Peer Reviewed

Wildlife Conservation and Management in Mexico

RAUL VALDEZ,[1] *New Mexico State University, Department of Fishery and Wildlife Sciences, MSC 4901, Las Cruces, NM 88003, USA*
JUAN C. GUZMÁN-ARANDA,[2] *Colegio de Postgraduados, Campus San Luis Potosí, Iturbide 73, Salinas de Hidalgo, San Luis Potosí 78600, Mexico*
FRANCISCO J. ABARCA, *Arizona Game and Fish, Phoenix, AZ 85023, USA*
LUIS A. TARANGO-ARÁMBULA, *Colegio de Postgraduados, Campus San Luis Potosí, Iturbide 73, Salinas de Hidalgo, San Luis Potosí 78600, Mexico*
FERNANDO CLEMENTE SÁNCHEZ, *Colegio de Postgraduados, Campus San Luis Potosí, Iturbide 73, Salinas de Hidalgo, San Luis Potosí 78600, Mexico*

Abstract

Mexico's wildlife has been impacted by human land use changes and socioeconomic and political factors since before the Spanish conquest in 1521. Presently, it has been estimated that more than 60% of the land area has been severely degraded. Mexico ranks in the top 3 countries in biodiversity, is a plant and faunal dispersal corridor, and is a crucial element in the conservation and management of North American wildlife. Wildlife management prerogatives and regulatory powers reside in the federal government with states relegated a minimum role. The continuous shifting of federal agencies responsible for wildlife management with the concomitant lack of adequate federal funding has not permitted the establishment of a robust wildlife program. In addition, wildlife conservation has been further impacted by a failure to establish landowner incentives, power struggles over user rights, resistance to change, and lack of trust and experience in protecting and managing Mexico's wildlife. We believe future strategies for wildlife programs must take into account Mexico's highly diversified mosaic of ecosystems, cultures, socioeconomic levels, and land tenure and political systems. The private sector, along with communal properties, in cooperation with federal and municipal governments, nongovernmental organizations, corporations, and international agencies may have the greatest potential of sustainable management of Mexico's wildlife. The present federal wildlife management strategy is an initial positive effort because it promotes participatory wildlife conservation by key stakeholders. We identify the aspects of this strategy that we believe will be needed to establish a sustainable program to manage Mexico's wildlife. (WILDLIFE SOCIETY BULLETIN 34(2):270–282; 2006)

Key words

biodiversity, conservation, laws, Mexico, policy, wildlife management.

The United Mexican States encompass an area of 1,972,000 km^2 and are comprised of 31 states and a federal district. Mexico is bounded in the north by the United States of America (USA) and in the south by Guatemala and Belize. The boundary with the USA extends 3,115 km. It is bordered in the east by the Gulf of Mexico and in the west by the Pacific Ocean. Mexico is divided into almost equal north and south parts by the Tropic of Cancer. It is the world's largest and most populous Spanish-speaking nation with an estimated population of 104,960,000 in 2004 (McGeveran 2004). It is the 14th-largest country but ranks third in biodiversity (McNeely et. al. 1990, Ramamoorthy et al. 1993).

Mexico's large size, great diversity of terrestrial, freshwater, and marine habitats, geomorphological features, climatic zones, and fauna and vegetation, and its zoogeographic position as the transition zone between New World temperate and tropical regions establish it as a crucial element in the conservation and management of North American wildlife and the world's biodiversity. For example, it is an important wintering area and migratory corridor for temperate North American nesting birds. Fifty-one percent of the bird species of the USA and Canada spend 6–9 months a year in Mexico (McNeely et al. 1990). It also is a major center for plant origins and domestication, a plant and faunal dispersal corridor, and is noted for its large number of endemics. Mexico's wildlife historically has been impacted by human land use patterns influenced by socioeconomic and political factors that have resulted in mismanagement of its wildlife resources and decreased biodiversity.

In this paper we review the status of wildlife conservation and management in Mexico, which has not been updated since the seminal work of Leopold (1959). In addition, we review the political, ecological, and socioeconomic issues associated with managing Mexican wildlife and their habitats. Finally, we discuss potential strategies for resolving the multifaceted wildlife management challenges of Mexico's terrestrial wildlife, principally game birds and mammals.

Climate, Geography, and Phytophysiography

Climate varies greatly across the country with 56% of Mexico's land area in arid or semiarid lands (northcentral and northwestern Mexico), 37% in subhumid terrain (temperate forested areas and coastal areas in the Atlantic and Pacific sides), and 7% in humid zones (southeastern Mexico). Annual precipitation varies from 100–200 mm in northcentral Mexico to 2,000–4,000 mm in southeastern Mexico (Tamayo 1990, De Alba and Reyes 1998).

The Central Mexican Plateau (Fig. 1) is composed principally of the Chihuahuan Desert and rises from the U.S. border south to Mexico City. The Plateau is bordered in the east by the Sierra Madre Oriental and in the west by the Sierra Madre Occidental. The Sierra Madre Occidental extends about 1,300 km and averages about 190 km in width. About 65% of this range is between 2,000 and 3,000 m and most is dominated by a temperate-humid climate. The Sierra Madre Oriental extends about 250 km in its north–south sector and 455 km in its transverse sector. This range averages about 130 km; the greater part lies at an elevation of 1,000–2,000 m, and its climate is

[1] *E-mail: rvaldez@nmsu.edu*
[2] *Present address: PROFAUNA—Capítulo Chihuahua, Colonia Pacífico, Chihuahua, Chihuahua 31030, Mexico*

Figure 1. Major physiographic features of Mexico.

temperate. The longest mountain range in the south is the Sierra Madre del Sur which extends from the Trans-Mexican Volcanic Belt to Oaxaca. Its climate ranges from tropical to temperate. The Sierra Madre de Chiapas, dominated by a tropical climate with dry winters, and the Yucatan Platform, dominated by a tropical rainy climate, occur in southern-most Mexico (Tamayo 1990, Ferrusquía-Villafranca 1993).

Toledo and Ordoñez (1993) recognized 6 basic terrestrial habitats or ecological zones (humid tropic, subhumid tropic, humid temperate, subhumid temperate, arid and semiarid, and alpine) based on vegetation, climate, and biogeography of Mexico. The arid and semiarid zone (ASA) was the largest, occupying an estimated area of 99 million (M) ha of scrub and grassland followed by the subhumid tropic (STR; 40 M ha) of deciduous forest, subhumid temperate (STE; 33 M ha) of pine, oak, and mixed forest, humid tropic (HTR; 22 M ha) of evergreen forests and savannahs, humid temperate (THE; 1 M ha) of mixed forests, and alpine zone (ALP; 0.3 M ha). The ASA zone (6,000 plant species) occupied >50% of the land area of Mexico, varied in annual rainfall from <40–700 mm, and was high in plant and animal endemics, especially amphibians and reptiles. The STR zone (6,000 plant species), covering 17% of Mexico and situated principally in the coastal areas and southern Mexico, was characterized by a hot climate and a dry period of 5–9 months and tropical deciduous forests. The STE zone, comprising 14% of the land area and concentrated in mountainous areas, was dominated by pines and oaks. It had a high diversity of flowering plants (7,000 species), conifers, oaks, and vertebrates, including a high proportion of endemics. The HTR zone, occurring in the southern and southeast Mexico, was characterized by high rainfall (2,000 mm), medium and tall forest trees and savannas, and high biodiversity (having about 5,000 species of angiosperms); within 1,000 ha, there can be >1,000 plant, 300 bird, and 150 herptile species. The HTE, occurring in 3% of the land area and situated at 600–2,500 m in mountain chains principally in eastern and southern Mexico, had temperate and tropical elements with about 3,000 angiosperm species. The ALP zone, occurring at >4,000 m and principally in the eastern Sierra Madre and transvolcanic belt, was noted for its high percentage of plant endemism.

Biodiversity of Mexico

Mexico has particularly high gamma and beta diversities. The high climatic and biological diversity in Mexico is a consequence of several factors, including 1) sharp contrasts in landscape attributed to changes in latitude and altitude (e.g., approximately 50% of Mexico is at an elevation >1,000 m), 2) convergence of coastal areas with mountainous systems, which influences rain and temperature patterns, 3) convergence of the Nearctic and Neotropical regions, and 4) a complex geological history. A significant number of plants and animals endemic to Mexico evolved since the late Pleistocene epoch (Neyra-González and Durand-Smith 1998).

Toledo and Ordoñez (1993) estimated that Mexico contains 8–12% of the world's total plant and animal species which ranks it the third-most-important country in biodiversity. It contains all of the 5 natural regions, 9 of 11 habitat types, and 51 of 191 ecoregions found in Latin America, which ranks it as the most diverse in the region. Fourteen Mexican ecoregions are considered a world conservation priority (Neyra-González and Durand-Smith 1998). It ranks first in the number of reptile species (717) and when combined with amphibians (285 species), it contains 9.8% of the world's herpetofauna and the most diverse (Flores-Villela 1993). It has the second-largest number of terrestrial mammal species (456 species) of which 79% are comprised of rodents (215 species) and bats (133 species) and the fourth-highest number of angiosperm species (26,000) in the world (Neyra-González and Durand-Smith 1998).

Large game mammals include 4 cervids: mule (*Odocoileus hemionus*) and whitetail (*O. virginianus*) deer, and brown (*Mazama gouazoupira*) and red brocket (*M. americana*) deer; 2 bovids: pronghorn (*Antilocapra americana*) and bighorn sheep (*Ovis canadensis*); 2 large felids: puma (*Puma concolor*) and jaguar (*Panthera onca*); 4 small felids; one tapir (*Tapirus bairdii*); 2 peccaries: collared (*Pecari tajacu*) and white-lipped (*P. pecari*); and one bear: black (*Ursus americanus*). Extinct large mammalian species include the grizzly bear (*Ursus arctos*), bison (*Bison bison*), wolves (*Canis lupus*), black-footed ferret (*Mustela nigripes*), monk seal (*Monachus tropicalis*), and sea otter (*Enhydra lutris*; Fa and Morales 1993, Peña-Jiménez and Neyra-González 1998). There are 40 species of game mammals and 55 species of game birds. Mexico has 1,007 species of birds, which represent 30% more species than the USA and Canada combined even though Mexico encompasses an area only 11% of their combined size. Galliform species include 5 tinamids, 35 anatids, 6 cracids, 17 phasianids including 2 turkey species (*Meleagris* spp.). There are 24 species of columbids. Extirpated and extinct large avian species include the California condor (*Gymnogyps californianus*) and the imperial woodpecker (*Campephilus imperialis*), respectively (Pliego et al. 1993). There are 21,600 known plant species in Mexico but it is estimated there may be as many as 29,000–34,000 total species. Mexico has more species of Asteraceae (323 genera and 2700 species), Agavaceae, and Pinaceae (54 species) than any other country (Perry 1991, Rzedowski 1993, Styles 1993, Challenger 1998).

Mexico also is exceptional in the number of endemic species. Of the 900 species of Cactaceae in Mexico, 687 are endemics as are 1,700 species of Asteraceae, and 48 species of Agavaceae. The

total percentage of vascular plant endemic genera is between 10% and 15% and includes 11,440 endemic species (Rzedowski 1993). Endemism is also high among vertebrates, of which 31.7% are restricted to Mexico. Among individual vertebrate orders, 32% of the mammals, 13% of the birds, 51% of the reptiles, 61% of the amphibians, and 32% of freshwater fishes are endemics (Ceballos and Navarro L. 1991, Arita 1993, Espinosa et al. 1993, Ceballos et al. 1998, Challenger 1998, Neyra-González and Durand-Smith 1998).

Land Tenure Systems in Mexico

The socioeconomic trends and their detrimental impacts on Mexico's natural resources have forced government agencies to seek alternatives in managing natural resources, resulting in major changes in land use laws. There are 3 major land tenure types (i.e., federal, private, and communal lands). After the Mexican revolution (1910–1917), the government established a collective land reform program in which lands were expropriated from large private landowners and redistributed to landless peasants. The 2 most common types of communal lands were ejidos and comunidades. Comunidades are primarily Indian communal landholdings which characterized land ownership before the Spanish conquest and were formally recognized as a land tenure system after the Mexican Revolution. Ejidos are another form of communal property in which land is distributed to a group of individual peasants but land ownership resides with the ejido community rather than the individual. The redistribution reform law stipulated the redistributed lands remained the property of the federal government. The administration and management of these lands and their resources are collective. In addition to agriculture, ejidos can participate in mining, forestry, wildlife conservation, handicrafts, and tourism. Communal property owners have to manage resources productively in order to retain the right to exploit them. However, there was a lack of incentives in terms of credits or income for conservation practices. Wildlife was not considered an economically viable resource and, consequently, efforts were not made to manage wildlife (Guzmán-Aranda 1995).

The ejido system has been criticized because it has been considered less productive than private enterprises (LaBaume and Dahl 1986, Yates 1980 cited in Wilson and Thompson 1992). Wishing to create future economic growth and stability and resource-augmenting technology through private investment, the federal government passed regulatory changes in 1991 which allowed, among other changes, the sale of ejidos (Wilson and Thompson 1992). Nonetheless, ejidos are the second-largest form of land tenure in Mexico. About half of the rural lands of Mexico are comprised of 28,000 ejidos occupied by over 3 million ejidatarios (communal land owners) and their families (Harvey 1996). Up to 80% of the forests of Mexico are managed in ejidos or indigenous communities (Bray and Wexler 1996).

International Wildlife and Biodiversity Collaborations

In the 1900s Mexico established a policy of active participation in international wildlife programs. It became a signatory of the Migratory Bird Act in 1936, Man and the Biosphere Program in conjunction with the United Nations in 1977, the Ramsar Convention of Wetlands in 1986, Convention on International Trade in Endangered Species and Convention on Biodiversity in 1993, the North American Agreement on Environmental Cooperation in 1993, and the North American Waterfowl Management Plan in 1994 (Secretaría de Medio Ambiente, Recursos Naturales y Pesca [SEMARNAP] 1997). In 1996 the wildlife conservation agencies of the USA, Mexico, and Canada signed a memorandum of understanding establishing the Canada–Mexico–United States Trilateral Committee for Wildlife and Ecosystem Conservation and Management. The Trilateral Committee was created to facilitate and enhance cooperation and coordination among the wildlife agencies of the 3 nations in projects and programs for the conservation and management of wildlife, plants, biodiversity, and ecosystems of mutual interest, including species of special concern, migratory species and wetlands. The Trilateral is one of Mexico's most significant international wildlife agreements because it implements a multitude of conservation projects ranging from biological inventories to capacity building. Mexico also is a collaborator in the Mesoamerican Biological Corridor which promotes the sustainable use of biodiversity in rural populations in Central America.

National Natural Protected Areas

National Natural Protected Areas (NPAs) consist of terrestrial and aquatic ecosystems where the environments have not been significantly altered by human activities and which provide diverse ecosystem services. Each designated protected area decree specifies which land uses and activities are allowed within the protected area. Most NPAs are inhabited by native and rural communities and some form of natural resource exploitation usually is allowed within protected areas. The National Commission of Natural Protected Areas (Comisión Nacional de Areas Naturales Protegidas [CONANP]) within the Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT]) is responsible for the protection, restoration, and sustainable use of natural resources, principally fauna and flora, within NPAs. By 2004 there were 148 national protected areas encompassing 17.8 million ha or 8.8% of the land area of Mexico (CONANP 2004). Protected areas include biosphere reserves, national parks, national monuments, areas for the protection of natural resources, areas for the protection of flora and fauna, and sanctuaries. Protected areas encompass habitats rich in wildlife and, consequently, wildlife conservation is a priority in many areas (Martinez 2003).

Prior to 1994 most of NPAs lacked sound and comprehensive management plans. Between 1994 and 2000, management plans were developed for approximately 30% of existing and newly created NPAs (Table 1). However, the NPA model, and, hence, the development of strategic management plans, not only lacked detailed information but in many cases could be considered obsolete (Guzmán-Aranda 2004). Also, most NPAs are comprised of conflicting land ownership interests because they are a composite of different land tenure types, including public, private, and communal lands. Hence NPAs are required to promote sustainable natural resource use but this goal often is unattainable because management plans often are compromised (Guzmán-Aranda 2004).

Table 1. List of federal natural protected areas in Mexico with date of management plans of those issued since 1995.

Management plan	Date of Plan	State(s)
Biosphere reserves (MAB-UNESCO)		
1. Management Program for the BR Sian Ka'an	01/1996	Quintana Roo
2. Management Program for the BR Alto Golfo de California y Delta del Rio Colorado	12/1996	Sonora and Baja California
3. Management Program for the BR El Triunfo	04/1999	Chiapas
4. Management Program for the BR Sierra Gorda	09/1999	Quintana Roo
5. Management Program for the BR Calakmul	11/1999	Campeche
6. Management Program for the BR Manantlan	01/2000	Jalisco-Colima
7. Management Program for the BR El Vizcaino	05/2000	Baja California Sur
8. Management Program for the BR Montes Azules	05/2000	Chiapas
9. Management Program for BR Islas del Golfo de California	11/2000	Baja California, Baja California Sur, Sonora, Sinaloa
Biosphere reserves (Mexico)		
1. Management Program for the BR El Pinacate y Gran Desierto del Altar	12/1995	Sonora
2. Management Program for the BR La Sepultura	10/1999	Chiapas
3. Management Program for the BR La Encrucijada	10/1999	Chiapas
4. Management Program for the BR Ria Lagartos	11/1999	Yucatán – Quintana Roo
5. Management Program for the BR Pantanos de Centla	02/2000	Tabasco
6. Management Program for the BR Banco Chinchorro	05/2000	Quintana Roo
National parks		
1. Management Program for the Parque Nacional Isla Contoy	05/1997	Quintana Roo
2. Management Program for the Parque Marino Nacional Arrecifes de Cozumel	05/1998	Quintana Roo
3. Management Program for the Parque Marino Nacional Costa Occidental de Isla Mujeres, Punta Cancun y Punta Nizuc	05/1998	Quintana Roo
4. Management Program for the Parque Nacional Cumbres de Majalca	05/1999 (revision)	Chihuahua
5. Management Program for the Parque Marino Nacional Arrecife de Puerto Morelos	10/1999	Quintana Roo
6. Management Program for the Parque Nacional Bahía de Loreto	11/2000	Baja California Sur
Flora and fauna protection areas		
1. Management Program for the APFF Maderas de Carmen	05/1997	Coahuila
2. Management Program for the APFF Cañon de Santa Elena	07/1997	Chihuahua
3. Management Program for the APFF Laguna de Términos	08/1999	Campeche
4. Management Program for the APFF Cuatrocienegas	11/1999	Coahuila

Evolution of Mexico's Wildlife Laws, Policy, and Administration

Native American cultures had been managing wildlife and habitats long before the Spaniards imposed their management schemes in Mexico in 1521. The Mayan Indians exploited the land through intensive agriculture, cleared forests, harvested wild plants, hunted and fished resulting in soil erosion, habitat destruction, and locally depleted wildlife populations. This resulted in the first implementation of laws to limit the exploitation of forests and wildlife. Apart from its utilitarian value, wildlife had cultural and esthetic values. During the Aztec period, the estimated human population of over 1 million in the Basin of Mexico alone exerted environmental pressures over a wide area (Deneven 1992, Simonian 1995, Challenger 1998).

The Spaniards greatly exacerbated environmental impacts through mining, lumbering, ranching, widespread agricultural schemes, and unregulated hunting and fishing. They also introduced livestock resulting in the overutilization of rangelands and extensive transformation of wildlife habitats which continues to the present (Simonian 1995). Large tracts of land were privatized and divided into estates (*haciendas*) which were governed like fiefdoms. The management and exploitation of natural resources were largely the prerogative of the hacienda owner. There were few social reforms in land tenure after the independence of Mexico in 1821. It was not until after the Mexican Revolution (1910–1917) that land reform resulted in rangelands and farmlands being distributed to formerly landless peasants. Although the necessity to protect forests and wildlife was sometimes recognized, national economic and social pressures prevented meaningful wildlife and other restrictive natural resource exploitation laws to be passed or enforced (Simonian 1995, Challenger 1998).

The recognition of the importance of wildlife conservation through the creation of federal administrative agencies and enactment of laws to administrate and manage wildlife populations and habitats has accelerated rapidly in the last 30 years. Protective wildlife laws date from 1894 when a federal department of game and fish was first established. Wildlife authority subsequently was subsumed in various agencies. Examples of early wildlife protective measures include a presidential decree issued in 1922 that placed a 10-year moratorium on the hunting of bighorn sheep and pronghorn antelope. In 1936 the USA and Mexico signed the Treaty for the Protection of Migratory Birds and Mammals which established cooperative wildlife conservation programs including a 4-month hunting season for migratory birds. Another significant waterfowl protective measure was the banning

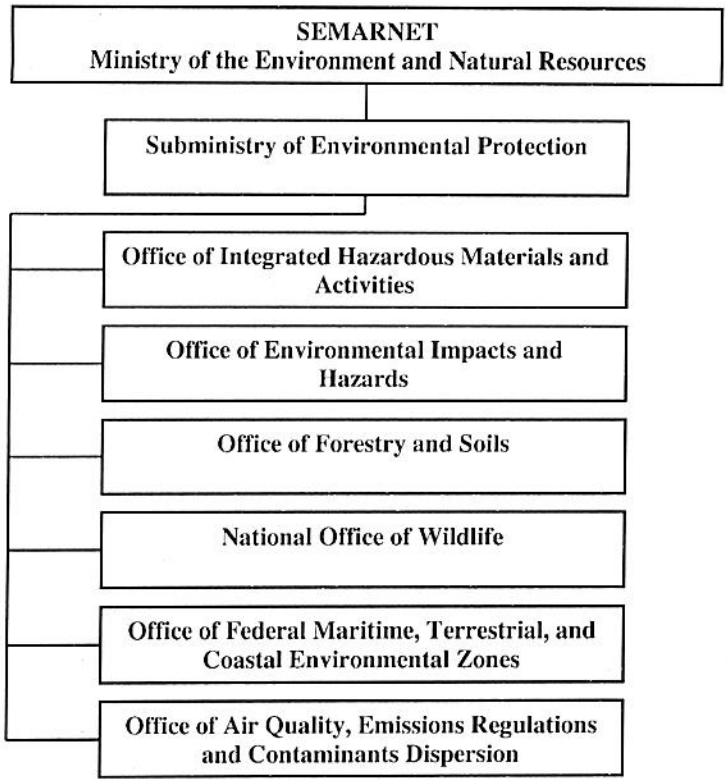


Figure 2. Administrative structure of Secretaría de Medio Ambiente y Recursos Naturales within the Subministry of Environmental Protection which includes the National Office of Wildlife.

of armadas (lines of guns rigged to shoot simultaneously) used to kill large numbers of ducks simultaneously (Simonian 1995).

It was not until 1940 that the first federal game law was passed and then revised in 1951. The 1951 revision, known as the Federal Game Law and which went into effect in 1952, established wildlife as public property and the federal government its legal custodian. This game law was the first attempt to specifically protect game species. It forbade the commercialization of wildlife raised in captivity or free-roaming including hunted species, the exportation of game species dead or alive, proscribed the use of poisons to kill wild animals, and required that hunters belong to a wildlife-related sportsmen organization such as a hunting club (Leopold 1959, Simonian 1995).

A federal agency was established to specifically deal with game animals with the creation of the Office of Forestry, Hunting, and Fishing and in 1964 elevated to the Office of Wildlife, both under the Subministry of Forestry Resources and Hunting. In 1982 wildlife management and law enforcement became the responsibility of the Ministry of Urban Development and Ecology (Secretaría de Desarrollo Urbano y Ecología [SEDUE]), and specifically of the Subministry of Ecology within the Office of Flora and Wildlife. In 1992 SEDUE was dissolved and jurisdiction over wildlife was divided between the Ministry of Social Development (Secretaría de Desarrollo Social [SEDESOL]) and the Ministry of Agriculture and Water Resources (Secretaría de Agricultura y Recursos Hidraúlicos [SARH]). The SEDESOL assumed all law enforcement functions, including setting hunting permit numbers and seasons. The National Institute of Ecology (Instituto Nacional de Ecología [INE]), an agency within SEDESOL, was responsible for issuing research permits and the capture and transportation of wildlife. In 1994 wildlife management authority was placed under the newly created Ministry of the Environment, Natural Resources, and Fisheries (Secretaría de Medio Ambiente, Recursos Naturales y Pesca [SEMARNAP]) in the Office of Wildlife within INE. In 2001 SEMARNAP was renamed the Ministry of the Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT]) and wildlife management responsibilities elevated to the Office of Wildlife, under the Subministry of Environmental Protection and independent of INE (Fig. 2). Responsibility of fisheries was relegated to the Ministry of Livestock, Agriculture, Rural Development, Fisheries, and Foods (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca, y Alimentación [SAGARPA]). Currently, wildlife law enforcement is under the jurisdiction of the Federal Agency of Environmental Protection (Procuraduría Federal de Protección del Ambiente [PROFEPA]) within SEMARNAT (Simonian 1995, Ruiz de Velasco 1999, Instituto Nacional de Ecología 2000).

The federal Office of Wildlife is responsible for conserving and protecting the biodiversity of Mexico, and the management and sustainable use of the fauna and vegetation and their habitats including endangered species, turtles, marine mammals, and endangered aquatic species. Specifically, it issues all permits and certifications relating to wildlife health and diseases and the authorization for the capture, collecting, research, production, possession, management, all matters relating to importation and exportation, and the shipment and transit within Mexico of all specimens and byproducts of native and exotic wildlife (Instituto Nacional de Ecología 2000).

Galindo-Jaramillo and Loa-Loza (1998) identified 3 modern environmental conservation eras in Mexico. The first era occurred during the 1970s, during which the Ministry of Health and Assistance addressed issues related mainly to pollution and health of the human environment. During that era the Mexican government restricted biodiversity conservation to regulation of forest and wildlife uses, and protection of charismatic species. The second era occurred during the 1980s, when protection of the environment was institutionalized and linked with national development policies. Events which characterized this decade included 1) creation of SEDUE with the purpose of linking biodiversity with environmental pollution, 2) passage of a stringent and extensive environmental law (General Law on Ecological Balance and Environmental Protection [LGEEPA]) in 1988, and 3) creation in 1989 of the National Commission of Water (Comisión Nacional del Agua [CNA]). The third era started in the early 1990s and introduced 5 key elements of the current status of the environmental policy in the country. These key elements were 1) the creation of SEDESOL, INE, and PROFEPA in 1992, 2) establishment in 1994 of SEMARNAP, 3) the updating in 1996 and subsequent revision in 2001 of LGEEPA, 4) issuance of the new wildlife conservation and management law in 2000 titled General Wildlife Law (Ley General de Vida Silvestre [LGVS]; SEMARNAT 2000), and 5) the issuance of the Official Mexican Norms (NOMs) beginning in 1994 to improve the administration of natural resources (Galindo-Jaramillo and Loa-Loza 1998, McBride 2000).

The LGVS is the most comprehensive wildlife legislation ever enacted in Mexico. Approved by the Mexican Congress in April 2000, it contains general provisions on the sustainable use of wildlife; incentives for land owners; cooperation among federal, state, and municipal governments and private individuals; wildlife diseases; ethical use of wildlife; restrictions on exotic species, wildlife research and rehabilitation centers; wildlife use by indigenous people; environmental education; species at risk and their critical habitat; reintroduction and translocation protocols; scientific collection permits; control of nuisance species; and law enforcement investigations and citations (Instituto Nacional de Ecología 2000, SEMARNAT 2000).

Current Wildlife Management Policy

Mexico's most ambitious wildlife conservation and management initiative is incorporated in the Wildlife Conservation and Production Diversification in the Rural Sector (Programa de Conservación de la Vida Silvestre y Diversificación Productiva en el Sector Rural) which was initiated in 1997. The major objective of this program is to integrate environmental, economic, social, and legal strategies to address wildlife needs while promoting broader societal participation and creating realistic economic incentives. This program promotes participatory conservation opportunities by involving key stakeholders in management decisions (Instituto Nacional de Ecología 2000).

This program was spearheaded by 2 strategies, the conservation and recovery of priority species, and the creation of a system of wildlife management units that emphasize the conservation, management, and sustainable use of wildlife. Priority species can be plants or animals and include those that are threatened or endangered, umbrella and charismatic species, and those that possess a cultural or economic value. Vertebrate priority species include the pronghorn, Mexican wolf (reintroduction program), black bear, desert bighorn (*O. c. mexicana*), jaguar, several species of sea turtles, gray whale (*Eschrichtius robustus*), golden eagle (*Aquila chrysaetos*), 2 species of macaws (*Ara* spp.), and crocodiles (*Crocodylus* spp.), among others (Diario Oficial de la Federación 1999, Instituto Nacional de Ecología 2000).

Management objectives for each priority species are coordinated by a Species-Specific Technical Advisory Committee comprised of landowners, biologists and other professionals, and community members. The members of committees are appointed by SEMARNAT. These committees also are responsible for incorporating societal concerns in conservation strategies.

Wildlife conservation units, officially titled Wildlife Conservation, Management, and Sustainable Utilization Units (Unidades para la Conservación, Manejo y Aprovechamiento Sustentable de la Vida Silvestre [UMAs]) also were an integral part of this program. The basic concept of wildlife units was to create economic incentives for the judicious management of wildlife resources by facilitating the integration of wildlife management programs in livestock, forestry, and agricultural schemes. Wildlife uses (including plants) within UMAs are broadly interpreted to include research, recreation, game parks, environmental education, game farms, and commercialization of wildlife byproducts which can be marketed through regulated laws. The UMAs are classified as extensive or intensive. Extensive units are those in which wildlife is free ranging such as game ranches. Intensive units are those in which wildlife or plants are raised under intense and controlled management schemes such as in botanical and zoological parks and wild animal breeding programs such as crocodile farms (Instituto Nacional de Ecología 2000).

The UMAs can vary in size depending on management objectives and economic viability. All UMAs must be registered with the federal Office of Wildlife (Dirección General de Vida Silvestre [DGVS]) and include a management plan. The management plan must include censusing and monitoring methods, species-specific use criteria, harvest verification, and protection of wildlife to prevent illegal use. By 2004 there were 5,893 registered units encompassing 20.5 million ha. Approximately 88% of these units include game-ranching and captive-breeding programs (SEMARNAT 2004).

Hunting Regulations

The Mexican Hunting Calendar, a publication issued yearly by SEMARNAP until 1997, established regulations for licenses, bag limits, hunting seasons, areas closed to hunting, and age and sex of game permitted to be hunted. Prior to the 1997–1998 hunting season, game animals were allowed to be hunted within designated regions within each state and categorized into 6 permit types with appropriate hunting seasons as follows: Type I (waterfowl: 33 taxa of ducks and geese) with open seasons from 13 October–11 February; Type II (columbiforms: 7 taxa) with seasons established for different species; Type III (galliforms: 14 taxa) with species-specific seasons; Type IV (small game: 30 taxa which include mammals such as squirrels [Sciuridae], lagomorphs, and meso-predators such as coyotes [*Canis latrans*] and raccoons [*Procyon lotor*]); Type V (limited permits for specific game birds and mammal species such as puma, peccaries, deer, tinamous [*Tinamus major* and *Crypturellus* spp.] and turkeys) with species-specific seasons; and Type VI (special permits issued for 3 species of artiodactyls in specific regions, i.e., bighorn sheep and mule deer in Sonora, and white-tailed deer [*O. v. texanus*]) in northeastern Mexico, with a hunting season from 9 December–28 January. Beginning in the 1998–1999 season, extractive sustainable sport hunting was allowed only in areas officially registered as UMAs (Fideicomisos Instituidos en Relación con la Agricultura [FIRA] 1998, Instituto Nacional de Ecología 2000).

During the 1999–2000 season, sport hunting permits were reduced to 2 types: game birds and game mammals, which incorporated those species originally under Types V and VI, and for which purchase of a big game tag became a requirement (Martinez 2003). All hunting permits are issued to UMAs who must formally request hunting permits to DGVS in Mexico City. The UMAs submit applications for a specific number of hunting permits which are based on their game censuses. The DGVS reviews the request and issues the appropriate number of permits. The UMAs then sell the permits to hunters. All revenues generated by the sale of hunting licenses revert to the federal treasury and none are specifically targeted for wildlife conservation.

Most of the hunting permits are sold to bird and big game hunters, principally for hunting white-tailed deer and doves in northern Mexico. During the 1996–1997 hunting season, 7,432

white-tailed deer permits were issued. The largest numbers of permits were issued in the following states: Sonora, 2,723; Nuevo Leon, 1,310; Coahuila, 1,166; Tamaulipas, 1,020; and Chihuahua, 579. All of these are northern states which border the USA. No other state was issued greater than 160 permits. Over 90% of the big game hunting permits were issued to foreign hunters (FIRA 1998). During the 1999–2000 hunting season, 7,639 big game tags (mule and white-tailed deer and wild sheep) were issued (Martinez 2003). Relative to game birds, in 1986 an estimated 2.4–3.2 million white-winged doves were harvested by American hunters in the combined states of Tamaulipas, Nuevo Leon, and Coahuila (Purdy and Tomlinson 1991) in northeastern Mexico. Foreign hunters are an integral part of the successful hunting programs in Mexico, especially in northern states; much of the advertising by outfitters in magazines and hunting conventions is targeted at American hunters. There also is a developing effort to expand hunting enterprises in central and southern Mexico to accommodate Mexican and foreign hunters.

Threats to Wildlife of Mexico

Mexico's wildlife is threatened by a host of environmental impacts whose roots lie in the burgeoning population growth of the country. The major direct threats are due to deforestation, mismanagement of livestock resulting in over-utilization and degradation of rangeland resources, unregulated agricultural enterprises, drainage of wetlands, dam construction, industrial pollution, and illegal exploitation of plant and animal resources (Challenger 1998). More than 60% of the land area has been severely affected by land degradation (Middleton and Thomas 1997); an estimated 80% of the country is affected by soil erosion, impacting one-third of Mexico's 31 states (Landa et al. 1997). Two-thirds of the poor of Mexico are farmers engaged in subsistence farming which is dependent on highly variable precipitation patterns, historically resulting in soil erosion. Because of the lack of permanent monitoring, deforestation rates in Mexico are difficult to estimate, but they range between 450,000 and 1,500,000 ha/year (Landa et al. 1997). The impact to wildlife habitats is especially devastating in tropical Mexico where forests could be eliminated in the next century (Bray and Wexler 1996). While the negative impacts of invasive species and wildlife diseases have been widely documented worldwide (Stedman-Edwards 2000), information relative to these threats in Mexico is limited.

Clearing of forests and grasslands for agriculture and livestock production constitute the greatest threat to conservation of terrestrial wildlife and ecosystems in Mexico (Garcia-Barrios et al. 1998, Peña-Jiménez and Neyra-González 1998, Zabin 1998). Between 1990 and 2000, Mexico converted 631,000 ha of forested land to agricultural use annually at a rate of 1.8%, one of the highest rates in North and Central America. Toledo et al. (1989) estimated it could be as high as 4% annually. About 95% of the original tropical forest, 50% of temperate forest, 65% of wetlands, and a significant, but unquantified percentage of grasslands and shrublands have been destroyed or altered (Peña-Jiménez and Neyra-González 1998, Abarca 2002). Although official estimates indicate that the 20 million ha of arable land in Mexico have remained stable over the last 20 years, these estimates do not include abandoned or newly cleared areas for agriculture (Peña-Jiménez and Neyra-González 1998).

Areas in Mexico that display some of the highest biological diversity, such as in the states of Oaxaca, Chiapas, and Guerrero in southern Mexico, also are home to some of the poorest people in the country. De Alba and Reyes (1998) estimated that 14 million people in Mexico (15.4% of the population) are unable to fulfill their basic needs. Living conditions for the poor have continued to worsen over the last 10 years because benefits and costs of conservation are not shared equally, and the number and quality of jobs have not increased (Peña-Jiménez and Neyra-González 1998). In addition, wildlife resources have been deleteriously impacted by a failure to establish landowner incentives, power struggles over user rights, resistance to change, and lack of trust and experience in protecting and managing Mexico's wildlife.

Environmental degradation in Mexico is not associated exclusively with poor farmers. Modern irrigation practices have led to salinization, desertification, and pollution of soils and waters, and traditional dryland farming has caused considerable soil erosion. Approximately 78% of Mexico's land area (154 million ha) is subject to erosion attributed to agriculture, deforestation, and grazing (Landa et al. 1997, Secretaría de Desarrollo Social [SEDESOL] 1994 cited in Peña-Jiménez and Neyra-González 1998). From 1950–1990, the area dedicated to cattle raising increased by 260%, from 50 million ha to 130 million.

Examples of direct and indirect threats to wildlife and habitats have been documented in the Calakmul Biosphere Reserve of the Yucatan Peninsula of southern Mexico. The 725,000 ha of lowland tropical forest in the state of Campeche provides habitat for endangered species and is an important refuge for migratory birds. It is one of only 2 reserves large enough to support viable jaguar populations in Mexico. The area sustains probably the greatest biodiversity and mammalian endemism, and supports the largest remnant of tropical rainforest, in Mexico (Medellin 1994). Logging, unmanaged subsistence hunting, vegetation extraction, shifting agriculture, oil exploitation, immigration (initially due to government programs to attract migrants to the area) in conjunction with rapid population growth, poverty, lack of education and limited availability of reproductive health services have resulted in unsustainable resource exploitation, habitat loss, and degraded habitats for wildlife. Many of the communities will double in human population size within 10 years (Medellin 1994, Escamilla et al. 2000, Stedman-Edwards 2000).

Although Mexico signed the CITES treaty in 1991, the illegal trade in wildlife and wildlife products, particularly for birds, reptiles, and ornamental plants, is rampant because of their high demand and lucrative profits. The greatest percentage of this trade is sold in the United States, followed by Europe. Protected species are openly sold in streets and markets. The PROFEPA, the federal agency responsible for enforcing wildlife and environmental laws, is understaffed and underfunded and is unable to adequately enforce existing wildlife laws. Estimates of economic profits from illegal trade of wild species are exceeded only by drug and arms dealing in Mexico (Pérez-Gil et al. 1995, Peña-Jimenez and Neyra-González 1998).

Mexico's failure to sustainably utilize its biodiversity and

consequently wildlife has arisen mostly due to a lack of integration of national development and conservation policies (Simonian 1995). National debt, land tenure reforms, and economic instability problems typically have been addressed with short-term policy shifts that have had disastrous long-term consequences for the environment. This lack of integration also has generated negative public attitudes towards enforcement of environmental laws. Mexico's large debt burden has prevented the government from investing sufficient funds in natural resource conservation programs to adequately resolve wildlife issues. In 1997 the budget for conservation of natural protected areas nationwide was only 23.4 million pesos ($2,127,272 U.S.) or 2.4 pesos/ha (Peña-Jimenez and Neyra-González 1998).

Wildlife continues to be utilized extensively by the diverse indigenous and mestizo Mexican cultures. The federal government recognizes 58 indigenous groups who speak 62 different dialects. They range from the Seris in arid northwestern Mexico to the Mayas in southern tropical rainforests with a total estimated population of >12 million throughout Mexico. Numerous species of animals are utilized as food, traditional medicines, ceremonial purposes, and artcrafts (Bravo and López 1999). Many of these species are regulated by Mexican law but their use by Mexican cultures remains imbedded in traditional customs and subsistence hunting; they often are harvested without regard to wildlife laws (Barrera de Jorgenson and Jorgenson 1995, Jorgenson 1995, Escamilla et al. 2000).

Challenges Facing Wildlife Conservation in Mexico

The continuous shifting of federal agencies responsible for wildlife management in conjunction with the lack of adequate federal funding has not permitted the establishment of a robust wildlife program in Mexico. Unlike the USA where most wildlife resources are managed by state agencies, Mexico has managed wildlife through a centralized system of relatively new and often conflicting federal policies. The federal government's efforts are also stymied by the lack of economic resources, lack of institutional capacity, and lack of trained personnel to resolve the wide range of challenges facing Mexico's wildlife. Mexico's pressing social problems in conjunction with its large federal budget deficits preclude the allocation of adequate funding to protect, manage, and resolve the wide range of challenges facing Mexico's wildlife resources. Wildlife is not a priority. Wildlife management agencies at the state level are practically nonexistent also for lack of funds and the slow process of the federal government to decentralized federal authority. As a consequence, a joint wildlife conservation effort among federal and state agencies, private landowners, ejidos, indigenous communities, and sportsmen failed to materialize in Mexico.

Biodiversity in Mexico, including wildlife, has been only recently recognized as a national priority. The National Commission for the Knowledge and Use of Biodiversity (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO]), established in 1992, initiated the introduction of biodiversity-related issues into the political discourse. During that period, there were several natural resource management agencies created such as SEMARNAP, PROFEPA, CNA, and INE. These new agencies lacked financial resources and experienced resource managers, particularly in the area of biodiversity management. Guzmán-Aranda (2004) evaluated 27 NPA management plans and found that 1) environmental problems, especially those associated with biodiversity and social issues, were poorly defined, 2) management goals and objectives lacked specific indicators of time, geographic location, and wildlife population data, among others, and 3) none of the management plans included the monitoring and evaluation of plan implementation. There is a critical lack of data throughout the country regarding species distribution, status of wildlife populations and their demographics, and habitat quantification, among others. The lack of population data is particularly true of nongame species.

The transformation of Mexico's rural sector, initiated in 1994 with the implementation of NAFTA (Diego-Quintana et al. 1998), contributed to what Whiteford et al. (1998) described as the devolution revolution, that is, the devolution of natural resource user rights to owners and users. The purpose of this revolution is the globalization of principles of privatization and decentralization. Efforts to decentralize are both fiscal (i.e., deferring monetary control from federal to local governments or stakeholders) and managerial (i.e., allocation of administrative power to participating constituencies). This not only affected land tenure but also resources such as fisheries, forests, and rangelands. The decentralization and expansion of user rights are likely to result in the sometimes uncontrolled exploitation of wildlife and other natural resources (De Walt 1998, Garcia-Barrios et al. 1998, Whiteford et al. 1998, Guerrero et al. 2000). The UMAs program was the consequence of this devolution revolution for wildlife.

Since the creation of UMAs in 1997, their numbers have increased rapidly to over 5,000 (SEMARNAT 2004). However, there is a lack of research data to determine whether wildlife is being sustainably harvested and wildlife populations and habitats restored in formerly degraded and depleted areas. Registered UMAs are required only to monitor approved uses but this does not imply that appropriate conservation strategies are being designed or implemented at any level. Because most UMAs focus on game birds and mammals, they are likely to promote single-species management rather than multispecies or ecosystem management strategies. It is unlikely that the federal government can establish monitoring programs and research efforts to determine the efficacy of UMAs because of the lack of institutional capacity, limited financial resources, and lack of expertise in natural resource agencies.

The lack of emphasis on educating Mexican wildlife professionals in the United States and Mexico has also been one of the major failures in developing a strong wildlife program in Mexico. American universities have graduated fewer than 15 Mexican professionals with degrees in wildlife science and only within the last 15 years. American wildlife university professors did not prioritize recruiting Mexican students relative to other foreign students despite the proximity, urgent necessity, and importance of Mexican ecosystems in managing North American wildlife. Mexican universities failed to establish wildlife programs. It was not until 1992 that a wildlife program was established at the graduate level. Wildlife undergraduate university programs in Mexico are nonexistent. Mexico lacked established mechanisms

for recognizing the importance of wildlife (Fortes and Lomnitz 1994), in particular its economic values, especially when incorporated in commercially diversified ranching and agricultural enterprises. This has been a major handicap in the development of a professional corps of Mexican wildlife biologists and stronger wildlife agencies and institutions in Mexico.

Strategies for Resolving Wildlife Management Challenges in Mexico

It is critically important to recognize that Mexico is comprised of a highly diversified mosaic of ecosystems, cultures, socioeconomic levels, and land tenure and political systems. These complex and intertwined factors require that localized approaches and strategies be devised to confront and resolve Mexico's multifaceted wildlife conservation challenges. Ideally, it would involve the integrated efforts of economists, sociologists, government agencies, and a host of natural resource specialists. However, the ideal is far from reality and strategies must be devised with the present human and technical resources available. Mexican wildlife will continue to be exploited and their habitats degraded. There must be concerted efforts to develop ecologically sustainable wildlife populations and wildlife management programs in order for wildlife to continue to meet human needs (Freese and Saavedra 1991, Redford and Robinson 1991, Shaw 1991, Bennett and Robinson 2000).

Despite its shortcomings, Mexico's present wildlife conservation effort is a concrete and pragmatic response toward incorporating ejidos, landowners, and indigenous communities, among other stakeholders, in sustainably managing wildlife in Mexico. Particularly pertinent is the importance the federal government has imparted in the UMA management strategy to integrate social issues while instituting wildlife management programs. However, it is patently clear that federal and state governments are unable to adequately fund, staff, and administer a viable wildlife program without the committed efforts of the private sector. The private sector also is a key element in protecting wildlife populations from illegal hunting.

Private landowners and communal property stakeholders have the greatest potential and incentives to sustainably manage wildlife in Mexico. Although it would be beneficial to create federal and state protected areas for critical wildlife and habitats, it is neither economically feasible nor pragmatic because of Mexico's social and economic pressures. It is urgent that lands outside present protected regions be incorporated in coordinated management units at the landscape level and to establish wildlife management programs to maintain and restore unprotected species and habitats and to avoid isolating existing protected areas (Ceballos et al. 1998). Wildlife in ejidos and the private sector should be prioritized to accomplish this goal. Given the necessary economic incentives, private landowners have shown that wildlife programs can be integrated and even prioritized in multispecies management schemes that economically benefit landowners, wildlife populations, and wildlife habitats.

The participatory efforts of the private sector and communal lands in the UMAs program is driven by the lucrative profits resulting from investments in producing huntable populations of wildlife and the prospect of local control of wildlife populations. The economic benefits of wildlife are evident in the wild sheep and mule deer hunting program in Sonora. Wild sheep hunts sell for $50,000 (U.S.) and sheep hunts have been auctioned for over $200,000 (U.S.) on Isla Tiburon in the Sea of Cortez, an island owned by the Seri Indians. Ranch owners also market mule deer and white-tailed deer hunts. Sonoran Desert ranchers were formally dependent on the livestock industry, which was not economically viable due to the region's aridity and unpredictable rainfall. Because of the high prices charged for these big game hunting permits in UMAs, they now prioritize wildlife populations resulting in decreased cattle-stocking rates, improved wildlife habitat conditions, and increasing wildlife populations (Lee and Lopéz-Saavedra 1994, Tarango and Krausman 1997, Rosas-Rosas et al. 2003). They also have greatly curtailed illegal hunting. Some landowners have abandoned livestock production and have concentrated their efforts on wildlife enterprises.

The corporate and nongovernmental sector also should be integrated in wildlife management programs. The corporate sector, especially, has the economic resources to fund wildlife research and management programs and purchase and efficiently manage protected areas on a landscape scale. In addition, they can be major conduits in transferring technical assistance to neighboring land owners and communities. An example of one large corporation in Mexico which has developed exemplary wildlife conservation programs is CEMEX, Mexico's largest cement producer. It manages over 100,000 ha of deeded and leased lands in northeastern Mexico in the state of Coahuila. The objective of this nature reserve within the Chihuahuan Desert is to restore native wildlife and ecosystems in an area that was seriously degraded by livestock mismanagement over hundreds of years. It also has donated millions of dollars to other wildlife projects (Herring 2004). Other Mexican corporations also are funding active wildlife programs through purchase and restoration of formerly degraded lands.

In the last 10 years, nongovernmental organizations (NGOs) have become major leaders in purchasing and managing wildlife habitats, initiating land restoration and natural resource education programs, acquiring conservation easements, and establishing buffer zones in cooperation with federal, state, and local governments and communities. These integrated private-land conservation programs are crucial to the ecologically sustainable management of wildlife in Mexico. Academic institutions also have become active participants. Partnerships between academic institutions and NGOs facilitate the establishment of long-term monitoring and research programs to determine the efficacy of conservation programs.

The NGOs have made great achievements in protecting critical wildlife habitats throughout Mexico and their continued success is vital to maintaining and restoring Mexico's biodiversity. Mexican NGOs also have forged strong alliances with international conservation agencies such as the Wildlife Conservation Society, Conservation International, World Wildlife Fund, and the Nature Conservancy, which has added to the effectiveness and success of their conservation efforts (Jolly 2002). Pronatura, Mexico's largest NGO, and other NGOs such as Profauna and Naturalia, through their state and ecoregional offices, are leading the effort nationwide in purchasing and managing critical wildlife habitats. Ramos

(1988) estimated there were as many as 200 environmental NGOs in Mexico.

If wildlife programs are to be successful, it will be necessary to modify the political and socioeconomic environment. Natural resource agencies should adopt and endorse the promotion of participatory conservation projects; decision-making needs to be equally shared among participants. Natural resource agencies and their personnel need to undergo a management and policy transformation; governmental agencies and other institutions should be required to practice, mentor, and promote participatory strategies. Power struggles, resistance to change, and lack of trust and experience are some of the major obstacles in achieving this transformation (Korten and Siy 1988). Especially important is the recognition that conservation needs and issues be framed as questions of human organization (Wilshusen et al. 2002) rather than natural resource concerns. All key stakeholders, including agencies, communities, and NGOs must engage and collaborate in developing strategies and goals that are realistic and enforceable. Socially fair and environmentally sound goals and objectives must be designed and agreed upon by all interested parties.

Wildlife remains a public resource in Mexico; however, a clear definition of natural resource-based user rights and responsibilities has yet to be established. Cartwright (1973) suggested that unless property rights and responsibilities are clearly defined, the concept of property becomes nonexistent. Wildlife programs are likely to fail unless long-term property rights are enforced and agreed upon by all interested parties. The recognition of community-based tenure, a form of property rights, by the Mexican government has enabled innovative, sustainable, locally adapted agro-ecosystems and natural resource management systems to evolve in ejidos and communities. The long-term guarantees of communal property rights over the last 75 years provided the land tenure stability for these systems to evolve (Alcorn and Toledo 1998).

Much of the world's biodiversity occurs outside protected areas. Wildlife programs involving stakeholders in unprotected areas require a higher level of collaboration and interdisciplinarity to resolve challenges. It also is in nonprotected areas where multiple resources, multiple uses, and multiple users can be accommodated. Wildlife conservation issues in Mexico can best be resolved through natural resource community-based planning approaches that are embedded in a strong component of social participation, especially in light of widespread rural poverty (Slocombe 1993, Zazueta 1995, Child 1996). Recognizing the importance of ejidos and indigenous communities in managing natural resources, the federal government initiated the campesino (peasant) ecological reserve program. This plan allows communities to retain the authority to plan and implement sustainable natural resource developments and they become eligible to receive technical aid from universities and NGOs. This is an example of an innovative conservation program that could provide wildlife corridors and protected areas and ensure the ecological sustainability of much of Mexico's biodiversity (Alcorn and Toledo 1998).

One of the most important objectives for improving wildlife conservation in Mexico is the education of wildlife biologists in order to develop professional expertise at all levels of Mexican society. These professionals are urgently needed to conduct the basic censusing and monitoring aspects required in managing UMAs and to institute scientifically rigorous methods. There should be strong efforts made to establish undergraduate wildlife curricula in Mexico. There are already established graduate curricula in several universities in Mexico but only one has a faculty with more than one professor with a doctoral degree in wildlife science. American wildlife professors should also make every effort to increase the recruitment of Mexican graduate students and to have these students conduct their research in Mexico. This strategy would enable Mexican students to blend Mexico's wildlife culture into their research academic activities rather than educating them to function in the United States system. Developing cooperative wildlife programs between American and Mexican universities would be another mechanism to educate Mexican students and also create an awareness in American professors and students of wildlife needs in Mexico and encourage future joint projects.

Acknowledgments

We thank M. Desmond, W. Boeing, P. Warshall, S. Smallidge, S. Coleman, A. Lafón-Terrazas, and J. Frey for reviewing earlier versions of the manuscript. We especially thank C. Méndez-González for his assistance and two anonymous reviewers for their constructive suggestions. Funding was provided by the New Mexico State University Agricultural Experiment Station, New Mexico State University, and the Colegio de Postgraduados, San Luis Potosí Campus.

Literature Cited

Abarca, F. J. 2002. Definición e importancia de los humedales. Pages 1–5 *in* F. J. Abarca, and M. Herzig, editors. Manual para el manejo y conservación de los humedales de México. Arizona Game and Fish Department, Ramsar Convention, United States Fish and Wildlife Service and Ducks Unlimited México Asociación Civil, Phoenix, USA.

Alcorn, J. B., and V. M. Toledo. 1998. Resilient resource management in Mexico's forest ecosystems: the contribution of property rights. Pages 216–249 *in* F. Berkes and C. Folke, editors, and J. Colding, editorial assistant. Linking social and ecological systems. Cambridge University Press, Cambridge, United Kingdom.

Arita, H. 1993. Riqueza de especies de la mastofauna de México. Pages 109–128 *in* R. A. Medellín and G. Ceballos, editors. Avances en el estudio de mamíferos de México. Asociación Mexicana de Mastozoología, México, D. F., México.

Barrera de Jorgenson, A., and J. P. Jorgenson. 1995. Use of forest resources and conservation in Quintana Roo, Mexico. Pages 16–20 *in* J. A. Bissonette and P. R. Krausman, editors. Integrating people and wildlife for a sustainable future. Proceedings of the First International Wildlife Management Congress. The Wildlife Society, Bethesda, Maryland, USA.

Bennett, E. L., and J. G. Robinson. 2000. Hunting for sustainability: the start of a synthesis. Pages 499–519 *in* J. G. Robinson and E. L. Bennett, editors. Hunting for sustainability in tropical forests. Columbia University Press, New York, New York, USA.

Bravo, C., and A. M. López. 1999. Inventario de especies vegetales y animales de uso artesanal. Biodiversitas 22:9–14.

Bray, D. B., and M. B. Wexler. 1996. Forest policies in Mexico. Pages 217–228 *in* R. Randall, editor. Changing structure in Mexico. M. E. Sharpe, Armonk, New York, USA.

Cartwright, T. J. 1973. Problems, solutions and strategies: a contribution to the theory and practice of planning. Journal of the American Institute of Planners 39:179–187.

Ceballos, G., and D. Navarro L. 1991. Diversity and conservation of Mexican

mammals. Pages 167–226 *in* M. A. Mares, and D. J. Schmidly, editors. Latin American mammalogy. University of Oklahoma Press, Norman, USA.

Ceballos, G., P. Rodriguez, and R. A. Medellin. 1998. Assessing conservation priorities in megadiverse Mexico: mammalian diversity, endemicity, and endangerment. Ecological Applications 8:8–17.

Challenger, A. 1998. Utilización y conservación de los ecosistemas terrestres de México. Pasado, presente y futuro. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Instituto de Biología, Universidad Nacional Autónoma de México, y Agrupación Sierra Madre, México, D. F., México.

Child, G. 1996. The practice and principles of community-based wildlife management in Zimbabwe: the CAMPFIRE Programme. Biodiversity and Conservation 5:369–398.

Comisión Nacional de Areas Naturales Protegidas. 2004. Comisión Nacional de Areas Protegidas. ⟨http://conanp.gob.mx/anp/anp.php.⟩ Accessed 2004 Aug 4.

De Alba, E., and M. E. Reyes. 1998. Contexto físico. Pages 2–23 *in* A. Peña-Jiménez, L. Neyra-Gonzaléz, E. Loa-Loza, and L. Durand-Smith, compilers. La diversidad biológica de México: estudio de país, 1998. Comisión Nacional para el Uso y Conocimiento de la Biodiversidad, México, D.F., México.

Deneven, W. M. 1992. North American populations in 1492: recent research and revised hemispheric estimates. Pages xvii–xxix *in* W. M. Deneven, editor. The native population of the Americas in 1492. University of Wisconsin Press, Madison, USA.

DeWalt, B. R. 1998. The ejido reforms and Mexican coastal communities: fomenting a blue revolution? Pages 357–379 *in* W. A. Cornelius and D. Myhre, editors. The transformation of rural Mexico: reforming the ejido sector. U.S.–Mexico Contemporary Perspective Series, 12. Center for U.S.–Mexican Studies, University of California at San Diego, San Diego, USA.

Diario Oficial de la Federación. 1999. Acuerdo de la SEMARNAP por el que se crea el comité técnico consultivo nacional para la recuperación de especies prioritarias. Diario Oficial de la Federación, México, D.F., México.

Diego-Quintana, R., L. Concheiro-Borquesz, and R. Perez-Aviles. 1998. Peasant logic, agrarian policy and land mobility and land market in Mexico. Working paper No 21, North America Series. Land Tenure Center, University of Wisconsin, Madison, USA.

Escamilla, A., M. Sanvicente, M. Sosa, and C. Galindo-Leal. 2000. Habitat mosaic, wildlife availability, and hunting in the tropical forest of Calakmul, Mexico. Conservation Biology 14:1592–1601.

Espinosa, H., P. Fuentes, M. T. Gaspar, and V. Arenas. 1993. Notes on Mexican ichthyofauna. Pages 319–364 *in* T. P. Ramamoorthy, R. Bye, A. Lot, and J. Fa, editors. Biological diversity of Mexico: origins and distribution. Oxford University Press, New York, New York, USA.

Fa, J. E., and L. M. Morales. 1993. Patterns of mammalian diversity in Mexico. Pages 319–364 *in* T. P. Ramamoorthy, R. Bye, A. Lot, and J. Fa, editors. Biological diversity of Mexico: origins and distribution. Oxford University Press, New York, New York, USA.

Ferrusquía-Villafranca, I. 1993. Geology of Mexico, a synopsis. Pages 3–108 *in* T. P. Ramamoorthy, R. Bye, A. Lot, and J. Fa, editors. Biological diversity of Mexico: origins and distribution. Oxford University Press, New York, New York, USA.

Fideicomisos Instituidos en Relación con la Agricultura. 1998. Ranchos cinegéticos, oportunidad de diversificación ganadera sustentable. Fideicomisos Instituidos en Relación con la Agricultura en el Banco de México. FIRA Boletin Informativo 30:1–100.

Flores-Villela, O. 1993. Herpetofauna of Mexico: distribution and endemism. Pages 253–281 *in* T. P. Ramamoorthy, R. Bye, A. Lot, and J. Fa, editors. Biological diversity of Mexico: origins and distribution. Oxford University Press, New York, New York, USA.

Fortes, J., and L. A. Lomnitz. 1994. Becoming a scientist in Mexico. The Pennsylvania State University, University Park, USA.

Freese, C. H., and C. J. Saavedra. 1991. Prospects for wildlife management in Latin America and the Caribbean. Pages 430–444 *in* J. G. Robinson and K. H. Redford, editors. Neotropical wildlife use and conservation. University of Chicago Press, Chicago, Illinois, USA.

Galindo-Jaramillo, J. M., and E. Loa-Loza. 1998. Marco jurídico e institucional para el uso y la conservación de la biodiversidad. Pages 238–283 *in* A. Peña-Jiménez, L. Neyra-González, E. Loa-Loza, and L. Durand-Smith, compilers. La diversidad biológica de México: estado de país, 1998. Comisión Nacional para el Uso y Conocimiento de la Biodiversidad, México, D.F., México.

Garcia-Barrios, R., H. Robles, N. McCarthy, and E. Erickson. 1998. Vulnerabilidad y recursos institucionales autóctonos de los campesinos pobres en el medio rural reformado: el caso del manejo colectivo de pastizales. Pages 255–290 *in* S. Zendejes and P. DeVries, editors. Las disputas por el México rural: transformaciones de prácticas, identidades y proyectos. El Colegio de Michoacán, Zamora, México.

Guerrero, M. T., C. Reed, and B. Vegter. 2000. La industria forestal y los recursos naturales en la Sierra Madre de Chihuahua: impactos sociales, económicos y ecológicos.

Guzmán-Aranda, J. C. 1995. Landowner wildlife conservation attitudes at Laguna de Babicora, Chihuahua, Mexico. Thesis, New Mexico State University, Las Cruces, USA.

Guzmán-Aranda, J. C. 2004. Evaluation of conservation planning in Mexico: stakeholder analysis approach. Dissertation, Virginia Polytechnic Institute and State University, Blacksburg, USA.

Harvey, N. 1996. The reshaping of agrarian policy in Mexico. Pages 103–110 *in* L. Randall, editor. Changing structure of Mexico. M. E. Sharpe, Armonk, New York, USA.

Herring, H. 2004. The El Carmen project: a wild vision shines in. Bugle 21:92–102.

Instituto Nacional de Ecología. 2000. Estrategia nacional para la vida silvestre. Instituto Nacional de Ecología, México, D. F., México.

Jolly, M. 2002. En México: lands of opportunity. Nature Conservancy Magazine 52:32–43.

Jorgenson, J. P. 1995. A profile of Maya subsistence hunters in southeastern Mexico. Pages 667–671 *in* J. A. Bissonette and P. R. Krausman, editors. Integrating people and wildlife for a sustainable future. Proceedings of the First International Wildlife Management Congress. The Wildlife Society, Bethesda, Maryland, USA.

Korten, F. F., and R. Y. Siy, Jr., editors. 1988. Transforming a bureaucracy: the experience of the Philippine national irrigation administration. Kumarian, West Hartford, Connecticut, USA.

LaBaume, J. T., and B. E. Dahl. 1986. Communal grazing: the case of the Mexican ejido. Journal of Soil and Water Conservation 41:24–27.

Landa, R., J. Meave, and J. Carabias. 1997. Environmental deterioration in rural Mexico: an examination of the concept. Ecological Applications 7:316–329.

Lee, R. M., and E. E. López-Saavedra. 1994. A second helicopter survey of desert bighorn sheep in Sonora, Mexico. Desert Bighorn Council Transactions 38:12–13.

Leopold, A. S. 1959. Wildlife of Mexico, the game birds and mammals. University of California Press, Berkeley, USA.

Martinez, A. F., coordinator. 2003. Informe de la situación del medio ambiente en México, compendio de estadísticas ambientales, 2002. Secretaria del Medio Ambiente y Recursos Naturales, México, D.F., México.

McBride, G. 2000. History of the environmental secretariat and legislation in Mexico. ⟨http://www.mexicanlaws.com/environmentallaw.htm.⟩ Accessed 2003 Jan.

McGeveran, W. A., Jr., editorial director. 2004. The world almanac and book of facts. World Almanac Books, New York, New York, USA.

McNeely, J. A., K. R. Miller, W. V. Reid, R. A. Mittermeier, and T. B. Werner. 1990. Conserving the world's biodiversity. International Union for the Conservation of Nature and Natural Resources, World Resources Institute, Conservation International, World Wildlife Fund—US, and World Bank, Gland, Switzerland.

Medellin, R. A. 1994. Mammal diversity and conservation in the Selva Lacandona, Chiapas, Mexico. Conservation Biology 8:780–799.

Middleton, N., and D. Thomas, editors. 1997. World atlas of desertification. United Nations Environment Program, Rome, Italy.

Neyra-González, L., and L. Durand-Smith. 1998. Biodiversidad. Pages 62–102 *in* A. Peña-Jiménez, L. Neyra-González, L. Loa-Loza, and L. Durand-Smith, compilers. La diversidad biológica de México: estudio de país, 1998. Comisión Nacional para el Uso y Conocimiento de la Biodiversidad, México, D.F., México.

Peña-Jiménez, A., and L. Neyra-González. 1998. Amenaza a la biodiversidad. Pages 157–181 *in* A. Peña-Jiménez, L. Neyra-González, L. Loa-Loza, and L. Durand-Smith, compilers. La diversidad biológica de México: estudio del país, 1998. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, México, D.F., México.

Pérez-Gil, S., F. J. Monroy, A. M. Muñiz Salcedo, and M. G. Torres Gómez. 1995. Importancia económica de los vertebrados silvestres de México.

Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, México, D.F., México.

Perry, J. P., Jr. 1991. The pines of Mexico and Central America. Timber Press, Portland, Oregon, USA.

Pliego, P. E., A. G. N. N. Giguenza, and A. T. Peterson. 1993. A geographic, ecological, and historical analysis of land bird diversity in Mexico. Pages 281–308 *in* T. P. Ramamoorthy, R. Bye, A. Lot, and J. Fa, editors. Biological diversity of Mexico: origins and distribution. Oxford University Press, New York, New York, USA.

Purdy, P. C., and R. E. Tomlinson. 1991. The eastern white-winged dove: factors influencing use and continuity of the resource. Pages 255–265 *in* J. G. Robinson, and K. H. Redford, editors. Neotropical wildlife use and conservation. University of Chicago Press, Chicago, Illinois, USA.

Ramamoorthy, T. P., R. Bye, A. Lot, and J. Fa. 1993. Introduction. Pages xxix–xxxix *in* T. P. Ramamoorthy, R. Bye, A. Lot, and J. Fa, editors. Biological diversity of Mexico: origins and distribution. Oxford University Press, New York, New York, USA.

Ramos, M. A. 1988. The preservation of biodiversity in Latin America: a perspective. Pages 428–436 *in* E. O. Wilson, editor. Biodiversity. National Academy, Washington, D.C., USA.

Redford, K. H., and J. G. Robinson. 1991. Subsistence and commercial uses of wildlife in Latin America. Pages 6–23 *in* J. G. Robinson and K. H. Redford, editors. Neotropical wildlife use and conservation. University of Chicago Press, Chicago, Illinois, USA.

Rosas-Rosas, O. C., R. Valdez, L. C. Bender, and D. Daniel. 2003. Food habits of pumas in northwestern Sonora, Mexico. Wildlife Society Bulletin 31: 528–535.

Ruiz de Velasco, F. R. 1999. Conservation, management, and sustainable utilization of wildlife. Pages 341–357 *in* S. A. Foucat, S. C. Castillo, and C. M Villarreal, compilers. Economics of biodiversity. Instituto Nacional de Ecología—Secretaría de Medio Ambiente, Recursos Naturales y Pesca, México, D. F., México.

Rzedowski, J. 1993. Diversity and origins of the phanerogamic flora of Mexico. Pages 129–146 *in* T. P. Ramamoorthy, R. Bye, A. Lot, and J. Fa, editors. Biological diversity of Mexico: origins and distribution. Oxford University Press, New York, New York, USA.

Secretaría de Medio Ambiente, Recursos Naturales y Pesca. 1997. Programa de conservación de la vida silvestre y diversificación productiva en el sector rural 1997–2000. Secretaría de Medio Ambiente, Recursos Naturales y Pesca, México, D.F., México.

Secretaría de Medio Ambiente y Recursos Naturales. 2000. Ley general de vida silvestre. ⟨http://www.semarnat.gob.mx/wps/portal.⟩ Accessed 2004 Sep 24.

Secretaría de Medio Ambiente y Recursos Naturales. 2004. Unidades de manejo para la conservación de vida silvestre registradas al 31 de Agosto, 2004. Dirección General de Vida Silvestre, Secretaría de Medio Ambiente y Recursos Naturales. ⟨http://www.semarnat.gob.mx/wps/portal.⟩ Accessed 2004 Aug 31.

Shaw, J. H. 1991. The outlook for sustainable harvests of wildlife in Latin America. Pages 24–34 *in* J. G. Robinson and K. H. Redford, editors. Neotropical wildlife use and conservation. University of Chicago Press, Chicago, Illinois, USA.

Simonian, L. 1995. Defending the land of the jaguar. University of Texas Press, Austin, USA.

Slocombe, D. S. 1993. Environmental planning, ecosystem science, and ecosystem approaches for integrating environment and development. Environmental Management 17:289–303.

Stedman-Edwards, P. 2000. Mexico: Calakmul Biosphere Reserve. Pages 231–254 *in* A. Wood, P. Stedman-Edwards, and J. Mang, editors. The root cause of biodiversity loss. Earthscan, Sterling, Virginia, USA.

Styles, B. T. 1993. Genus Pinus: a Mexican purview. Pages 397–420 *in* T. P. Ramamoorthy, R. Bye, A. Lot, and J. Fa, editors. Biological diversity of Mexico: origins and distribution. Oxford University Press, New York, New York, USA.

Tamayo, J. L. 1990. Geografía moderna de México. Tenth edition. Editorial Trillas, México, D.F., México.

Tarango, L. A., and P. R. Krausman. 1997. Desert bighorn sheep in Mexico. Transactions of the Desert Bighorn Council 41:1–7.

Toledo, M. V., and Ma. de Jesus Ordoñez.. 1993. The biodiversity scenario of Mexico: a review of terrestrial habitats. Pages 757–779 *in* T. P. Ramamoorthy, R. Bye, A. Lot, and J. Fa, editors. Biological diversity of Mexico: origins and distribution. Oxford University Press, New York, New York, USA.

Toledo, V., J. Carabias, and C. González. 1989. La producción rural en México: alternativas ecológicas. Fundación Universo Veintiuno, Cd. México, México.

Whiteford, S., F. A. Bernal, H. Díaz-Cisneros, and E. Valtierra-Pacheco. 1998. Arid-land ejidos: bound by the past, marginalized by the future. Pages 381–399 *in* W. A. Cornelius and D. Myhre, editors. The transformation of rural Mexico: reforming the ejido sector. U.S.–Mexico Contemporary Perspective Series, 12. Center for U.S.–Mexican Studies, University of California at San Diego, San Diego, USA.

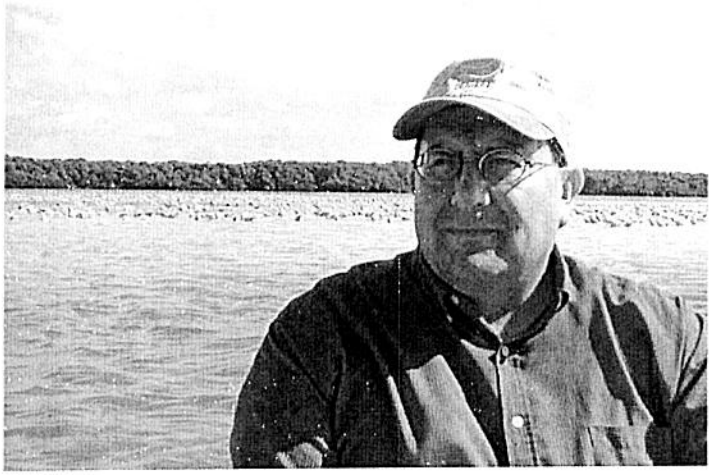
Wilshusen, P. R., S. R. Brechin, C. L. Fortwanger, and P. C. West. 2002. Reinventing a square wheel: critique to a resurgent "protection paradigm" in international biodiversity conservation. Society and Natural Resources 15: 17–40.

Wilson, P. N., and G. D. Thompson. 1992. Common property and uncertainty: compensating coalitions by Mexico's pastoral *ejidatarios*. The Pakistan Development Review 31:299–318.

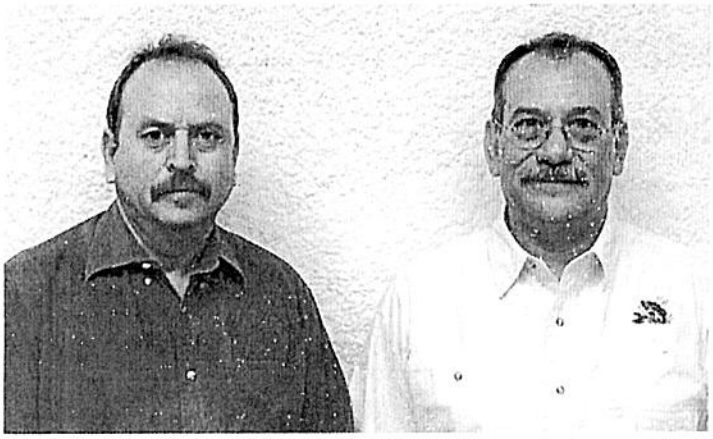
Zabin, C. 1998. Free markets and forests: community-based forestry in the era of neo-liberal reforms. Pages 401–425 *in* W. A. Cornelius and D. Myhre, editors. The transformation of rural Mexico: reforming the ejido sector. U.S.–Mexico Contemporary Series, 12. Center for U.S.–Mexican Studies, University of California at San Diego, San Diego, USA.

Zazueta, A. E. 1995. Policy hits the ground: participation and equity in environmental policy-making. World Resources Institute, Washington, D.C., USA.

Raul Valdez (not shown) is professor of wildlife in the Department of Fishery and Wildlife Sciences at New Mexico State University. One of his main interests is wildlife conservation in Mexico. ***Juan C. Guzman-Aranda*** (not shown) received a Ph.D. in wildlife from Virginia Tech. His main areas of interest are human dimension aspects of wildlife conservation and conservation planning and he is currently working with PROFAUNA, a Mexican natural resource conservation NGO.



Francisco "Paco" Abarca (above) is the International and Borderland Projects Manager for the Arizona Game and Fish Department. He received a B.S. degree in aquatic ecology and fisheries from the National University of Mexico in Mexico City and an M.S. from Arizona State University. He has worked with endangered species, wetlands and waterfowl, invasive species, wildlife management, environmental education, and public outreach over the past 25 years. ***Luis A. Tarango-Arámbula*** (photo next page, on the left) is Director of the Regional Center for Research, Education and Extension and wildlife professor at the San Luis Potosí Campus of the Colegio de Postgraduados. He received a B.S. from the Universidad Autónoma Chapingo, M.S. in wildlife science from New Mexico State University, and a Ph.D. in wildlife from the University of Arizona. ***Fernando Clemente-Sánchez*** (photo next page, on the right) received a B.S. from the



Universidad Autónoma Chapingo, M.S. from the Colegio de Postgraduados, and a Ph.D. from New Mexico State University. He is adjunct researcher and professor and Chair of the Maestría Tecnológica en Manejo y Administración de Vida Silvestre of the Colegio de Postgraduados, San Luis Potosí Campus. His main areas of interest are ecology and management of game birds and mammals.

Associate Editor: Krausman.