

Sierra de Huautla State Ecological Conservation Area

Location: Consisting of 31,314 ha in southern Morelos, in the municipalities of Tlaquiltenango and Tepalcingo, adjacent to Guerrero and Puebla, with center at 18°27' N, 98°59' W.

Physiography: Lying in the Transvolcanic Belt, the eastern end of the Sierra de Huautla is broken by clusters of numerous hills rising from 1000 m on the reserve's boundaries to 1600 m in the interior. In the western portion, a maze of ridges and mesas extends from 750 m along the Río Amacuzac up to 1670 m at the summit of Cerro de Huautla.

Climate: Warm subhumid, with mean annual temperature of 24° C, and mean annual precipitation of 885 mm (Taboada 1996).

Habitat: Tropical deciduous forest (90%), with thorn, oak, and riparian forest, as well as desert scrub and aquatic vegetation. The Centro de Educación Ambiental e Investigación de la Sierra de Huautla of UAEM (CEAMISH 1994) reports a total of 629 vascular plant species of 83 families. Dominant genera include *Conzattia*, *Lysiloma*, *Bursera* (11 endemic to Mexico), *Ceiba*, *Acacia*, and *Mimosa*.

Fauna: In the section of the Río Amacuzac near the reserve boundary are nine species of fish (three endemic and two introduced). Thirteen reptile species have been identified, including the Spiny-tailed Iguana, a threatened endemic. Among birds, 127 species are known, 34 of which are endemic; six are threatened. Range-

restricted endemics include Banded Quail, Gray-breasted Woodpecker, and Black-chested Sparrow, and the threatened species Balsas Screech-Owl and Pileated Flycatcher; recent studies (Peterson *et al.* in prep.) suggest that this area may constitute the richest site known for birds endemic to deciduous tropical scrub in southwestern Mexico. Mammals are represented by 45 species, eight of which are Mexican endemics, and one threatened. Endemic species include *Marmosa c. canescens, Rhogheessa alleni, R. gracilis, R. parvula major,* and the threatened *Choeronycteris mexicana*.

Research: Carillo (1996) studied the fish of the Río Amacuzac in an area bordering the reserve. Contreras MacBeath (1995) reported on the displacement of a native ciclid fish by an introduced exotic. Castro and Aranda (1984) mentioned some species from the area in their study of Morelos reptiles. Argote is preparing a distributional study of the birds of the Sierra de Huautla. Sánchez and Romero (1995) reported on mammals of the area.

Land Ownership: Primarily ejidal, with some private.

Management: Decreed in 1993 by the state. Management responsibilities are divided between the Secretaría de Desarrollo Ambiental (Department of Environmental Development), the town councils of Tlaquiltenango and Tepalcingo, and UAEM. Five core zones have been identified: Cañada Ajuchitlán (869 ha), Cerro Prieto (610 ha), El Limón (414 ha), Piedra Desbarrancada (3601 ha), and Río Amacuzac (2835 ha). Near the community of Huautla, UAEM has a research and environmental education facility.

Comments: Within the reserve, near Huautla, is a silver mine that in the past employed many local people. However, it has not been in operation for five years, and resulting unemployment has caused people to turn to the exploitation of forest resources through logging and the opening of new lands to ranching and agriculture.

POTENTIAL AREAS

Cerro Frío

Description: A proposed area of 2000 ha in the southern sierras having Cerro Frío (2300 m) as the main feature; it lies in southeastern Morelos in the municipality of Puente de Ixtla on the Guerrero border, with center at 18°27' N, 99°25' W. Tropical deciduous forest dominates lower elevations, giving way to oak forest above 1400 m. Depending on elevation, climate varies from hot to temperate, with mean annual temperature of 27° C and precipitation of 905 mm. Overall, the area is mountainous with deep barrancas.

Comments: This largely pristine area is an island of oak forest surrounded by tropical deciduous forest.

San Gaspar

Description: A mountainous area of 8375 ha rising from 1200 to 1780 m, it lies in central Morelos in the municipalities of Emilano Zapata, Jiutepec, and Tlaltizapán, centered at 18°46' N, 99°8' W. Tropical deciduous forest dominates, with dense patches of oak at higher part elevations. Mean annual temperature is 22° C, and annual mean precipitation is 918 mm.

Comments: This sierra serves as a corridor between the Transvolcanic Belt and the southern sierras. The region includes the Cañon de Lobos, an area well known to researchers for holding populations of such rare species as Pileated Flycatcher and Blue Seedeater.

Tetecala

Description: A proposed area of 3812 ha in western Morelos in the municipalities of Tetecala, Coatlán del Río, and Miacatlán, with center at 18°41' N, 99°22' W. Tetecala is an area of ridges and valleys at 1000-1200 m, dominated by tropical deciduous forest, with an adjacent pastured valley. The climate is warm subhumid, with annual mean temperature of 27° C, and annual mean precipitation of 905 mm.

Comments: This area is well-preserved despite its focus on grazing. Construction of numerous water tanks has contributed to maintaining a wide diversity of wildlife. Although frequently visited by hunters, the area has not been severely impacted.

ASSESSMENT OF CURENT SITUATION

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Chapter 10. PROTECTED AREAS OF GUERRERO - Griselda Escalona Segura and Adolfo G. Navarro Sigüenza

INTRODUCTION

Of all Mexican states, Guerrero has special importance because it is there, along the Pacific Slope, that many species having Neotropical affinities (e.g., Emerald Toucanet) reach northern distributional limits, and many Nearctic species extending south through mountainous regions reach their southernmost limit (e.g., Northern Goshawk). In addition, the state has great topographic variation and a corresponding diversity of discontinous habitats. As a result, it contains numerous areas rich in plant and animal endemism. The mix of Nearctic and Neotropical elements, coupled with high endemism, make Guerrero one of Mexico's biologically richest states (Flores Villela and Gerez 1988).

The importance of the state to biodiversity conservation is enormous. Although not well studied, what is known indicates that Guerrero has high species diversity, high endemism, and that it is used extensively by wintering migrants. For this reason, in this document, we present information on natural areas and bird diversity relevant to the conservation of birds in the state.

PHYSIOGRAPHIC OVERVIEW

Guerrero is located on the Pacific Coast of southern Mexico, between 16 and 19° N, and 98 and 102° W. To the northwest are Michoacán, Morelos, and Puebla, to the east is Oaxaca, and to the south lies the Pacific Ocean. Guerrero has a total surface area of 63,675 km², of which 500 ha are islands and islets (Figueroa de Contín 1980). Four physiographic regions are represented in the state, (1) Transvolcanic Belt, represented by the Sierra Norte, (2) the Balsas Basin, (3) the Sierra Madre del Sur, represented by a 360 km section of mountain range chiefly above 2000 m, and (4) the southern Pacific coastal plain, a 420 km strip constricted by the proximity of the Sierra Madre del Sur. Principal habitats include montane cloud, pine, pine-oak, and oak forest (28%), tropical semideciduous and deciduous forest (21%), subtropical scrub (6%), and agricultural and secondary growth (44%).

The highest points of the state are Cerro Teotepec (3507 m), Macizo de Tlacotepec (3198 m), Cerro Tejamanil (3189 m), Yahuitépetl Peak (3081 m), and San Pedro or Cerro El Baule (3036 m). Guerrero divides into two main watersheds: the interior Balsas Basin and the exterior Pacific Slope of the Sierra Madre del Sur. Guerrero has 36 important rivers, of which 23 flow into the interior basin and eventually to the Pacific Ocean, and 13 flow directly to the sea. The most important are the Río Balsas and the Río Grande de Atenango in the interior basin, and the Río Papagayo and the Río Grande de Tecuanapa in the exterior. Many streams and rivers disappear to flow underground, especially in the northern part of the state, and around Chilpancingo and Tixtla. In less permeable areas, gorges and rocky canyons are formed; those of Río Mexcala, the Media Luna, and the Balsas near Apaxtla and Zinrándaro are the most important.

Some interior lagoons of importance are Laguna de Tuxpan near Iguala, and Laguna de Tixtla, which drains underground. Several artificially created reservoirs also exist. In the northwest region near Cuajuinicuilapa several swampy areas are present, and coastal lagoons (Mitla, Tres Palos, San Valentín, Nuxco, Coyuca, and Chiautengo) are to be found on the littoral, some of which contain islands (Quije, Culebra, and Magueyes in Mitla; Caballos and Culebras in Coyuca; and Pájaros in Chiautengo).

PROTECTED AREAS

El Veladero National Park

Location: Inland from, and partly surrounding, the city of Acapulco, this area lies between the edge of the city and the first mountain ridge. Its center is at 16°54' N and 99°52' W, consisting of 3159 ha (Fig. 10.1).

Physiography: In the vicinity of Acapulco, the Sierra Madre del Sur reaches the ocean, with bays surrounded by precipitous cliffs, elevation 100▪900 m.

Climate: Sea level to 200 m is very hot subhumid, with temperatures of 26▪28°C and annual rainfall of 1000▪1200 mm; higher up, it is warm humid, with temperatures of 22▪24°C and annual rainfall of 1400▪1600 mm.

Habitat: Tropical deciduous, tropical semideciduous, and oak forest, in conjunction with 139 orchards, a 650 ha deforested portion being reforested with seeds and plants cultivated in the park (Márquez *et al.* 1984), and an inhabited portion holding 480 families. In all, 391 species of 94 plant families have been recorded, of which the families Leguminosae, Rubiaceae, Compositae, Euphorbiaceae, and Gramineae are notable for their outstanding richness.

Fauna: In the high parts (the best preserved areas) are found White-tailed Deer, Collared Peccary, squirrel, rabbit, Coatimundi, and Nine-banded Armadillo. Birds observed in the park include Citreolene Trogon, Orange-fronted Parakeet, Least Pygmy-owl, Golden-cheeked Woodpecker, San Blas Jay, Happy Wren, Rufous-backed Robin, Red-breasted Chat, Orange-breasted Bunting, and Black-chested Sparrow. Extirpation of the parrots in the park is imminent because they are trapped and sold. Reptiles include iguanas, *Sceloporus* lizards, rattlesnakes, boas, coral snakes, and whipsnakes (Márquez *et al.*1984).

Research: The only study from the park is the floristic work of Noriega Acosta (1990).

Land ownership: The park's creation necessitated relocation of human settlements in the area. Because many houses were constructed immediately prior to the park's decree, the Fideicomiso de Acapulco began relocating families to the new population center, Renacimiento. The process stopped short, however, with 930 families refusing to be relocated, and forming the Consejo General de Colonias Populares de Acapulco. Eventually, 314 families accepted relocation, but the rest remained in the park. As a result, the park boundary was modified, reducing the number of families in the park to 480, who still occupy the same land, although legally it belongs to the park.

Also within the park are 139 orchards whose relocation has caused their owners to apply for special compensation beyond that given for regular plots of land. Thus far, this situation has not been resolved. Presently, only 21% (741 ha) of the park has been paid for, at a value of $358,069,545 old pesos. Furthermore, legal boundaries do not correspond with the established physical boundaries.

Management: Decreed in 1980, El Veladero was established for pollution control and establishment of green forested areas. As a national park, it comes under the regulations of the General Law for Ecological Balance and Protection of the Environment, of the Ley Forestal. Four differently managed zones exist within the park: one addressing preservation of existing natural habitat, a second for the orchards, a third for the deforested area now undergoing reforestation, and a fourth for the inhabited portion.

Staff includes 116 SEDESOL workers, of whom 108 sign a new contract every three months, and the rest being permanent. A two story, 150 m² administration building with an office, small information area, storeroom, and staff bathroom has been constructed. Part of the park has a ceremonial area with a monument to José María Morelos y Pavón, paved pathways, well-kept gardens, and a 1 km dirt track. Six entrance gates are located at the points called Icacos, Hermenegildo Galeana, Francisco Villa, Palma Sola, El Mirador and Santa Cecilia, and signs indicate park boundaries. Foundations of some abandoned houses are being used as sites for reproducing trees for reforestation.

Comments: El Veladero is too small to meet international national park standards, so IUCN suggests it is more appropriately considered a state park (Flores Villela and Gerez 1994). Principal problems for the area are related to human settlements within the park, and continued attempts by new settlers to colonize. Fires often occur in areas used for crops, and uncontrolled tree felling, unsupervised extraction of rocks for construction, and poaching (mainly of parrots and iguanas) all propose challenges. Also, rocks with inscriptions of unknown historic significance are being stolen (Márquez *et al.* 1984).

The main value of the area is to maintain some natural habitat for Acapulco, which has grown sufficiently to have severe impact on the surrounding countryside. The city has apparently gained an awareness that successful tourism is aided considerably by intact natural landscapes. Protection of the surrounding tropical deciduous forest helps maintain the scenic surroundings of the amphitheater of Acapulco Bay for the recreation of both inhabitants and visitors.

Alexander von Humboldt National Park

Location: Also known as Cerro del Huizteco National Park, located approximately 4 km northeast of Taxco on the summit of Cerro del Huizteco at 18°36' N, and 99°36' W, consisting of 1080 ha.

Physiography: The park is located in the Sierra de Taxco, a southern branch of the Transvolcanic Belt. The summit of Cerro del Huizteco is at 2580 m, and the eastern escarpment is steep, falling 600 m in less than 2 km.

Climate: Warm subhumid with summer rains. Mean annual temperature is 18▪22°C, and annual rainfall is 1500▪2000 mm. Rainfall for the driest month is 40 mm.

Habitat: Pine forest, cloud forest, subtropical scrub, oak forest and pine-oak forest.

Fauna: Endemism is high for birds, butterflies, and mammals but not for reptiles, which are mainly of wide distribution (Morales and Navarro 1991, León and Romo 1993). Léon and Romo (1993), have discovered what may prove to be a new species of rodent (*Abromys*) in the area. Birds include Bumblebee Hummingbird, Blue Mockingbird, Rufous-capped Brushfinch, Green-striped Brushfinch, and Black-chested Sparrow.

Research: Historically, botanical studies were made by Abbott, Bravo, Lyonnet, Miranda, Paray, and Rzedowski. More recently, researchers with the Facultad de Ciencias of UNAM inventoried several taxonomic groups (Torres and Castelo 1986, Morales and Navarro 1991, León and Romo 1993).

Land ownership: A part of the highland area was donated by Sr. Francisco Moreno Torres to the government of Guerrero, and accepted as the Cerro del Huizteco Recreation Park.

Management: Decreed in 1936, and in spite of the gift of the highland area, this park's decree was later repealed because funds for the purchase were never made available (Vargas 1984). No administration or management exists. The park is equipped with playgrounds, gravel pathways, grills, and a pink stone monument called the "Temple of the Wind." Materials for the Church of Santa Prisca were extracted by the donor from this area; similar exploitation continues on a small scale.

Comments: Apparently, many of the ancient oaks which gained the admiration of Alexander Von Humboldt have long since been cut down. The inhabitants of Taxco have long used the forest in this region as a source of wood, and more recently for construction of country homes (Torres and Castelo 1986). The resulting

fragmentation of the forests in this region is serious. Cerro del Huizteco, though lacking protected legal status, has escaped some of this exploitation and remains an excellent example of Transvolcanic Belt forested habitat. Furthermore, it holds many Mexican endemic taxa not found elsewhere in Guerrero. More research on the flora and fauna is desperately needed. In the meantime, high priority should be given to protecting this park.

Grutas De Cacahuamilpa National Park

Location: This area is located north of the city of Taxco in the municipality of Tetipac, with center at 18°39' N, 99°30' W, consisting of 1600 ha.

Physiography: The park is located in the Transvolcanic Belt at 850▪1300 m, with irregular topography of steep gorges and waterfalls. The entrance to the caves is at 980 m.

Climate: Hot subhumid, with summer rains and annual temperatures of 18▪20°C.

Habitat: A type of tropical deciduous forest confined to limestone, known as "cuajiotal," so-called because the dominant trees are "cuajiotes" (*Bursera* sp.) (Bonet 1971). This forest has short trees (3▪4 m), with an open canopy and a dense shrub and vine understory. A dominant tree is *Pseudosmodingium perniciosum*, which has a strongly caustic resin.

Fauna: The caves are used by insects, other invertebrates, birds, and bats. No detailed information is available.

Research: Speleological and biospeleological research is the only work done to date (Hoffmann *et al.* 1986).

Land ownership: Federal.

Management: Decreed in 1936, the park has been administered under different agencies: the Ministerio de Fomento, the Instituto de Geología de México, the Secretaría de Economía Nacional, and Petróleos Mexicanos, during which time the Esplanade was constructed, where the administration building and the road that leads to Dos Bocas are located. In 1941, it came under the control of the Secretaría de Gobernación. Presently, it is administered by the Secretaría de Turismo, and, although decreed a national park, this administrative designation caused its exclusion from the Mexico's National Park System.

The Park is well-designed for tourism, with access from two highways, a large parking lot, hotel, swimming pool, restaurants, and concession. Guides are available for trips into the caves, and security services, tourist assistance, and electric lighting exists inside the grottos.

Comments: Lastra (1975) mentions that most of the surrounding area is disturbed, with only portions of the cave itself preserved in a natural state. A complete biological inventory is desirable before further perturbations occur, such as the Jurassic Park-style amusement park proposed in 1995 by a now-discredited Canadian entrepreneur. Given the high degree of disturbance, small size, and heavy tourism, the park should not be considered a priority area for biodiversity in general.

Juan N. Álvarez National Park

Location: Located northeast of the town of Chilapa, 30 km east of Chilpancingo, in a woody mountainous region known as "El Ocotal." It consists of 528 ha, and includes portions of the ejidos Xulchichio, Petatlán, and La Macintla.

Physiography: Barrancas and hills between the Sierra Madre del Sur and the upper reaches of the Balsas Basin, at 1300 m.

Climate: Semiarid subtropical, with summer rains.

Habitat: Oak forest, pine-oak forest, and pine forest in the best preserved portions. On the eastern side is a flat savanna-like area with grasses such as *Andropogon* sp., *Paspalum* sp., and *Trichachne* sp.

Fauna: Birds of the area include West Mexican Chachalaca, Banded Quail, Montezuma Quail, Red-billed Pigeon, Band-tailed Pigeon, Mourning Dove, White-winged Dove, White-tipped Dove, and Ruddy Quail-Dove. Some rare and endemic species, such as Pileated Flycatcher and Slaty Vireo, may also be present. Many mammals occur, including Mountain Lion and Collared Peccary.

Research: None.

Land ownership: Uncertain.

Management: Decreed in 1964, this park comes under the regulations of the General Law for Ecological Balance and Protection of the Environment of the Ley Forestal. However, no management or administration exists for the area. Its creation was based on political and economic criteria related to its location in the upper Río Atzacualoya watershed, a major tributary of the Río Balsas, where the Infiernillo Dam generates large amounts of electricity.

Comments: The probable presence of several rare and endemic species makes this a potentially very important reserve. Hence, a thorough biological inventory of the area is a high priority.

Cerro Teotepec National Park

Location: Cerro Teotepec is the highest mountain of the Sierra Madre del Sur, located east of Puerto El Gallo at 17°28' N, and 100°8' W. The park's extent is unknown.

Physiography: The area has extremely irregular topography, with many steep ravines and canyons dropping from the crest of the Sierra Madre del Sur at 3200 m towards the Pacific Ocean. It is rich in surface water, the largest being the Río Las Delicias, which crosses the area in a north-south direction and is fed by numerous streams, of which the rivers Golondrinas, Palmitas, and Teotepec stand out.

Climate: Temperate subhumid.

Habitat: Fir-pine, cloud, and pine-oak forest.

Fauna: The fauna of this area is diverse and rich in endemism. A large variety of mammals, as well as rare and endemic birds, including Singing Quail, Scaled Antpitta, and White-throated Jay. This area is one of the three known sites for White-fronted Swift (Navarro et al. 1992), one of two known sites for White-throated Jay and White-tailed Hummingbird, and it is the only locality for the endangered Short-crested Coquette (Navarro 1986, 1992). Other birds include Bumblebee Hummingbird, Pine Flycatcher, Aztec Thrush, Red Warbler, Rufous-capped Brushfinch, and Collared Towhee.

Research: Some ornithological (Navarro 1986, 1992, Navarro et al. 1992) and herpetological collecting has been done in the area; but no formal research has been done in the park.

Land ownership: Situation unknown.

Management: Lacking a formal decree date, this park exists on paper only, and no management or administration exists. Although included on the list of areas where bird hunting is forbidden, it is not accorded any official status.

Comments: This part of the Sierra Madre del Sur is one of few that hold well-preserved fir forests. However, forest exploitation and agricultural activities are causing extensive damage, and vegetation structure has already been dramatically altered in some areas (Navarro 1986). The importance of protection for this area cannot be stressed too highly. It is rich in biological diversity, and serves as the type locality for a great number of endemic taxa.

Omiltemi Ecological State Park

Location: 15 km west of Chilpancingo, with center at 17°33' N, 99°41' W, consisting of 3613 ha.

Physiography: Omiltemi is located on the crest of the Sierra Madre del Sur, at 1800▪2800 m. Its topography is complex and rugged, with steep gorges and barrancas.

Climate: Temperate subhumid, with mean temperature of 12▪18°C. Coldest monthly temperature is ▪3▪18°C, and warmest is 7▪22°C. Annual precipitation is 1247 mm.

Habitat: Pine, cloud, pine-oak, and oak forest (including humid oak forest), with some dry scrub elements. Thus far, 595 species of vascular plants from 102 families have been identified, and estimates for the entire flora approach 700 species; twelve plant genera endemic or quasiendemic to Mexico are found in Omiltemi (R. Jiménez *et al*. 1993). Studies of the orchids of Omiltemi indicate that this family constitutes a fifth of the total flora for the area, with 103 species of 41 genera. Several plant species recorded here were new to science, such as *Lephantes hagsateri* and *Trichosalinx nageliana*; others, such as *Corallorrhiza* sp., *Cyclopogon* sp. and *Lephantes* spp., await description (Salazar 1993).

Fauna: Thus far, 161 butterfly species have been identified. The herpetofauna includes five families, seven genera, and ten species. Though not very diverse, it is highly endemic at the specific and subspecific levels: among amphibians, 50% of the species are Mexican endemics (Flores Villela and Muñoz 1993). A. Jiménez *et al*. (1993) reported 54 mammal species, for eight of which Omiltemi is the type locality. The avifauna of the region includes 160 species, of which 28 (22%) are migrants or winter residents; 20 forms are endemic to the Sierra Madre del Sur of Guerrero and Oaxaca (Navarro and Escalante 1993). Bird species include: Long-tailed Wood-Partridge, Singing Quail, Banded Quail, White-faced Quail-Dove, Military Macaw, Dusky Hummingbird, White-tailed Hummingbird, Pine Flycatcher, White-throated Jay, Boucard's Wren, Aztec Thrush, Blue Mockingbird, Red-headed Tanager, Rufous-capped Brushfinch, and White-throated Towhee. Faunal information is summarized in Luna Vega and Llorente Bousquets (1993).

Research: Scientific studies have been carried out in the region for many years, beginning with collectors associated with Salvin and Godman in the nineteenth century. A major contribution was that of Luna Vega and Llorente Bousquets (1993), a book summarizing the knowledge of the biology of the area.

Land ownership: The land belongs to the state of Guerrero.

Management: Two applications for official protected status were made in 1966 by the community of Amojileca and by the then-Governor of the state, but no official decree has yet been granted. Consequently, the park is still only proposed, and no formal administration or management exists.

Comments: This park is one of the few regions of the country where the population no longer causes deterioration of natural habitats, because the population is small and getting smaller, as people move to areas where it is easier to subsist. Agricultural activities, ranching, and wood cutting are scarce, and, for the present, not done inside the Park. Formerly, this zone was important for wood production, although exploitation caused deforestation, soil degradation, and erosion (León and Luna Vega 1993).

Omiltemi has great economic and biological significance. Its economic importance derives from being a water source for Chilpancingo, which was the main reason for its being proposed. Its biological relevance comes from its being the most important historical locality in the Sierra Madre del Sur. As a result, many taxa of animals and plants endemic to the region were first described here (Navarro and Muñoz 1990). The biological richness and uniqueness of Omiltemi is exceptional, and it is one of the best preserved areas in Guerrero.

City of Taxco Forest Protection Area

Location: An area of 23,000 ha surrounding Taxco, located at 16°56' N, 99°53' W, including land belonging to the towns of San Pedro Chichila and San Juan Tenería.

Physiography: The city is surrounded by mountains (1500▪2000 m) constituting a southern spur of the Transvolcanic Belt, and including the barrancas La Trinidad, Cantarranas, El Chorrillo, Casallas, and El Salto, where waterfalls are present.

Climate: Warm, with mean annual temperature of 22° C, and rainfall of 1418 mm.

Habitat: Tropical deciduous forest below Taxco, and, to a lesser degree, cloud forest in the mountains of Atachi and Huizteco. Close to the city are patches of montane pine forest.

Fauna: Mammals include Coyotes, foxes, skunks, Bobcats, Long-tailed Weasels, Nine-banded Armadillos, Racoons, rabbits, hares, Virginia Opossums, Badgers, and White-tailed Deer. Birds include Bumblebee Hummingbird, Red Warbler, Rufous-capped Brushfinch, and Black-chested Sparrow.

Research: None.

Land ownership: Federal property.

Management: Decreed in 1936, but no formal administration or management program exists.

Comments: Since 1928, Taxco has preserved its traditional character by forbidding modern buildings, and the town and its surroundings are considered among the most picturesque in Mexico. Nevertheless, the area has been an important source for mineral resources since 1529, and extensive logging activity has gone on for centuries. These activities, coupled with present tourist activity, have spoiled much of the area's natural richness, and the flora and fauna have been seriously affected. Therefore, considering the vicinity of Taxco as a forest protection area is probably not very appropriate, because extensive disturbance by people is almost

inevitable.

Port of Acapulco Forest Protection Area

Location: An 80,000 ha area of low mountains (0▪900 m) surrounding the port of Acapulco.

Physiography: In the vicinity of Acapulco, where the Sierra Madre del Sur reaches the ocean, with bays surrounded by precipitous cliffs.

Climate: Sea level to 200 m, very hot subhumid, with temperatures of 26▪28°C and annual rainfall of 1000▪1200 mm; at higher elevations, warm humid, with temperatures of 22▪24°C and annual rainfall of 1400▪1600 mm.

Habitat: Tropical deciduous, tropical semideciduous, and oak forest.

Fauna: In the high parts, such mammals as White-tailed Deer, Collared Peccary, squirrel, rabbit, Coatimundi, and Nine-banded Armadillo are found. Birds include American Kestrel, Orange-fronted Parakeet, Least Pygmy-owl, Golden-cheeked Woodpecker, and White-throated Magpie-Jay. Reptiles include iguanas, *Sceloporus* lizards, rattlesnakes, boas, coral snakes, and whipsnakes (Márquez *et al.*1984).

Research: No formal study has been conducted in this area.

Land ownership: Federal property.

Management: Decreed in 1937, no administration or management plan exists.

Comments: Principal problems for this area are related to the proximity of Acapulco. People use the land extensively without official approval or monitoring, and human-caused disturbance is ubiquitous. Fires often occur in areas used for crops, and uncontrolled logging and poaching are common.

This area was given protected status to assist with pollution control and to maintain a scenic amphitheater behind Acapulco Bay for inhabitants and visitors. It was not created with any idea of conserving natural habitat. Because of high risk of urban disturbance, this area should not be considered a high priority for conservation. However, a biological inventory of the area is desirable to understand better its true conservation value.

Chilpancingo De Los Bravos Forest Protection Area

Location: An area of 80,000 ha surrounding the city of Chilpancingo de los Bravos.

Physiography: This area consists of a large valley cutting across the Sierra Madre del Sur (700▪2700 m).

Climate: Temperate semihumid; driest months are March, April, and May.

Habitat: Pine-oak forest, with some patches of tropical deciduous forest. No complete flora has been developed for this locality.

Fauna: This locality is well known for specimens collected here, now deposited in museum collections

throughout the world. Its richness in vertebrate species and unique forms ranks among the highest for all of Mexico. Birds present include West Mexican Chachalaca, Long-tailed Wood-Partridge, Buff-collared Nightjar, Dusky Hummingbird, Green-fronted Hummingbird, White-tailed Hummingbird, Beautiful Hummingbird, Pileated Flycatcher, Boucard's Wren, Happy Wren, Rufous-backed Robin, Aztec Thrush, Golden Vireo, Red-headed Tanager, Rufous-capped Brushfinch, Rusty-crowned Ground-Sparrow, and Black-chested Sparrow.

Research: None.

Land ownership: Federal.

Management: Decreed in 1938, with undetermined management status.

Comments: Most bird studies in Guerrero have been carried out in the highlands near Chilpancingo. This area includes the last forest patches in the vicinity of Chilpancingo; more importantly, this area is one of the richest for endemism in Guerrero. Its preservation is crucial, and a conservation plan for the region is urgently needed.

La Calera Reservoir Forest Protection Area

Location: An area of 250,000 ha located 40 km from Ciudad Altamirano on Río El Oro (26°18' N and 100°59' W), and 10 km from where it joins the Río Balsas, near the town of Zirándaro.

Physiography: The reservoir is located in the middle part of the Balsas Basin at 300 m.

Climate: Hot subhumid, with mean annual temperature of 30° C, and annual rainfall of 947 mm.

Habitat: Tropical deciduous forest, thorn scrub, and some agricultural lands.

Fauna: In the river are turtles (*Pseudemis palustris*) and fish (mostly introduced) such as rainbow trout (*Salmo gairdensis*), river catfish (*Istlarius balsanus*), hotland trout (*Agnostomus monticola*), black bass (*Micropterus salmonoides*), "gobia" (*Guillichthys mirabilis*), fresh water mojarra (*Petenia splendida*), "puyeque" (*Awous talacha*) and "charal" (*Chiristonia splendida*) (Nava 1982). No avifaunal studies have been done, except for some scattered collecting. Known birds include Golden-cheeked Woodpecker, Banded Wren, Rufous-backed Robin, and Yellow-winged Cacique.

Research: No biological studies have been conducted in the area. Nava (1982) assessed the area for an irrigation system for the dam, compiling some faunistic information.

Land ownership: The area is federal property. However, the area is not properly legalized because the regularization of land ownership has not been completed.

Management: Decreed in 1942, no management or administration plan exists.

Comments: Some agricultural land is found in the surroundings, mainly planted in garlic, sesame seed, beans, corn, avocado, limes, mangoes, bananas, and tamarind. Cattle, pigs, goats, horses, mules, chickens, turkeys, ducks, and geese are also raised. Agricultural methods are mostly seasonal (Nava 1982). The reservoir exists primarily as a source of water for the agricultural fields and other human uses. A biological inventory is needed to assess the status of the natural resources of the area, and to determine need for conservation action.

Laguna de Tuxpan Reservoir Forest Protection Area

Location: An area of 10,000 ha immediately east of Iguala, at 18°19' N and 99°27' W.

Physiography: The reservoir lies at the transition between the Transvolcanic Belt and the upper Balsas Basin (730 m).

Climate: Hot subhumid.

Habitat: Secondary vegetation.

Fauna: Little information exists on the fauna of the area. Some bird specimens have been collected in the vicinity.

Research: None.

Land ownership: Federal property.

Management: Decreed in 1942, neither administration nor management plan exists. The area is not recognized under any IUCN designation.

Comments: Owing to the relative closeness to Iguala la Independencia, this area is subject to human disturbance. Most of its birds are likely to be associated with secondary vegetation, such as Groove-billed Ani, Blue-black Grassquit, Great-tailed Grackle, etc. Inventories are needed to determine the area's value to the preservation of the ecosystems and biodiversity of Guerrero.

Valerio Trujano Reservoir Forest Protection Area

Location: An area of 45,000 ha approximately 10 km southeast of Iguala la Independencia, and 1 km upstream from the village of Tepecoacuilco, at 18°19' N, 99°27' W.

Physiography: This reservoir is located in the transition between the Transvolcanic Belt and the upper Balsas Basin. The basin above the dam encompasses 40,900 ha.

Climate: Hot subhumid. Temperatures range 25▪32°C.

Habitat: Tropical deciduous forest and woody scrub. No floristic inventory exists for the region.

Fauna: Among the common mammals that inhabit this region are Nine-banded Armadillos, rabbits, Coyotes, White-tailed Deer, Racoons, and Opossums.

Research: None.

Land ownership: Federal.

Management: Decreed in 1942, no administration exists, and the land management plan is uncertain.

Comments: Available information regarding local natural resources is so scant as to make impossible determination of the conservation value of the area. Therefore, the first step in deciding if this locality is of importance or not is to conduct a general biological inventory. The creation of the reservoir has been a significant disturbance factor and has resulted in increased agriculture and cattle-raising.

Vicente Guerrero Reservoir Forest Protection Area

Location: An area of 80,000 ha on the Río Poliutla, about 35 km upstream from its confluence with the Río Balsas and 8 km northeast of Arcelia; center at approximately 18°25' N, 100°15' W.

Physiography: Located at 500 m in the upper Balsas Basin in an earthquake-prone region. The basin above the dam encompasses 157,600 ha, with a maximum depth of 50 m.

Climate: Subhumid hot, with temperatures of 24▪32°C.

Habitat: Tropical deciduous forest, with grassland and scrub forest.

Fauna: The fish of the reservoir have commercial value, principally two native species of mojarra (*Cichlasoma* sp.). A species of the genus *Tilapia* has also been introduced (Vera 1976).

Research: Personnel of the Centro de Ciencias del Mar y Limnología and the Facultad de Ciencias, UNAM, have carried out physicochemical and fish productivity studies (Vera 1976).

Land ownership: Federal property.

Management: Decreed in 1993, no management plan or administration exists.

Comments: This reservoir was created to increase the availability of water in the region (Vera 1976). An active fishing industry, as well as some agriculture and ranching exists in the region. The area is intensively affected by human activies and is probably a low conservation priority.

Piedra De Tlacoyunque Beach Natural Reserve Area

Location: Located west of San Luis de la Loma, an area of 1190 ha, approximately 160 km west of Acapulco in the municipality of Tecpán, at 17°16' N, 101°7' W.

Physiography: This beach lies on the portion of the Pacific coastal plain known as the Costa Grande.

Climate: Subhumid hot, with average annual temperature of 27°C. Hottest months are April and May, with temperatures reaching 40°C. During the cold season (December and January) temperatures reach as low as 17°C.

Habitat: Tropical deciduous forest, with patches of mangrove. No floristic list exists for the area.

Fauna: This beach is one of the most important sea turtle nesting sites in the country. Collared Peccary, Ocelot, Bobcat, and Jaguar are also found here.

Research: None.

Land ownership: Federal property.

Management: Decreed in 1986. In the national framework, this locality falls within the categories of SINAP, and the IUCN considers it a managed natural reserve (Flores Villela and Gerez 1988). Neither administration nor managment plan exists, but military vigilance is present during the sea turtle reproductive period, which has helped to preserve the area's pristine condition.

Comments: This beach is one of the few well-preserved areas on the coast of Guerrero. It could represent an important sanctuary, not only for sea turtles, but also for aquatic birds and tropical mammals. It definititely should rank among the higher priority conservation areas for Guerrero.

Tierra Colorada Beach Natural Reserve Area

Location: An area of 2700 ha in the southeast corner of the state, in the region known as Costa Chica; center at 16°28' N, 98°24' W.

Physiography: Most of the region is flat, coastal plain.

Climate: Subhumid hot; maximum temperature is 34°C (April and May); minimum temperature is 19°C (December and January).

Habitat: Coastal dunes, tropical deciduous forest, and mangroves. No floristic list exists for the region.

Fauna: No formal studies exist; however, some birds recorded are Snowy Egret, American Oystercatcher, Semipalmated Plover, Yellow-crowned Night-Heron, Social Flycatcher, and Brown-crested Flycatcher.

Research: None.

Land ownership: Unknown.

Management: Decreed in 1986, but no administration exists, and it is unknown if a management plan exists. IUCN (1985) considers the area a managed natural reserve.

Comments: Tierra Colorada is the only coastal area in Guerrero relatively far from the coastal highway, making it possibly the least disturbed beach in the state. The variety of habitats suggests that it may be the most biologically diverse beach in the state; however, no detailed information is available.

Cañon del Zopilote Biosphere Reserve

Location: Between Chilpancingo to the south, the Río Balsas to the north, the Río Xochipala to the west, and the Tianguistengo, Bordo Alto, and Xomizlo mountains to the east, this area covers 100,000 ha. It includes the valley of Zumpango, all of Zopilote Canyon and Río Tepecualcuilco Canyon, with center at 17°46' N, 99°39' W.

Physiography: Zopilote Canyon is a semiarid areas in the Balsas Basin. The reserve extends from 2750 m in the Sierra Madre del Sur, dropping abruptly in steep barrancas to 500 m at the Río Balsas. Major river valleys included in the area include the ríos Zopilote, Chichihualco, Xochipala, and Coloapa.

Climate: Very hot and dry, subhumid hot, and subhumid warm, depending on elevation.

Habitat: Pine forest, oak forest, montane cloud forest, tropical deciduous forest, *Brachea* palm groves, and gallery forest (Lozano and Arias 1980). This canyon is considered a center of floristic diversity with a particularly high concentration of cactus species, including *Cephalocereus guerreronis*, *Coryphanta bumama*, *Hylocereus hundatus*, and *Mammillaria guerreronis* (Groombridge, 1992). Dominant species are *Pachycereus weberi* and *Neobyxbaumia mezcalensis*, columnar cacti that characterize distinct associations of tropical deciduous forest where they are exclusively present (Blanco and Castañeda 1983).

Fauna: Studies of rodents and bats have detected 9 and 17 species, respectively (Lozano and Arias 1980). Birds include West Mexican Chachalaca, Green-fronted Hummingbird, Golden-cheeked Woodpecker, Gray-breasted Woodpecker, Gray-crowned Woodpecker, Pileated Flycatcher, Boucard's Wren, Happy Wren, Blue Mockingbird, Golden Vireo, Red-headed Tanager, and Black-chested Sparrow.

Research: Research conducted in this area has been primarily botanical (Blanco and Castañeda 1983), with several theses conducted by students of the Herbarium of the Facultad de Ciencias, UNAM. For fauna, Floyd (1962) and Winkelmann (1962) documented records of Northern Yellow Bat and Trumpet-nosed Bat. Ramírez Pulido (1975) studied material regurgitated by owls from the caves of Zopilote Canyon, by means of which he analyzed the ecology of some rodent species. The most recent work from the area is the terrestrial vertebrate study of Lozano and Arias (1980).

Land ownership: Unknown.

Management: Proposed as a protected area in 1994.

Comments: In the valley, corn, tomatoes, loofahs, and chiles are cultivated, surrounded on nearby slopes by the natural vegetation described above. The area has special ecological relevance because of the number of Nearctic species reaching southern limits and Neotropical species reaching northern limits. The area provides a meeting point for several distinct faunas, and has many endemic species and subspecies (Lozano and Arias 1980).

Papalutla Biosphere Reserve

Location: Along the Río Balsas, or Papalutla, in northeastern Guerrero near the Puebla border, at 18°0' N, 98°52' W, of undetermined size.

Physiography: Papalutla lies in the upper Balsas Basin, and has an irregular terrain with an extensive system of barrancas. In this region, the Río Balsas is known as the Papalutla; it divides the reserve in half. The slope north of the river is markedly steeper than that to the south (600-1500 m rise) and is characterized by five barrancas up to 5 km long. On the less steep southern slope, three barrancas are present, with lower parts located close to the town of Papalutla. The highest peaks around Papalutla are Cerro Tepepixatle (1840 m), Cerro Tlalixtlapan (960 m), the southeastern part of Cerro Amate Amarillo (1680 m), and the southern part of Cerro Las Trojes (approximately 1000 m).

Climate: Dry and hot, with maximum mean temperature of 28°C in May, and minimum of 23°C in January. Heaviest rains come in September (170 mm) and July (178 mm).

Habitat: Tropical deciduous forest, tropical semideciduous forest, gallery forest, and oak forest (Martínez and Valencia 1992). For plants, 369 species, 254 genera and 84 families are reported for the area, the principal families being Legiminosae, Compositae, Burseraceae, Euphorbiaceae, and Gramineae (Martínez and Valencia 1992).

Fauna: No birds have been listed for this area; however, given habitat and location, the presence of such rare endemic species as Eared Poorwill, Pileated Flycatcher, and Slaty Vireo is anticipated.

Research: The only research done concerns the flora (Martínez and Valencia 1992).

Land ownership: Unknown.

Managment: Proposed in 1994, neither management nor administration exists.

Comments: A biological inventory is urgently needed to determine the importance of this reserve to the conservation of Guerrero's habitats.

POTENTIAL AREAS

Alcozacuca

Description: This mountainous region of pine-oak forest is located in eastern Guerrero, 25 km southeast of Tlapa on the border with Oaxaca (Fig. 10.2). The center is at 17°28' N, 98°23' W, at approximately 1200 m, at the interface of the upper Balsas Basin and the Sierra Madre del Sur as they begin to grade into the Oaxaca interior highlands (Sierra Mixteca). Topography is extremely rugged with great geomorphological and ecological diversity. Annual average temperature is 11°C and annual rainfall is 846 mm. The land is owned communally.

Mammals known from this region include Coyotes, rabbits, Bobcats, and Ocelots. Birds likely for this area include West Mexican Chachalaca, Golden-browed Warbler, Blue-hooded Euphonia, and Rufous-capped Brushfinch. Overall, the fauna remains largely unknown.

Comments: In much of Guerrero, the principal agent of habitat deterioration is soil erosion. Hence, many agencies have conducted studies on how natural resource use should be modified to avoid environmental degradation. Results have emphasized improvement of living conditions for local people. However, most of the agricultural policies lack not only continuity, but often indicate poor understanding of biological processes (Landa 1989). At present, a research-production project entitled "Use and Management of Renewable Natural Resources in the Mountainous Region of Guerrero," is being carried out. This effort was initiated in 1983 as a multidisciplinary program of the Facultad de Ciencias, UNAM, and the government of Guerrero (Carabias *et al*. 1994).

No ornithological studies have been conducted in this area, so inventories are urgently needed to determine the area's value to conservation. Furthermore, although the region holds many people, they are interested in the idea of conservation, and an integrated plan of conservation, such as that already begun, could greatly assist forest preservation in many areas.

Mitla Coastal Lagoon

Description: The Mitla Lagoon is in a narrow portion of the Pacific coastal plain, approximately 30 km northwest of Acapulco, at 17°4' N, 100°20' W. It is about 25 km long, separated from the Pacific Ocean by a sandy barrier formed by historical coastlines and series of dunes. It has a surface area of 3600 ha, and average depth of 3 m (Contreras 1985). Three islands (Quije, Culebras, and Magueyes) are found in this lagoon. Habitats around the lagoon are primarily mangrove and tule, as well as coconut palms and fruit trees. Important fish families are the Clupeidae, Ariidae, Garridae, Eleotridae, and some Peocilidae (Contreras 1985), with 13 species recorded (Yáñez Arancibia 1978).

Comments: Aquatic habitats are poorly known ornithologically, and remain unrepresented in the present protected areas system of Guerrero. The area around this lagoon has not been studied by scientists, but rare and endemic animal species may inhabit the mangroves and tule. The area merits scientific study to assess its potential importance as a protected area.

Potosí and El Tular Coastal Lagoons

Description: Laguna Potosí covers 450 ha, 18 km southeast of Zihuatanejo, at 17°35' N, 104°30' W; Laguna El Tular covers 100 ha, 25 km southeast of Petatlán. Fish of 88 species have been recorded from Laguna Potosí, from families including Cichlidae, Poecillidae, Gobiidae and Elotridae (Yáñez Arancibia 1978). The avifauna of the two mangrove-surrounded lagoons is very similar, with 54 species recorded in preliminary surveys (Navarro and Peterson unpublished), of which 48 were new records for the west coast of Guerrero, indicating how little is known of the birds of Guerrero. The only previous information on birds is an incomplete list provided by Gaviño *et al.* (1979), and some specimens deposited in the Instituto de Biología, UNAM, and the Western Foundation of Vertebrate Zoology.

Comments: Although few studies have focused on the plants and animals of these lagoons, the 88 fish species in Potosí make it impressively rich ichthyofaunistically (Yáñez Arancibia 1978). Habitats remain largely intact, so these lagoons merit time spent in detailed biotic inventory.

Tres Palos (Nahuala) Coastal Lagoon

Description: This 6100 ha lagoon and surrounding mangroves are located on the Costa Chica of Guerrero, 25 km southwest of Acapulco, at 16°48' N, 99°43' W, between the Papagayo and La Sabana rivers. Starting at the eastern end of the lagoon, a meandering channel winds 10 km toward the Pacific Ocean. However, final communication with the sea is blocked by a sand bank for all but a few days each year. The Río La Sabana flows into the north end of the lagoon, although during the dry season it contibutes minimal water. Subplankton present include protozoa, ciliates, sarcodinae, heliozoa, Rotipherae, Crustaceae, Copepodae, Nauplius, Mysis and Anelidae, Nematodae, molluscs (bivalves and veligers), and coelenterate and fish larva.

The little work conducted in this area has been focused on fish. Ramírez Granados (1952), working for the Comisión de la Pisicultura Rural, did a preliminary ecological study of Laguna Tres Palos and Coyuca, presenting an avifaunal list with analyses of the stomach contents of some species. Additional work was related to establishment of a fishery program.

In 1970, SEMARINA and the Departamento de Turismo created a program to fill Laguna Tres Palos with salt water for cultivation of seafood and widening of the Acapulco's tourist area along the perimeter of the lagoon. The Dirección General de Fuentes de Abastecimiento of SARH (1971▪1972), foreseeing possible negative consequences, conducted a geohydrological study in the area of Tres Palos▪La Sabana focused on

tourist development. In the 1970's, an agreement was signed between the Comisión del Río Balsas of SARH and the Centro de Ciencias del Mar y Limnnología (today Instituto de Ciencias del Mar y Limnología) of UNAM. From that agreement came studies on the area's geology (Gutiérrez and Carranza unpublished) and ecology (Yáñez Arancibia 1978).

Comments: The presence of tule marshes and mangroves in this area may provide good habitat for rare and endemic species, although fishery and tourism development may be lessening that possibility. Careful surveys are urgently needed in order to determine the lagoon's importance to conservation.

Lower Reaches of the Sierra De Atoyac

Description: The Sierra de Atoyac is an arm of the Sierra Madre del Sur northwest of Acapulco, at 17°25' N, 100°15' W. The most important rivers are the Santiago and the Imperial, which flow into the Grande. The climate is hot, subhumid, influenced for the most part by the climatic systems of the Pacific Ocean (Navarro 1992). The region has been disturbed by nearby human populations, but elements of montane rain forest and tropical semideciduous forest persist in gorges. In the Sierra de Atoyac, 161 bird species are known to occur, of which 31% are Neotropical migrants. Altitudinal distributions of bird and mammal species are closely related to vegetation types (Navarro 1986, 1992, Juárez 1992). Initial butterfly surveys have identified 475 species for the area with five percent endemism (Vargas *et al.*1991, Andrew Warren pers. comm.).

Comments: The tropical semideciduous forest on the coastal slope contains the only known population of Short-crested Coquette (Ornelas 1987, Banks 1990), and probably the only viable populations of White-throated Jay, and White-tailed Hummingbird. Therefore, protection of viable examples of these habitats is critical to avoiding extinction of three species. It also holds the greatest avian diversity for the region of the Sierra de Atoyac (Navarro 1986, 1992, Peterson *et al* 1993). Other bird species present include Long-tailed Wood-Partridge, White-faced Quail-Dove, Yellow-headed Parrot, Bumblebee Hummingbird, Smoky-brown Woodpecker, Gray-crowned Woodpecker, Sinaloa Wren, Happy Wren, Rufous-backed Robin, Golden Vireo, and Red Warbler.

Agua De Obispo and Acahuizotla

Description: These areas lie 2▪3 km southwest of Acahuizotla, 38 km south of Chilpancingo, at 17°20' N, 99°30' W, on the Pacific Slope of the Sierra Madre del Sur, above the valley of the Río Acahuizotla, which later becomes the Chapalapa. The climate is hot subhumid. Principal habitats are tropical deciduous forest, tropical semideciduous forest, coniferous forest, oak forest and pastureland. These localities represent some of the richest areas for birds in Guerrero, holding approximately 27 Mexican endemic bird species. Dixon and Davis (1958) listed seven bird records new for Guerrero from the area. Among the birds present are Eared Poorwill, Buff-collared Nightjar, Flamulated Flycatcher, and Happy Wren. The herbarium of the Facultad de Ciencias, UNAM, is preparing flora lists for the region. Already, some important plant species have been found, such as *Peltogyne mexicana*, an endemic to the region.

Comments: The avifauna of Acahuizotla and Agua de Obispo is among the best-known for the state, thanks mainly to a professional collector who has collected bird specimens there for almost 40 years. Many forms are known in Guerrero only from this region (e.g., Great Swallow-tailed Swift) and several endemic forms of the Sierra Madre del Sur region are present.

ASSESSMENT OF CURRENT SITUATION

The protected areas of Guerrero were created primarily because of the importance of natural areas for mining, watershed protection, forestry, or tourism. Areas such as the reservoirs behind hydroelectric dams were protected only because they represent sources of water for electrical production or the needs of people in large cities. Herein, we have presented the information available for each protected area to assess its importance in the conservation of biodiversity. Unfortunately, the completeness and consistency of data available vary considerably. Worse still, for some areas, no biological information exists. However, some interesting aspects can be discussed:

Endemic species: Guerrero holds 48 bird species strictly endemic to Mexico, and one species endemic to the state. Guerrero and Oaxaca encompass almost the entire Sierra Madre del Sur physiographic region, and together hold 34 endemic bird species. More than 50% of bird species endemic to southwestern Mexico are represented in but three localities: Omiltemi Ecological State Park, the mountains near Chilpancingo, and Acahuizotla. Similar patterns of endemism exist in mammals, reptiles, and amphibians (Peterson *et al.* 1993).

We strongly urge that these three areas should be given high priority for protection. However, some important additional habitats remain unrepresented. For example, neither mangrove nor tule marsh habitats are included in the present reserve system. Furthermore, the one bird species unique to Guerrero is the Short-crested Coquette, which is known only from the area around San Vicente de Benítez (17°18' N, 100°16' W), in the lower portion of the Sierra de Atoyac, an area not presently included among the protected areas of Guerrero.

Species richness: No complete analysis of geographic patterns of species richness can be done for the state without additional information (Peterson *et al.* 1993). Almost all information regarding Guerrero's birds comes from localities close to federal highways 95 and 200. General surveys are badly needed for distant localities, in particular in arid areas of the Sierra Madre del Sur. Remote sensing data may help to complete the picture for these isolated areas.

Degree of conservation: Most areas have been affected by humans, and long-term preservation is impossible without development of an effective protection system. Specific needs range from knowing what species occur in an area to providing local managers with vehicles and technical assistance (Table 10.1). Few really well-preserved areas remain in the state: Piedra de Tlacoyunque Beach, Omiltemi, Cañón del Zopilote, and some areas in the Sierra Madre del Sur, including the Sierra de Atoyac. Most other areas hold only small fragments of forest.

Representativeness of habitats: Fourteen major vegetation types are found in Guerrero; of these, the current protected areas system includes 10. We suggest inclusion of the remaining four types of vegetation (mangrove, savanna, halophilus vegetation, and freshwater vegetation, including tule marsh). The best means to this end would be to preserve Playa Piedra de Tlacoyunque, Laguna de Tres Palos, and/or Laguna de Mitla. Because protected areas in lowlands generally are under greater human pressure, we suggest this triple coverage to preserve more lowland vegetation.

Synthesis: Protected and potential areas can be ranked on the basis of the presence of endemic bird species because these species are those most vulnerable to extinction, and because correspondence of patterns among taxonomic groups is high (Ramamoorthy *et al.* 1993, Peterson *et al.* 1993). We prioritized areas using avian endemism at three different scales: (1) within Guerrero, (2) within southwestern Mexico, and (3) within Mexico. Cumulative numbers of endemics at each scale were tallied for 14 protected and potential areas across the state, and complementarity among reserves maximized for the first criterion; when the first criterion was equivocal, we continued to the second, and then to the third. In this way, a system maximally complementary

on the three endemism scales was constructed.

The criterion of species strictly endemic to Guerrero indicates (1) the Sierra de Atoyac and lower slopes (the only known locality for the Short-crested Coquette) as the first locality to protect. This first criterion then becomes inoperative, as the state holds no other endemic bird species. Under the second criterion, (endemism in southwestern Mexico), the mountains around Chilpancingo added more southwestern endemic species than any other area (nine), followed by Omiltemi and El Veladero which each added one southwestern endemic. However, the choice between the two is clear under the third criterion (endemism in Mexico), because Omiltemi holds more Mexican endemics than El Veladero. Overall, six localities could be chosen using these criteria, and were prioritized as follows: (1) Atoyac and lower slopes, (2) Chilpancingo, (3) Omiltemi, (4) El Veladero, (5) Cerro Teotepec, and (6) Acahuizotla. Cañón del Zopilote adds one more Mexico endemic and we would suggest it as a seventh area (Table 10.2). This seven-reserve system would therefore include the only species endemic to the state, 59% of the endemics of southwestern Mexico, and 32% of all Mexican endemics that are found in the state.

Five southwestern Mexican endemic species—Balsas Screech-Owl, Spotted Wren, Ocellated Thrasher, Slaty Vireo, and Dwarf Vireo—are not known to occur either in Guerrero's protected areas or in those herein proposed. However, because information is so poor, these species could be present but not yet detected, or could be absent, so inclusion of additional areas should be considered. These species occur in such habitats as mesquite, tropical deciduous forest, oak scrub, and pine-oak woodland, having in common a preference for dry habitats, which remain generally unstudied.

Three of the above five endemics were found by Morales and Navarro (1991) in the vicinity of Taxco in the northern portion of the state: Spotted Wren (km 26.5 Taxco–Ixcateopan Highway, 18°31' N and 99°47' W), Ocellated Thrasher (Los Jarillos, 6 km south of Zacualpan, 18°39' N, 99°47' W), and Slaty Vireo (Arroyo de las Damas, km 19 Taxco–Tetipac Highway, 18°42 N, 99°39' W). Unfortunately, these localities hold only small fragments of intact forest. Marshall (1967) noted the occurrence of the Balsas Screech-Owl in the lower Río Balsas drainage in Guerrero in tropical deciduous forest with giant cardón cacti. Dwarf Vireo is also found in the Río Balsas drainage in semiarid scrub and oak forest, and may eventually be found along the interior slopes of the Sierra Madre del Sur. Hence, a program of careful inventories will be necessary for final establishment of priorities.

A large-scale approach to conservation in Guerrero, including three major physiographic regions, could be implemented with a system of protected areas starting in the central portion of the state with the Cañón del Zopilote. This region could be connected to the mountains around Chilpancingo, and to Omiltemi; then a set of localities could be chosen to reach the forested areas of Cerro Teotepec, Sierra de Atoyac, and areas to the west. Large, intact forested areas may exist above Tecpán de Galeana, which could then be used to tie the highlands of the Sierra Madre del Sur to the Pacific coastal plain and such areas as Piedra de Tlacoyunque beach and Laguna de Mitla. The resulting system of reserves would protect a unique example of the state's biodiversity.

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Chapter 11. PROTECTED AREAS OF OAXACA - A. Townsend Peterson and Rosa M. Salazar

INTRODUCTION

Oaxaca, a large state in southern Mexico (93,952 km^2), has principal habitats of pine, oak, and montane cloud forest (20%), tropical evergreen forest (5%), tropical deciduous forest (9%), subtropical scrub (7%), and agricultural and secondary growth (57%). It is is an immensely varied region, with diverse floras and faunas, including almost 700 bird species—more than are known for any country in Central America (Binford 1989). Eighty-nine vertebrate species are endemic to the state (44 reptiles, 28 amphibians, 10 mammals, and 7 birds; Flores Villela and Gerez 1994), placing it among the greatest concentrations of local endemism anywhere in Mesoamerica (Hernández Baños *et al*. 1995). At the same time, Oaxaca's natural riches are all but completely unprotected. Only three substantial protected areas exist in the whole state (Fig. 11.1), encompassing only a small sample of its variety of habitats and natural communities. Important, biologically diverse, and globally unique ecosystems remain ignored in the protected areas system of the state.

Thus, Oaxaca is simultaneously rich in biological diversity, unique in its richness of endemic species, and vulnerable to destruction, be it at the hands of large-scale commercial interests, local farmers, wildfires, or urban populations. The purpose of this chapter is to analyze the current status and design of its protected areas system, and make suggestions regarding priority areas for further conservation action. Information available is patchy and incomplete, assembled from our knowledge of the state, Gómez Pompa (1994), and documents kindly provided to us by SARH and SEDESOL. We describe the eight currently protected areas and twelve potential areas for conservation attention, and analyze the merits of each from the point of view of richness of bird species endemic to the state, species endemic to Mexico, and of overall bird species diversity.

PROTECTED AREAS

Lagunas de Chacahua National Park

Location: On the Pacific coast of southwestern Oaxaca, 10 km west of the mouth of the Río Verde, and approximately 50 km east-southeast of Santiago Pinotepa Nacional. Located in the municipality of Tututepec, with center at 15°48' N, 97°40' W; its size is 14,187 ha. Adjacent human settlements include Chacahua, La Grua, El Azufre, Zapotalito, Pastoria, and Charco Redondo.

Physiography: The park is located on the Pacific coastal plain (0–200 m). It consists of three lagoons (Pastoria, Salinas, and Chacahua) as well as two small rivers, the Chacalapa and the San Francisco. Topographic relief is minimal, with two low mountains: Cerro Hermoso and Cerro Punta Galeana, also known as Cerro Chacahua. Four rivers discharge their contents into the basin: the San Francisco, Zapotalito, Carrizo, and Gallinero. Occasional flooding by the Río Verde and the Río Chacalapa also contribute to the total volume of water captured by the basin. The lagoon system is 23 km long, with a surface area of 2967 ha. The water is briny, with a depth of 3–7 m.

Climate: Warm tropical, with summer rains, annual precipitation of 2719–3737 mm, and average daily temperatures of 16–35°C.

Habitat: Tropical semideciduous forest, tropical deciduous forest, mangrove swamp, marsh, savanna, coastal sand dunes, coastal lagoons, disturbed areas, and cultivated areas.

Fauna: The park holds many mammal species, including Mountain Lion, Margay, White-tailed Deer, Two-toed Anteater, Baird's Tapir, Collared Peccary, Coatimundi, and Kinkajou. Among birds, large-bodied species

include Ospreys, Great Egret, Brown Booby, Neotropic Cormorant, Wagler's Chachalaca, and White-fronted Parrot. Reptiles present include the large Spiny-tailed and Green Iguanas, American Crocodile, Boa, and rattlesnakes, as well as five species of sea turtles all in danger of extinction: Pacific Ridley, Leatherback, Hawksbill, Loggerhead, and Black.

Perhaps equally important is that Lagunas de Chacahua holds extents of two important habitat types—tropical deciduous forest and mangrove swamp—sufficient to be able to preserve their faunas more or less intact. The avifaunas of these habitats may include rare and poorly known species such as the Cinnamon-sided Hummingbird, Mangrove Hawk, and Pacific Screech-Owl. These communities are otherwise unrepresented in the protected areas of the state.

Some 20–30 years ago, the park held considerable populations of additional large and endangered species; however, more recently, several species (e.g., American Crocodile, Jaguar, Baird's Tapir, and Margay) have declined or disappeared, probably as a result of increasing encroachment by human populations on the reserve. Fish populations in the lagoons also have diminished: the first reports from the region in 1921, indicated that the species now commercially important were previously considered not worth keeping, because of the abundance of better species.

Research: Aside from brief explorations and collecting efforts for various taxonomic groups (e.g., Binford 1989), scientific research in Lagunas de Chacahua has been essentially nil.

Land ownership: Decreed in 1937, the entire park (14,187 ha) is under federal ownership. However, human settlements on this land are increasing. Reports indicate that in 1921 and 1936, 10–12 families resided within the confines of the park; by 1970, the population was assessed at 480 persons in 84 houses, with 60% of the population illiterate.

Management: The park is plagued by several problems resulting from its burgeoning human population. Erosion due to planting coconut palm, corn, cotton, bananas, oranges, and limes; grazing; wood-cutting; hunting; fishing; and illegal collecting of sea turtle eggs all contribute to to degradation of the natural landscape. Domestic animal populations within the park are estimated at 1000–3000 cattle, 400 pigs, 50 burros, and 20 horses. Approximately 3525 ha of the park are used for commercial fishing, 2000 ha have been subject to erosion, 1900 ha are presently used for agriculture, and 1000 ha are used for grazing—thus, a total of 8425 ha, or more than 55% of the park are being used for human needs, rather than constituting a "natural area."

Other, more subtle, problems also exist for Lagunas de Chacahua. Boat drivers often approach nesting areas for aquatic birds closely, causing mortality of young and abandonment of nests. Because sea channels have not opened in the last eight years, contaminants have become concentrated in the water, and pollution of the lagoons has increased.

Several management measures have been implemented, with fairly disappointing results. A crocodile farm was constructed in the 1970s, with the idea of both repopulating the park, and making profitable the maintenance of natural habitats in the region; unfortunately, production was not abundant. Worse still, efforts focused on the nonnative species *Crocodylus moreletti*, while the wild *C. acutus* population is in imminent danger of extirpation. For long-term protection of the lagoon system, construction of offshore breakwaters is important. In 1987, the sea channels were dredged, allowing water to flow, but the channel filled in again with marine sediments 48 hr afterwards. In 1990–1991, construction began on a breakwater, but work was never completed.

Members of the Univ. Autónoma Benito Juárez de Oaxaca initiated the "Proyecto Tortuga" in the park several years ago. Results have been encouraging, with hatchling survivorship as high as 60%. The project has since been extended to include both large iguana species. Principal causes of destruction for both turtles and iguanas have been poaching by humans and depredation by dogs.

SARH documented that the only way in which damage to the natural habitats of Lagunas de Chacahua can be avoided is to remove human populations and erect a fence to prevent further colonization. Other

suggestions proposed include raising admission fees for visitors, or construction of a tree farm to assist in reforestation of degraded habitats. A more viable alternative is to involve the local population in the economic profitability of the national park. If investment were made in making the park more attractive to visitors—access roads, advertisement, training of natural history guides, etc.—the influx of visitors and money into the region could be considerable. With adequate planning, activities incompatible with the natural landscape could be abandoned, and local residents could orient their activities increasingly toward the profitability and preservation of the park.

As a national park, the area is managed and administered by SEDESOL. The single administrator, three guards, and one person in charge of the crocodile farm all lack specialized training. Infrastructure in the park is minimal, including eight cabins, and three booths for security guards. Access to the park is difficult, with one dirt road that is passable March–May only, and a "mobile aquatic" access route that is usable year-round. In surrounding areas, services available to visitors, include taxis, boats for hire, fishing and natural history guides, restaurants, and hotels.

Comments: Lagunas de Chacahua National Park is important for two reasons. First, very few protected areas in the region include tropical deciduous forest or mangroves. In fact, apart from this area, no significant extent of these habitats is protected south of Jalisco. The tropical habitats of Mexico's Pacific Slope hold an exceptional concentration of endemic taxa, so conservation of remaining natural areas in this region is of great importance. Species restricted to this zone include the Happy Wren, Sinaloa Wren, Golden Vireo, and West Mexican Chachalaca. Archeological remains are known to exist within the park, but information on their importance or extent is not available.

Benito Juárez National Park

Location: North of Oaxaca City on the slopes of the Cerro San Felipe massif, consisting of 2737 ha, including portions of the municipalities of Oaxaca de Juárez, Dolores, San Felipe del Agua, and Huayapan, including populated areas such as Viguera and Donají.

Physiography: The park lies on the southern slopes (1700–3200 m) of an isolated mountain range in the interior of the state. The very wet highest elevations hold the headwaters of the rivers San Felipe del Agua and Huayapan, which are critical both in providing the surface water supply for the Valley of Oaxaca, and to recharging aquifers.

Climate: Warm subtropical at lower elevations to cool temperate at highest elevations, with summer rains.

Habitat: The highest portions of the park hold a mixture of pine-oak forest, pine forest, oak forest, and canyons with relict elements of cloud forest. At lower elevations, arid tropical habitats dominate, including tropical deciduous scrub, tropical semideciduous forest, and elements of chaparral. Disturbed vegetation is rapidly becoming the dominant habitat in the area.

Fauna: Most important among bird species known from the park is the Dwarf Jay, which formerly ranged from central Veracruz south to northern Oaxaca. However, because no records indicate its continued presence in Veracruz, or northern Oaxaca, Cerro San Felipe likely holds the only remaining populations (Stewart and Peterson in prep.). Mammal species known include Mountain Lion, Collared Peccary, Gray Fox, Raccoon, and Nine-banded Armadillo.

Research: Cerro San Felipe was one of the first sites in Oaxaca to see scientific study, beginning in the 1850s, with collections made by Adolphe Boucard and others, including numerous bird species new to science. Many

species were described based on specimens taken at Cerro San Felipe, creating a concentration of type localities (Binford 1989), in some nonavian cases for species that have yet to be discovered elsewhere. Nevertheless, a modern biological inventory of the area is lacking.

Land ownership: No part of the park is federal property. SARH reports that the entire park is communal land, whereas other documents indicate that 356 ha belong to ejidos, and the remaining 2381 ha are communal.

Management: Cerro San Felipe area has a long history of human presence. The *Relaciones Geográficas* in 1577 described the region as holding 160 Indians, as compared with 10,000–20,000 people who lived there prior to the Conquest (Acuña 1984). Hence the region was seriously affected by the arrival of the Europeans, and the long history of human habitation can be seen clearly.

Two principal objectives motivated the formation of the park in 1937: to conserve a forested area close to Oaxaca City for the enjoyment and recreation of its citizens, and to protect water resources for the city. The first of these objectives, as can be seen in numbers of visitors, has been amply fulfilled; the second, however, owing to widespread misuse and destruction of forest on Cerro San Felipe, has not, and water supplies for the city have suffered.

Although the park was decreed almost 60 years ago, it has never existed, lacking personnel, administration, or plan of action. At least 1000 ha (approximately 37%) of the land has been subject to overgrazing by cattle, woodcutting, clandestine forestry, wildfires, agriculture, and erosion. The Río San Felipe is channelized underground in its lower portion just outside the park to hold water for Oaxaca City, and a northern bypass highway around Oaxaca City that passes within 500 m of the park's southern border has caused heavy silting. The Corporación Mexicana de Radio y Televisión, S. A. de C. V., has leased 1500 m^2 within the park for a broadcast tower. Surprisingly, though, about 1000 ha of forest in the northern sector of the park remains relatively undisturbed, more because of inaccessibility than because of any management practice. Presently, SARH documents indicate totals of 125,000 visitors annually.

Comments: A report provided to us by SARH suggests that Parque Nacional Benito Juárez has been largely forgotten because no threatened or endangered species have been found to reside within the park's boundaries. This statement is intriguing, given that the park is actually rich in forms endemic to Mexico and/or Mesoamerica (Hernández Baños *et al.* 1995), and therefore most likely reflects lack of information on the part of its authors. Most prominent on the list for the park is the Dwarf Jay, which is presently nearly endemic to the mountain range, and certainly globally endangered (Stewart and Peterson in prep.).

A diagnostic study carried out by SARH pinpointed the central problem for the park (apart from not having budget, or staff, or adequate federal supervision): two different, and to some degree exclusive, entities are trying to coexist in the same space. The recreational purpose serves to attract people and development that compromise conservation objectives, and the park as a whole suffers. We suggest that the SARH document was largely correct in recommending that the park be divided into a portion dedicated to public enjoyment (and potentially under state or local supervision), and a portion dedicated to preserving maximally the biological diversity and water resources of the region.

Los Chimalapas "Campesina" Reserve

Location: In the eastern arm of Oaxaca, extending from the Veracruz border south to the Pan American Highway, and from east of Matias Romero east to the Chiapas border, including the municipalities of Santa María Chimalapa and San Miguel Chimalapa. The area consists of approximately 516,580 ha, with about 45,000 ha centered on the Sierra Espinazo del Diablo now designated as a core area. Large portions of the region are planned for addition to the core, or, if it will see limited use and habitation, to serve as a buffer zone.

Physiography: The Chimalapas (200▪2250 m) include some of the roughest and most difficult terrain in Mexico. The main axis of the region is the valley of the Río Corte, which runs roughly ESE▪WNW, and which is bordered on the north by the low Sierra de Tres Picos (1300 m), and on the south by the higher Sierra Atravesada (2250 m). From the north, the rivers Chalchijapa and Uxpanapa also penetrate the region, and the southeastern corner of the region consists of a complex knot of mountains including Cerro Baúl, Cerro Retén, Cerro Guayabitos, and Cerro Salomón. The region includes almost the entire upper watersheds of the three rivers, and hence represents an opportunity to preserve the set of ecosystems along these important drainages in a state that is both intact and functional.

Climate: Humid tropical in the lowlands, and humid subtropical to temperate in the highlands, with summer rains.

Habitat: The Chimalapas region holds the following habitats, from lowest to highest elevations: lowland rain forest and semideciduous tropical forest, cloud forest, pine-oak forest, and elfin forest. On the southern slopes of the region, in the municipality of San Miguel Chimalapa, the lowlands are dominated by tropical deciduous scrub and semideciduous tropical forest. Wendt and colleagues (1983, 1987, 1988, 1989; Wendt and Lott 1985, Wendt *et al*. 1985, Ishiki 1988, Vera Caletti 1988) studied the flora of the region, and documented distributions of plants in detail. They also discovered numerous endemic species and genera of trees, and the presence of tree species belonging to groups known previously only from the Old World tropics, suggesting that the Chimalapas rain forest has been isolated from other New World rain forests since the Cenozoic (Wendt 1989). Current estimates are that these rain forests are the most extensive and best preserved remaining in Mexico, and that some 300,000 ha of undisturbed forest exist in the Chimalapas. Along the highest points of the Sierra Atravesada lies a patch of elfin forest, a vegetation type never studied scientifically in Mexico that should hold many unique taxa.

Fauna: The fauna of the Chimalapas is extremely rich. The rain forests hold the most diverse avifaunas yet documented in Mexico, and mammal, reptile, and amphibian faunas are similarly diverse. The Chimalapas rain forests hold populations of many endangered species, including Jaguar, Baird's Tapir, Great Curassow, Scarlet Macaw, and possibly the only populations of Harpy Eagle in Mexico outside of the Petén and Chiapas (Escalante Pliego and Peterson 1994).

Cloud forests in the Chimalapas are extensive, but only a few peaks in the southeastern corner of the region have been studied in any detail. On Cerro Baúl, and along other mountaintops in the vicinity, healthy populations of Resplendent Quetzals, Black Guans, at least eight endemic species of reptiles and amphibians, and many other rare cloud forest animals are present (Hernández Baños *et al.* 1995, Peterson *et al.* unpubl.) . Explorations of other peaks in the region, especially the Sierra de Tres Picos and the Sierra Espinazo del Diablo, indicate that cloud forest faunas are similarly rich with rare and endangered species, and have resulted in the discovery of two lizard species new to science in the last year (one *Anolis* and one *Xenosaurus*). Indications from the local people and other sources are that the region also holds populations of the extremely endangered Horned Guan. The high-elevation elfin forests in the Sierra Atravesada remain unstudied faunistically, and promise to hold many exciting discoveries.

Research: Scientific documentation of the extremely rich flora and fauna of the Chimalapas remains incomplete. For many years, based on limited explorations in the vicinity of Santa María Chimalapa and Cerro Baúl, the area was considered merely an extension of the mountain systems of Chiapas with little biological interest. However, beginning with the detailed studies of Wendt and colleagues (Wendt 1983, 1987, 1988, 1989; Wendt and Lott 1985, Wendt *et al*. 1985, Ishiki 1988, Vera Caletti 1988), and continuing with studies presently under way, the region is now being seen as a treasure trove of biological diversity unequalled anywhere in Mexico, or probably in all of Mesoamerica.

Land ownership: The Chimalapas region is owned by the municipalities of Santa María Chimalapa and San Miguel Chimalapa. The core area is contained entirely within the former, and the buffer zone projected to encompass portions of both.

Management: The Chimalapas has always been sparsely populated. At the time of the arrival of Europeans, Santa María Chimalapa and San Miguel Chimalapa seem to have been the primary settlements, although archeological remains elsewhere in the region suggest that human presence may have been more extensive. The sixteenth century Spaniards knew of the rich natural resources of the region, but were unable to exploit them because of its inaccessibility (Acuña 1984).

The Chimalapas have been a perpetual mystery and fascination in Mexico. As far back as the 1870s, the area was the subject of many different plans for development, including as the site of a transisthmic canal (instead of Panama)! In this century, the Mexican government has proposed a series of development plans, including highways, railroads, national parks, and irrigation dams, but each project terminated on encountering the region's frightfully difficult topography. The region was not even mapped completely until the mid-1980s, and parts of the Chimalapas remain unexplored to this day.

The reserve, established in 1990, is the only one in Mexico that has the designation "Reserva Campesina." Los Chimalapas is unique in that it is not a reserve imposed on a local populace by federal decree, but is rather an area preserved by and for the local peasants, or *campesinos*. In this regard, the reserve is a landmark conservation effort in Mexico.

Because it was established only recently, management strategies for the region are only now being discussed. Local people are enthusiastic about making their reserve "work," in the sense of finding a long-term approach to its conservation, and of making it economically profitable. Strategies under discussion include that of attracting tourists to the region by opening a tourist lodge and natural history museum in Santa María Chimalapa, and exploiting certain, high-profit forest products in a sustainable fashion. Decisions regarding the use and management of the Chimalapas' wild areas are made by the local governments of the two municipalities, with limited advice and assistance from SEDESOL, the non-governmental and academic communities, and the government of the state of Oaxaca.

Comments: The Chimalapas represents one of the highest priorities for conservation action in all of Mesoamerica for several reasons. First, the large extent of virgin tropical forests and the low human population place the area among the wildest and least perturbed places of its size, and allow for the preservation of a very complete and intact fauna and flora. Second, being a complete watershed, the Chimalapas offer the opportunity to preserve the entire system intact. Finally, the region has a highly diverse and endemic flora and fauna that is unique and unequalled elsewhere in Mesoamerica.

An important feature of the Chimalapas region is that the local people and the governments of Santa María Chimalapa and San Miguel Chimalapa are excited about their reserve and its future. Although cautious about outside influences, the local people have welcomed the participation of scientific researchers in the exploration of natural resources and planning of the future management of the reserve. An intriguing possibility is that of linking Los Chimalapas with Selva del Ocote Special Biosphere Reserve nearby in Chiapas to create a megareserve, the “Selva Zoque.”

City of Oaxaca Forest Protection Area

Location: 19,100 ha in the Valley of Oaxaca, including the city of Oaxaca and the municipalities of San Andrés Huayapan, Santa Cruz, San Felipe Tejolopan, San Pablo Etla, and Cuilapan.

Physiography: The area (1000▪2000 m) extends from the broad, flat valley floor up its northern wall on the interior slopes of Cerro San Felipe, including the basin of the Río Hondo.

Climate: About 80% of the area is semiarid subtropical, 15% subhumid subtropical, and 5% subhumid temperate. Average annual precipitation is 600▪1000 mm.

Habitat: Primarily disturbed vegetation, agricultural areas, and urbanized areas. North and southwest of the city of Oaxaca, seasonal agriculture dominates; to the southeast, an element of irrigation is introduced; and in the eastern, southwestern, and southeastern portions of the area, introduced grasses dominate. Some pine-oak forest is found in the northern portion, ascending the slopes of Cerro San Felipe, but is rapidly being destroyed by the sprawl of Oaxaca City.

Fauna: Historical records indicate the presence of many species of birds and other animals in the vicinity of the city of Oaxaca (Goodwin 1969, Binford 1989). However, habitats have been so seriously modified that the fauna presently consists chiefly of species characteristic of disturbed habitats such as Groove-billed Anis, Great-tailed Grackles, and Cattle Egrets. The Valley of Oaxaca holds several species of birds endemic to the state, such as the Oaxaca Sparrow, White-throated Towhee, and Dwarf Vireo. These species may once have inhabited this area, but have probably been extirpated (although Oaxaca Sparrows are still found at Monte Albán nearby), with the exception of the towhee, which commonly lives in close association with humans. Hence, the importance of the area for conservation of biological diversity is probably minimal, and conservation efforts are better focused elsewhere in the Valley of Oaxaca, where natural habitats have not been so seriously disturbed.

Research: None, apart from historical collections and surveys.

Land Ownership: Outside of urban areas, land is owned by different ejidos.

Management: The original decree of this area (1937) stated its purpose as the protection of the water resources of the city of Oaxaca by prohibiting commercial exploitation of the forests within the area. The area has never had administration, management, staff or budget, so realization of its goals has been decidedly unsuccessful.

Comments: Water is a critical resource for Oaxaca, and the importance of this area for the purposes of water conservation may be substantial. Watershed considerations have been effective in preservation of forested areas elsewhere (see Omiltemi Ecological State Park, Guerrero), and could potentially be used to raise consciousness regarding conservation issues in Oaxaca, perhaps in conjunction with the contiguous (and more biologically important) Benito Juárez National Park.

City of Ixtepec Forest Protection Area

Location: In the vicinity of the city of Ixtepec, including 35,200 ha in the surrounding low hills on the Isthmus of Tehuantepec. Human settlements apart from the city of Ixtepec include Santo Domingo, Chihuitan, Asunción Ixtaltepec, and Santiago Laollaga.

Physiography: The region is flat, with low surrounding hills (0▪200 m). No permanent streams or rivers exist, just a few intermittent watercourses (including Río de los Perros) of little hydrological importance.

Climate: The climate is subhumid tropical. Summer rains provide most of the 100▪1200 mm annual precipitation.

Habitat: The entire area is presently used for seasonal agriculture.

Fauna: Little known, but disturbed habitats on the Isthmus are generally dominated by Groove-billed Anis, Great-tailed Grackles, Cattle Egrets, etc.

Research: None.

Land ownership: Ejidal.

Management: The original purpose of this area was to guarantee climatic and environmental conditions conducive to the health and well-being of the inhabitants of the city of Ixtepec. Given its early date of establishment (1938), it is tempting to speculate on the motives for the designation of Ixtepec, out of all the small cities in Oaxaca, as a forest protection area. Regardless of history, however, we are left with a "protected area" that is neither protected, nor has any biological reason to merit protection. The area apparently exists only on paper, and has no administrative authority in the region.

Comments: The original vegetation in the region probably held a number of rare, little-known, and endemic species of birds and other animals. However, given the high level of perturbation, the importance of the region for conservation is not particularly great. Other motives, such as protection of watersheds, control of erosion, and dust control, may provide better motives for the existence of this area.

Presidente Benito Juárez Reservoir Forest Protection Area

Location: Although a SARH document places this protected area in the municipality of Tuxtepec in northern Oaxaca, we believe that it lies in the municipality of Jalapa de Márquez in east-central Oaxaca, about 30 km WNW of the city of Tehuantepec. This confusion might result from a "Laguna de Temascal Natural Park" appearing on some maps near Tuxtepec and the Miguel Alemán Reservoir, which apparently was never decreed, and has never in truth existed. The area referred to herein, however, includes 970,000 ha of the Presa Presidente Benito Juárez and surrounding lands. Legal boundaries are undetermined.

Physiography: The reservoir lies in the broad, open basin formed by the confluence of the Río Tehuantepec and the Río Tequisistlán, surrounded by a series of low hills. The area is essentially the southeasternmost extreme of the mountains of Mexico north of the Isthmus of Tehuantepec.

Climate: Arid tropical, with summer rains.

Habitat: The reservoir is located in highly disturbed tropical deciduous scrub typical of the basin of the Río Tehuantepec. Casual observations in the region suggest that little natural vegetation exists intact.

Fauna: Little information. However, faunas before and after disturbance would closely resemble those found nearby in the vicinity of Nejapa de Madero. This fauna would likely include many species endemic to Mexico, such as the Cinnamon-sided Hummingbird, a Oaxaca endemic.

Research: None.

Land ownership: Undetermined, but most likely communal or ejidal.

Management: This area was decreed in 1949, and appears to have been essentially nonexistent from that point on. No funds have ever been appropriated, nor has any administrative mechanism ever been implemented.

Comments: The region surrounding the reservoir holds extensive areas of tropical dry scrub that could potentially support populations of species endemic to the dry lowlands of the Isthmus of Tehuantepec, such as Cinnamon-tailed Sparrow and Rose-bellied Bunting, among others. The presence of these endangered taxa in the region, however, has yet to be demonstrated, and the extent to which the area holds any native habitat has not been evaluated. This area clearly is not deserving of focused attention for the purposes of the conservation of biodiversity.

Playas de la Bahía de Chacahua Sea Turtle Reserve

Location: Undetermined; 1740 ha closely associated with the Lagunas de Chacahua National Park.

Comments: Decreed in 1986. Apparently an important breeding site for five sea turtle species, all endangered.

Playa Escobilla Sea Turtle Reserve

Location: Undetermined; 1500 ha closely associated with the Lagunas de Chacahua National Park.

Comments: Decreed in 1986. Apparently an important breeding site for sea turtles.

POTENTIAL AREAS FOR CONSERVATION IN OAXACA

What follows are two lists of areas that constitute potential additions to the protected areas system of the state of Oaxaca: one of areas that we have identified during seven years of work in the state as constituting large patches of forest and holding well-preserved faunas and floras, and the other of areas proposed as potential conservation areas by the Mexican government.

Sierra de Juárez

Description: This sierra in northern Oaxaca, extends from the Río Santo Domingo and Santos Reyes Pápalo south and east to Yolox, where it approaches the Sierra de los Mixes and the Zempoaltepec massif, which continue south and eastward to the Quetzaltepec area. The extent of humid montane forest in the complex of mountain ranges is more than 300,000 ha, and probably constitutes the largest expanse of such intact forest in northern Mesoamerica.

Comments: The Sierra de Juárez includes the best remaining humid montane forests north (and to a good distance south) of the Isthmus of Tehuantepec. Bird species diversity is impressive, with more than 200 bird species known from the foothill forests (Binford 1989), and more than 80 from the montane forests (Torres Chávez 1992). Several species of reptiles, amphibians, mammals, and plants are known only from this region. The entire eastern Mexican humid montane forest avifauna (Hernández Baños *et al*. 1995) is best represented at this site, and this area should be considered the highest priority area in montane forest in eastern Mexico (Peterson *et al*. 1993).

La Cañada

Description: The La Cañada region lies in the northern part of the state, in a broad, largely arid basin between the Sierra Madre Oriental to the east and the Alta Mixteca to the west. La Cañada extends from Tehuacán, Puebla, south to near Oaxaca City, in the districts of Teotitlán, Cuicatlán, and Etla, and marginally in Coixtlahuaca and Asunción Nochixtlán. The area is a broad basin along the rivers Grande, Salado, Santo Domingo, and Tomellín. The western escarpment leads to the Alta Mixteca, a dissected high plain. The eastern wall is steeper, ascending to above 2800 m in the Sierra Mazateca and Sierra de Juárez. An almost uninhabited smaller valley parallel to the main axis of La Cañada is that of the Río Tomellín, separated from the valley of the Río Grande by a narrow, low mountain range.

The region consists of a mosaic of different habitat types that crisscross the basin in a complex manner. The dry habitats that cover most of the region include tropical deciduous scrub and cactus forest. The basin is traversed by stands of tropical riparian forest along rivercourses, and dotted with islands of dry oak scrub, dry pine-oak forest, and humid pine-oak forest on mountaintops. The eastern rim holds extensive stands of humid pine-oak and cloud forest in the Sierra Mazateca and the Sierra de Juárez.

Comments: The fauna of La Cañada is a fascinating mix of distinct elements, including species characteristic of Mexican deserts, lowland rain forests, oak scrub, pine-oak forest, and cloud forest, complexly distributed across local habitats and microhabitats. Several endangered species were detected in La Cañada during recent intensive studies (Peterson *et al*. in prep.), including the widespread but globally threatened Military Macaw, Jaguarundi, and the bat *Leptonycteris nivalis*; poorly known species such as the Yellow Grosbeak (Binford 1989); as well as restricted-range endemic species, such as the Gray-breasted Woodpecker and Bridled Sparrow. These species are assorted evenly among different habitats, making the preservation of the entire mosaic of habitats in the region necessary. Among plants, endemism is pronounced, even to the extent of species unique to particular valleys in the cycads of the genus *Dioon*.

Most importantly, La Cañada represents a unique opportunity for conservation efforts in Mexico because it is simultaneously an important center of local endemism for plants, a fascinating pattern of habitats holding many rare and poorly known animals, and a surprisingly well-preserved set of habitats. Although the region as a whole has a substantial human population, many areas remain essentially undisturbed, and some large expanses, such as the canyon of the Río Tomellín, are even uninhabited.

Chontal

Description: The Chontal region is located along the Pacific coast of southern Oaxaca, between the resort city of Huatulco and the Isthmus of Tehuantepec. Similar to the Chimalapas, the region is inhabited by people that have looked little to the outside, and the region remains unstudied and apparently well preserved. The Chontal holds substantial portions (about 16,000 ha) of semideciduous tropical forest.

Comments: Semideciduous tropical forest on the western slope of Mexico is everywhere patchy and restricted in its distribution, and the expanses in the Chontal appear to rank among the largest south of Jalisco. The biological importance of tropical deciduous forests has been emphasized greatly in recent years (Mares *et al*. 1992), and many of the west-Mexican lowland endemic species are likely to occur there (Escalante Pliego *et al*. 1993). However, because of the remoteness and difficulty of access to the region, the fauna and flora of the Chontal are completely unknown.

Sierra Mazateca

Description: The Sierra Mazateca is located in the northern extreme of the state, southwest of the Miguel

Alemán Reservoir. The mountains are isolated from the Sierra de Juárez by the deep valley of the Río Santo Domingo, and from the mountains of central Veracruz (Orizaba or Citlaltépetl massif) by the low pass near the city of Orizaba. One of the highest points, Puerto de la Soledad, is accessible from Teotitlán del Camino, and holds a fine example of *Podocarpus* forest. Other montane areas (e.g., the Cerro Rabón area) are more isolated, and have been disturbed only by remote coffee-planting settlements. The region has a long history of human habitation, including the pueblos Huautla de Jiménez, Jalapa de Díaz, and others, and has seen a fair amount of perturbation of forests, especially for seasonal agriculture and coffee plantations.

Comments: Recent studies in the region indicate the presence of well-preserved forests with rich faunas of high species diversity and levels of endemism. Mexican endemic species of birds, such as Hooded Grosbeak, Bumblebee Hummingbird, Crescent-chested Warbler, and Sumichrast's Wren, are present in good numbers (Peterson *et al*. in prep.). Although the region has extensive human populations, people there are interested in the idea of conservation, and a multiple-use, integrated plan of conservation and human activity could potentially be implemented.

Ayotzintepec

Description: At the northeastern base of the Sierra de Juárez, an area of more than 15,000 ha of lowland rain forest remains more or less intact in the vicinity of the pueblo of Ayotzintepec on the Río Cajones. It has rain forest, marshes, and swamp forest.

Comments: Swampy habitats in tropical rain forest are both poorly known biologically and unrepresented in the protected areas system of Oaxaca. The area around Ayotzintepec has not been studied by scientists. Nevertheless, expected are several species of rare herons and rails, as well as the full complement of rain forest fauna and flora. The area merits careful scientific study to assess its potential importance as a protected area.

Mar Muerto and other coastal lagoons

Description: On the Pacific side of the Isthmus of Tehuantepec exists an extensive system of coastal lagoons, including Mar Muerto. The area has been heavily disturbed by human presence, and how much native vegetation remains intact is not known.

Comments: Mar Muerto and associated lagoons, being one of the largest systems of coastal lagoons in Mexico, probably constitute important stopover points for migrating shore and marine birds in southern Mexico. The tropical dry scrub that dominates neighboring terrestrial habitats is likely to hold several forms endemic to the Pacific lowlands of the Isthmus of Tehuantepec. Our brief visits to the area indicate the presence of ample habitat for migrating waterbirds, and at least some native tropical dry scrub, so we suggest that more careful study is merited to assess the area's importance.

OTHER AREAS PROPOSED BY THE MEXICAN GOVERNMENT

Sierra de Loxicha ▪ Located between the ríos Colotepec and Tonameca between 200 and 2000 m of elevation, this mountain range lies on the southern slope of the Sierra de Miahuatlán in southern Oaxaca. Fauna would likely include many of the same species as in the Lagunas de Chacahua National Park. Status of preservation of vegetation remains unevaluated, the presence of endemic species like the Blue-capped Hummingbird is unconfirmed, and the potential importance of this area unknown.

Sierra de Zaachilac ▪ Located southwest of Oaxaca City, this area includes the higher parts of San Francisco Totla, San Antonio de la Cal, San Agustín de las Juntas, Buenavista la Lobera, San Pablo Cuatro Venados, and Santa Inés del Monte, south to the Río Peras. This region is apparently the Sierra de Cuatro Venados of Binford (1989). Its fauna is typical of that of interior montane forest islands in southern Mexico (Hernández Baños *et al*. 1995), but either reduced or poorly known; lower portions might hold populations of rare and endemic species such as Slaty Vireo, Dwarf Vireo, and Eared Poorwill. Our understanding is that the forest is rapidly being devastated by removal of pulpwood, so the importance of this area for conservation purposes remains unclear.

Uxpanapa ▪ Several SARH documents list the Uxpanapa region as a possibility for conservation action in the state. However, the lower Uxpanapa region (principally in Veracruz) is an ecological disaster, with only fragments of forest remaining intact. The upper Uxpanapa, in the vicinity of San Francisco Ixhuatán, San Isidro La Gringa, and the Sierra Espinazo del Diablo, is already under protection (see Los Chimalapas "Campesina" Reserve above). Wendt (1989) has amply demonstrated the uniqueness of the Uxpanapa in terms of rain forest tree diversity, and the region holds good populations of Nava's Wrens, an endangered genus endemic to Mexico. Hence, the possibility of extending the Chimalapas reserve northward to include the distinctive lower portions of the basin should be examined.

Cerro Guiengola ▪ This area, a low hill 12 km west of the city of Tehuantepec (Binford 1989), was an important locality for the collectors Nelson and Goldman at the turn of the century. Because it served as the type locality for many Isthmus endemics, and given the possible occurrence of rare species such as Rose-bellied Bunting, it has some importance biologically. An area of 4350 ha has been under study for conservation. However, its vegetation is increasingly disturbed, and a more rewarding tactic might be to seek an undisturbed and more remote area nearby that could be preserved more effectively.

Santa Elena ▪ An area of 2000 ha is listed on several documents examined. We have no information as to its location or status.

Mazunte ▪ An area listed on several documents examined. We have no information as to its location or status.

ASSESSMENT OF CURRENT SITUATION

How "good" a protected areas system really is becomes a difficult question to answer. Any number of yardsticks may be used to evaluate how well priorities for conservation are fulfilled: richness of species, richness of endemic species, diversity of species of birds, mammals, butterflies… anything. Because the purpose of this paper is to evaluate the protected areas system of the state of Oaxaca on the basis of its avifauna, a good first step is to evaluate whether species unique to the state are adequately protected. Then, categories, such as species endemic to Mexico and overall species richness, can be examined as well. Only three areas of those currently protected in Oaxaca are considered here (Lagunas de Chacahua National Park, Benito Juárez National Park, and Los Chimalapas "Campesina" Reserve), because they are the only ones that include significant expanses of natural habitats. In addition, we consider the potential areas listed above as possible additions to the reserve system.

Oaxaca Endemics

Seven bird species are restricted completely, or almost completely, to Oaxaca (Fig. 11.3). For these species, if protection is inadequate in Oaxaca, they will go extinct. Bird species endemic to the state are as

follows, with notes on distribution and conservation needs:

- Oaxaca Sparrow ▪ Endemic to arid scrub in northern Oaxaca, known from Ejutla de Crespo, Tamazulapan del Progreso, Cerro San Felipe, near Oaxaca City, and in the vicinity of Santiago Matatlán (Binford 1989); probably exists in similar habitats in adjacent Puebla as well. The Cerro San Felipe locality is close to Benito Juárez National Park, but populations appear more predictably encountered farther east in the vicinity of Santiago Matatlán.

- Rose-bellied Bunting
- Cinnamon-tailed Sparrow ▪ Endemic to the lowland tropical deciduous forests of the Pacific Slope of the Isthmus of Tehuantepec. Unprotected by any existing reserve in the state, and though undocumented at Chontal or Mar Muerto, a reserve at either location might include populations.

- Dwarf Jay ▪ Originally occurring from central Veracruz south to northeastern Oaxaca, this species has apparently gone extinct in all sites except Cerro San Felipe (Stewart and Peterson in prep.). Therefore, adequate preservation of Cerro San Felipe is critical to the survival of this species.

- Blue-capped Hummingbird ▪ Endemic to the Sierra de Miahuatlán of southern Oaxaca, this species is unprotected in the present system of reserves or potential areas. Little forest remains intact in its range for a protected area to be established for its preservation. Expanses of appropriate habitat in the Miahuatlán massif far from roads or trails should be sought on satellite images.

- White-throated Towhee ▪ Endemic to southern Puebla, easternmost Guerrero, and northern and central Oaxaca, this species is common in disturbed landscapes and around human habitation. Its preservation should not be a major issue of concern, given its broad tolerance of human activity.

- Cinnamon-sided Hummingbird ▪ This form, part of the confusing complex of populations currently referred to as Green-fronted Hummingbird, is clearly a separate species (Howell 1993). It is distributed along the arid southern slopes of the Sierra Madre del Sur, and could conceivably occur in Chontal or Lagunas de Chacahua National Park, although it has yet to be documented at either location.

The endemic bird species of Oaxaca are distributed unevenly across the state. In fact, only two species pairs occur sympatrically (White-throated Towhee and Oaxaca Sparrow, Rose-bellied Bunting and Cinnamon-tailed Sparrow). The three protected areas that are decreed and hold native habitats protect populations of possibly one of the seven species (Dwarf Jay), and thus are poorly situated to preserve adequately populations of bird species found only in Oaxaca.

Six potential areas for conservation action (Sierra de Juarez, La Cañada, Chontal, Sierra Mazateca, Ayotzintepec, and Mar Muerto) would provide opportunities for the protection of several more of the Oaxacan avian endemics. A reserve in La Cañada would include populations of White-throated Towhee and probably Oaxaca Sparrow as well. A reserve at Mar Muerto might hold populations of Rose-bellied Bunting and Cinnamon-tailed Sparrow. Finally, a reserve at Chontal would likely hold populations of Cinnamon-sided Hummingbird. Thus, the existing national park at Benito Juárez (Dwarf Jay), together with reserves at La Cañada, Mar Muerto, and Chontal, would protect six of the seven species endemic to the state. Preservation of the seventh species (Blue-capped Hummingbird) depends on the detection of a significant expanse of montane forest habitat in the Sierra de Miahuatlán. Focusing on reserves instead of individual species, we can rank areas by importance in preserving species endemic to Oaxaca. La Cañada and Mar Muerto would be highest on the list (possibly 2 species each), then Benito Juárez National Park and Chontal (1 species each); the remaining areas hold no Oaxaca endemic species.

Mexican Endemics

Species endemic to Oaxaca are in a way an artificial assemblage, because they result from making biological elements conform to human political boundaries. An alternative approach consists of expanding the scale of analysis to include species endemic to Mexico as a whole, thus avoiding to some degree the problem by making the political boundaries more distant from those of the area of interest. Hence, we evaluate the diversity of Mexican endemic bird species in the current and potential protected areas system of Oaxaca.

Depending on the taxonomy employed, approximately 153 species of birds are endemic or nearly endemic to Mexico (Escalante Pliego *et al*. 1993, Navarro Sigüenza and Peterson in prep.). Of these, 72 occur in the state and would ideally be included in a protected areas system for the state (Table 11.1).

The three areas currently protected together hold 46 species endemic to Mexico. Benito Juárez National Park holds populations of 24 Mexican endemic species; Lagunas de Chacahua National Park holds populations of 20; and Los Chimalapas holds three (Table 11.1). The combination of Lagunas de Chacahua and Benito Juárez would protect 43 endemic species, whereas the combination of either with Los Chimalapas would protect only 24–28 species. Thus, the combination of just two of the already decreed areas would protect 60% of the Mexican endemics that occur in Oaxaca.

Addition of other potential protected areas to the system allows for the protection of many more Mexican endemic species. The six potential areas hold from as many as 23–26 (Sierra de Juárez, La Cañada, Sierra de Mazateca) to as few as three species (Ayotzintepec). Because of the wide geographic distribution of these areas, each holds a distinct set of species.

In reality, however, the protected areas system of Oaxaca consists of multiple reserves, and so we must consider *sets* of reserves for the optimal composition of species to protect maximally the state's biodiversity. Therefore, we evaluated avifaunal similarity of the nine current and potential reserves according to their Mexican endemic species using Simpson's index of faunal similarity, and then clustered them using the unweighted pair-group method of analysis (UPGMA). The resulting dendrogram (Fig. 11.4) summarizes overall similarity of Mexican endemic bird faunas in the nine areas: four very distinct clusters can be identified, none of which shares more than 35% of its species with any other. Hence, an optimal combination of protected areas would focus on areas falling in different clusters to maximize protection of as many species as possible.

Choosing pairs of areas, and calculating numbers of species present in one or both (Table 11.2), we can see the effectiveness of different combinations of areas. Pairs of areas from the same clusters in hold 3–28 species, whereas combinations of areas from different clusters ranged from 14 up to as many as 47 species protected. Similarly, selecting sets of four reserves, one from each cluster, species protected ranged from 57 to 61, whereas duplicating just one of the clusters in a set of four reduced the number to around 50 species. Thus, by incorporating information on species' distributions, designs for conservation of endemic forms can be made considerably more effective.

Species Richness

Preliminary species lists for the three currently protected areas showed broad differences in richness among regions. Benito Juárez National Park holds at least 67 species, Lagunas de Chacahua National Park at least 113 species, and Los Chimalapas at least 289 species. With further study, lists for each would undoubtedly be lengthened, but differences in species richness are nonetheless pronounced.

Because some areas remain unstudied by ornithologists (e.g., Ayotzintepec), while others have seen years of study (e.g., Sierra de Juárez, Torres Chávez 1992), direct comparisons of overall species richness are impractical. However, a rough ranking of areas in terms of species richness can be created based on our working understanding of patterns in southern Mexico (Navarro Sigüenza 1992, Escalante Pliego *et al*. 1993, Peterson *et al*. 1993): (1) the Chimalapas is likely to hold all species of lowland rain forests, plus species of cloud forest and tropical deciduous forests, and so would clearly exceed 350 species if the list were complete (Peterson *et al*. in prep.); (2) Ayotzintepec and Chontal (both unexplored), Lagunas de Chacahua, La Cañada, and Sierra de Juárez, hold more limited (but still diverse) avifaunas of 200–250 species (Torres Chávez 1992,

Peterson *et al*. in prep.); and (3) the areas of Benito Juárez, Mar Muerto, and Sierra de Mazateca, each of which would hold a more limited set of species owing to the simplicity of their respective sets of habitat types (Hernández Baños *et al*. 1995).

Overall Patterns and Options

The preceding three sections evaluated the biological diversity of current and potential protected areas of Oaxaca on the basis of three spatial scales: endemism in Oaxaca, endemism in Mexico, and overall species richness. For each scale, we provided rough rankings of importance (Table 11.3). Averaging these three rankings and assuming equal importance for each spatial scale, current and potential protected areas can be ranked in order of decreasing importance as follows (1) La Cañada, (2) Benito Juárez, Chontal, Lagunas de Chacahua, Mar Muerto, and Sierra de Juarez, (3) Los Chimalapas, and (4) Sierra de Mazateca and Ayotzintepec.

A set of four reserves as priority areas can then be chosen based on the following set of criteria: (1) average ranking (Table 11.3), (2) representation of all four main clusters (Fig. 11.4), (3) extent of well-preserved forest habitat, and (4) existing status as a reserve. First choice would be La Cañada (on criterion 1), then Sierra de Juárez (over Benito Juárez on criterion 3) and Lagunas de Chacahua (over Mar Muerto on criteria 3 and 4), and finally Los Chimalapas (criterion 2). (A potential alternative to the conflict between criteria 3 and 4 in choosing Sierra de Juárez over Benito Juárez, and which would allow for protection of all known remaining populations of the Dwarf Jay is the linkage of the two areas in a larger reserve that includes the human settlements scattered throughout the region.) This priority list therefore gives the most efficient manner in which to attack the challenge of the preservation of the bird diversity of the state of Oaxaca, based on the criteria and assumptions outlined above.

Discussion

The incomplete nature of Oaxaca's protected areas system becomes evident from the above text. Areas currently "protected" are poorly funded (e.g., Lagunas de Chacahua National Park), located in nonnative habitat (e.g., City of Oaxaca Forest Protection Area), or simply nonexistent (e.g., Benito Juárez National Park). Perhaps the only viable protected area in the state is the Los Chimalapas "Campesina" Reserve, a fledgling effort on the part of local inhabitants.

Moreover, the existing protected areas system fails to protect adequately the birds of Oaxaca. The three existing protected areas hold approximately 400 of the almost 700 bird species known from the state (Binford 1989), 46 of the 72 Mexican endemics known to occur in the state, and only one of the seven species endemic to the state. A more carefully designed protected areas system could clearly improve the preservation of the state's enormous biological diversity.

The above discussions provide an objective approach to the design of such a system of reserves. We propose four "first priority" reserves—La Cañada, Sierra de Juárez/Benito Juárez National Park, Lagunas de Chacahua National Park, and Los Chimalapas—which would together protect 60 of the 72 Mexican endemic species and a significant proportion of bird species diversity. Smaller reserves at Mar Muerto and Chontal (or perhaps just Chontal, if Cinnamon-tailed Sparrows and Rose-bellied Buntings were found there) would probably make the protected areas system hold six of the seven bird species endemic to the state; search for a suitable area in the Sierra de Miahuatlán could afford protection to the seventh.

Having entered into such depth regarding avifaunal diversity as a measure of importance for conservation, we hasten to add several cautions regarding this approach.

- Biodiversity isn't everything ▪ many considerations must enter into the process of situating protected areas.

Sometimes a suitable extent of primary habitat cannot be located in what would otherwise be a high-priority area (e.g., Sierra de Miahuatlán); in other situations, special considerations, such as the preservation of an entire watershed (e.g., Los Chimalapas) or archaeological remains, enter into the equation as well. In these situations, biological diversity must be taken into account as *one* factor among several important in the process.

- Human presence ▪ an ancient human landscape such as Oaxaca has very few uninhabited areas. In fact, many areas that presently seem at least sparsely populated (e.g., Los Chimalapas) were actually depopulated in the plagues that swept the region following the Conquest (Acuña 1984). Therefore, modern protected areas systems must take into account human considerations such as the presence of communities, local hunting activities, and agricultural needs. Conservation efforts can turn this consideration into a benefit by involving the local people in both the management *and* the profit of a protected area.

- Known versus unknown ▪ many of the better-known sites in the Oaxaca landscape are fast becoming degraded, and probably no longer represent the best candidates for protection as examples of primary habitat. Still, large areas remain undisturbed, precisely because they are inaccessible and difficult to study (or to colonize and destroy). Methodologies for using existing information to predict occurrences of species in inaccessible areas, permitting planning of reserves for areas that are difficult even to visit are presently being explored.

A more venturesome proposal, which would certainly provide more viable reserves from the standpoint of biological diversity, would involve the linkage of different reserves into systems. Joining Benito Juárez National Park, Sierra de Juárez, La Cañada, Sierra Mazateca, and Ayotzintepec would create a super-reserve protecting a superb example of most major ecosystems of the interior and Atlantic Slope of Oaxaca. Similarly, joining a montane forest area in the Sierra de Miahuatlán with an adjacent lowland area such as Lagunas de Chacahua National Park or Chontal would create a viable example of Pacific Slope ecosystems. These super-reserves, even if managed piecemeal, would permit coordination of protection efforts when decisions in one area affect processes in another. Gap analysis, a geographic information system based routine for exploring interconnections among geographic entities, would be an ideal approach for building proposed limits for corridors and interconnections among areas.

In summary, we have described existing protected areas for the state of Oaxaca as well as potential protected areas identified during more than six years of exploration. We assessed the importance of each area based on three spatial scales of avian diversity, and made recommendations according to a quantitative consideration of that information. Our hope is that this contribution will serve both as a guide to current conservation planning in the region, and as a stimulus for more detailed studies.

OAXACA CONTACTS

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CONCLUSIONS

Need to resolve similarities of recommendations from each state. Many points are repeated while others are unique to the state.
Major point - incorporation of locals into conservation management**IN PREPARATION**

Biodiversity of W MEX impressive
- Many rare and endangered microendemic species
  - DW J, SH-CR COQ, plants, herps endemic to single reserves
  - Many impt challenges for conservation

Appendix A. VERTEBRATES - ENGLISH AND SCIENTIFIC NAMES

REPTILES

Common Name	Scientific Name
Gila Monster	*Heloderma h. horridum*
Sand Lizard	*Uma paraphygas*
Spiny-tailed Iguana	*Ctenosaura pectinata*
Green Iguana	*Iguana iguana*
Spiny Lizard	*Scelophorus spp.*
Whiptail Lizard	*Cnemidophorus spp.*
American Crocodile	*Crocodylus acutus*
Pacific Ridley Sea Turtle	*Lepidochelys olivacea*
Leatherback Turtle	*Dermochelys coriacea*
Pacific Hawksbill Turtle	*Eretmochelys imbricata*
Loggerhead Turtle	*Caretta caretta*
Black Turtle	*Chelonia agassizii*
Mud Turtle	*Kinosternon integrum*
Bolson Tortoise	*Gopherus flavomarginatus*
Boa Constrictor	*Boa constrictor*
Milk Snake	*Lampropeltis triangulum*

BIRDS

Common Name	Scientific Name
Townsend's Shearwater	*Puffinus auricularis*
Red-billed Tropicbird	*Phaethon aethereus*
Blue-footed Booby	*Sula nebouxii*
Brown Booby	*Sula leucogaster*
Red-footed Booby	*Sula sula*
American White Pelican	*Pelecanus erythrorhynchos*
Brown Pelican	*Pelecanus occidentalis*
Double-crested Cormorant	*Phalacrocorax auritus*
Neotropic Cormorant	*Phalacrocorax brasilianus*
Anhinga	*Anhinga anhinga*
Magnificent Frigatebird	*Fregata magnificens*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Snowy Egret	*Egretta thula*
Little Blue Heron	*Egretta caerulea*
Tricolored Heron	*Egretta tricolor*
Cattle Egret	*Bubulcus ibis*
Black-crowned Night-heron	*Nycticorax nycticorax*
Yellow-crowned Night-Heron	*Nyctanassa violaceus*
Boat-billed Heron	*Cochlearius cochlearius*
White Ibis	*Eudocimus albus*
Roseate Spoonbill	*Ajaia ajaja*
Wood Stork	*Mycteria americana*
Fulvous Whistling-duck	*Dendrocygna bicolor*
Black-bellied Whistling-Duck	*Dendrocygna autumnalis*
Snow Goose	*Chen caerulescens*
Canada Goose	*Branta canadensis*
Muscovy Duck	*Carina moschata*

Green-winged Teal	*Anas crecca*
Northern Pintail	*Anas acuta*
Blue-winged Teal	*Anas discors*
Northern Shoveler	*Anas clyptera*
Gadwall	*Anas strepera*
Canvasback	*Aythya valisineria*
Ruddy Duck	*Oxyura jamaicensis*
Masked Duck	*Oxyura dominica*
Turkey Vulture	*Cathartes aura*
Osprey	*Pandion haliaetus*
Northern Goshawk	*Accipiter gentilis*
Mangrove Hawk	*Buteogallus subtilis*
Golden Eagle	*Aquila chrysaetos*
Harpy Eagle	*Harpia harpyja*
American Kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Aplomado Falcon	*Falco femoralis*
Wagler's Chachalaca	*Ortalis wagleri*
West Mexican Chachalaca	*Ortalis poliocephala*
Black Guan	*Penelopina nigra*
Crested Guan	*Penelope purpurascens*
Horned Guan	*Oreophasis derbianus*
Great Curassow	*Crax rubra*
Wild Turkey	*Meleagris gallopavo*
Long-tailed Wood-Partridge	*Dendrortyx macroura*
Singing Quail	*Dactylortyx thoracicus*
Montezuma Quail	*Cyrtonyx montezumae*
Banded Quail	*Philortyx fasciatus*
American Coot	*Fulica americana*
Semipalmated Plover	*Charadrius semipalmatus*
American Oystercatcher	*Haematopus palliatus*
Black-necked Stilt	*Himantopus mexicanus*
American Avocet	*Recurvirostra americana*
Heermann's Gull	*Larus heermanni*
Least Tern	*Sterna antillarum*
Sooty Tern	*Sterna fuscata*
Brown Noddy	*Anous stolidus*
Red-billed Pigeon	*Columba flavirosrtis*
Band-tailed Pigeon	*Columba fasciata*
White-winged Dove	*Zenaida asiatica*
Mourning Dove	*Zenaida macroura*
Socorro Dove	*Zenaida graysoni*
White-tipped Dove	*Leptotila verreauxi*
White-faced Quail-Dove	*Geotrygon albifacies*
Ruddy Quail-Dove	*Geotrygon montana*
Socorro Parakeet	*Aratinga brevipes*
Orange-fronted Parakeet	*Aratinga canicularis*
Military Macaw	*Ara militaris*
Scarlet Macaw	*Ara macao*
Thick-billed Parrot	*Rhychopsitta pachyrhyncha*
White-fronted Parrot	*Amazona albifrons*
Lilac-crowned Parrot	*Amazona finschi*
Yellow-headed Parrot	*Amazona oratrix*

Groove-billed Ani	*Crotophaga sulcirostris*
Balsas Screech-Owl	*Otus seductus*
Pacific Screech-Owl	*Otus cooperi*
Least Pygmy-Owl	*Glaucidium minutissimum*
Spotted Owl	*Strix occidentalis*
Stygian Owl	*Asio stygius*
Eared Poorwill	*Nyctiphrynus mcleodii*
Buff-collared Nightjar	*Caprimulgus ridwayi*
White-fronted Swift	*Cypseloides storeri*
White-naped Swift	*Streptoprocne semicollaris*
Great Swallow-tailed Swift	*Panyptila sanctihieronymi*
Short-crested Coquette	*Lophornis brachylopha*
Dusky Hummingbird	*Cynanthus sordidus*
Mexican Woodnymph	*Thalurania ridgwayi*
Green-fronted Hummingbird	*Amazilia viridifrons*
Cinnamon-sided Hummingbird	*Amazilia wagneri*
Blue-capped Hummingbird	*Eupherusa cyanophrys*
Stripe-tailed Hummingbird	*Eupherusa eximia*
White-tailed Hummingbird	*Eupherusa poliocerca*
Beautiful Hummingbird	*Calothorax pulcher*
Bumblebee Hummingbird	*Atthis heloisa*
Citreolene Trogon	*Trogon citreolus*
Eared Trogon	*Euptilotis neoxenus*
Resplendent Quetzal	*Pharomachrus mocinno*
Emerald Toucanet	*Aulacorhynchus prasinus*
Acorn Woodpecker	*Melanerpes formicivorus*
Golden-cheeked Woodpecker	*Melanerpes chrysogenys*
Gray-breasted Woodpecker	*Melanerpes hypopolius*
Smoky-brown Woodpecker	*Veniliornis fumigatus*
Gray-crowned Woodpecker	*Piculus auricularis*
Gray-breasted Woodpecker	*Melanerpes hypopolius*
Imperial Woodpecker	*Campephilus imperialis*
Scaled Antpitta	*Grallaria guatimalensis*
Pileated Flycatcher	*Xenotriccus mexicanus*
Pine Flycatcher	*Empidonax affinis*
Flamulated Flycatcher	*Deltarhynchus flammulatus*
Brown-crested Flycatcher	*Myiarchus tyrannulus*
Social Flycatcher	*Myiozetetes similis*
Steller's Jay	*Cyanocitta stelleri*
White-throated Magpie-Jay	*Calocitta formosa*
Tufted Jay	*Cyanocorax dickeyi*
San Blas Jay	*Cyanocorax sanblasianus*
Dwarf Jay	*Cyanolyca nana*
White-throated Jay	*Cyanolyca mirabilis*
Gray-barred Wren	*Campylorhynchus megalopterus*
Spotted Wren	*Campylorhynchus gularis*
Boucard's Wren	*Campylorhynchus jocosus*
Sumichrast's Wren	*Hylorchilus sumichrasti*
Nava's Wren	*Hylorchilus navai*
Happy Wren	*Thryothorus felix*
Sinaloa Wren	*Thryothorus sinaloa*
Banded Wren	*Thryothorus pleurostictus*
Clarion Wren	*Troglodytes tanneri*

Socorro Wren	*Troglodytes sissonii*
Ruby-crowned Kinglet	*Regulus calendula*
Rufous-backed Robin	*Turdus rufopalliatus*
Aztec Thrush	*Ridwayia pinicola*
Socorro Mockingbird	*Mimodes graysoni*
Ocellated Thrasher	*Toxostoma ocellatum*
Blue Mockingbird	*Melanotis caerulescens*
Slaty Vireo	*Vireo brevipennis*
Dwarf Vireo	*Vireo nelsoni*
Golden Vireo	*Vireo hypochryseus*
Crescent-chested Warbler	*Vermivora superciliosa*
Golden-cheeked Warbler	*Dendroica chrysoparia*
Red Warbler	*Egraticus ruber*
Golden-browed Warbler	*Basileuterus culicivorus*
Chapala Yellowthroat	*Geothlypis chapalensis*
Red-breasted Chat	*Granatellus venustus*
Blue-hooded Euphonia	*Euphonia elegantissima*
Red-headed Tanager	*Piranga erythrocephala*
Black-headed Saltator	*Saltator atriceps*
Yellow Grosbeak	*Pheucticus chrysopeplus*
Rose-bellied Bunting	*Passerina rositae*
Orange-breasted Bunting	*Passerina leclancherii*
Rufous-capped Brushfinch	*Atlapetes pileatus*
Green-striped Brushfinch	*Atlapetes virenticeps*
Rusty-crowned Ground-Sparrow	*Melozone kieneri*
Collared Towhee	*Pipilo ocai*
White-throated Towhee	*Pipilo albicollis*
Blue-black Grassquit	*Volatinia jacarina*
Blue Seedeater	*Amaurospiza concolor*
Slaty Finch	*Haplospiza rustica*
Bridled Sparrow	*Aimophila mystacalis*
Black-chested Sparrow	*Aimophila humeralis*
Cinnamon-tailed Sparrow	*Aimophila sumichrasti*
Oaxaca Sparrow	*Aimophila notosticta*
Sierra Madre Sparrow	*Xenospiza baileyi*
Great-tailed Grackle	*Quiscalus mexicanus*
Yellow-winged Cacique	*Cacicus melanicterus*
Hooded Grosbeak	*Coccothraustes abeillei*

MAMMALS

Common Name	Scientific Name
Big Long-nosed Bat	*Leptonycteris nivalis*
Mastiff Bat	*Eumops peroti*
Trumpet-nosed Bat	*Choeronycteris harrisoni*
Northern Yellow Bat	*Lasiurus intermedia*
Virginia Opossum	*Didelphis virginiana*
Two-toed Anteater	*Cyclopes didactylus*
Nine-banded Armadillo	*Dasypus novemcinctus*
Eastern Cottontail	*Sylvilagus floridanus*
Volcano Rabbit	*Romerolagus diazi*
White-sided Jackrabbit	*Lepus callotis*

Humpback Whale	*Megaptera novaeangliae*
Coyote	*Canis latrans*
Gray Fox	*Urocyon cinereoargenteus*
Kit Fox	*Vulpes macrotis*
Raccoon	*Procyon lotor*
Coatimundi	*Nasua nasua*
Kinkajou	*Potus flavus*
Long-tailed weasel	*Mustela frenata*
Badger	*Taxidea taxus*
Southern River Otter	*Lutra longicaudis*
Jaguar	*Felis onca*
Mountain Lion	*Felis concolor*
Ocelot	*Felis paradilis*
Margay	*Felis wiedii*
Jaguarundi	*Felis yagouaroundi*
Bobcat	*Lynx rufus*
Baird's Tapir	*Tapirus bairdii*
Collared Peccary	*Dicotyles tajacu*
White-tailed Deer	*Odocoileus virginiana*

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