
Changing the Course of Biodiversity Conservation in the Caatinga of Northeastern Brazil

INARA R. LEAL,* § JOSÉ MARIA CARDOSO DA SILVA, † MARCELO TABARELLI,*
AND THOMAS E. LACHER JR. ‡

*Departamento de Botânica, Universidade Federal de Pernambuco, Recife 50670-901, Pernambuco, Brasil

†Conservação Internacional—Brasil, Avenida Nazaré 541/310, Belém 66035-170, Pará, Brasil

‡Center for Applied Biodiversity Science, Conservation International, 1919 M Street NW, Suite 600, Washington, D.C. 20036, U.S.A.

Abstract: *The 735,000-km² Caatinga is a mosaic of thorn scrub and seasonally dry forests, with more than 2000 species of vascular plants, fishes, reptiles, amphibians, birds, and mammals. Endemism in these groups varies from 7% to 57%. Inappropriate land use has already caused serious environmental damage and accelerating desertification, which is currently threatening about 15% of the region. Moreover, the rich and diversified biota of the Caatinga is poorly protected: only 11 reserves (<1% of the region) are strictly protected areas. A conservation strategy for the Caatinga biota should be designed to (1) avoid further habitat loss and desertification, (2) maintain key ecological services necessary for improving the living standards of the rural population, and (3) promote the sustainable use of the region's natural resources. Implementing an effective conservation agenda for the Caatinga is not an easy task but, with creativity and consistent financial support, it should be possible to nurture this unique biome and guarantee the preservation of its rich and diversified fauna and flora, and, with this, the well-being of its rural populations.*

Cambiando el Curso de la Conservación de Biodiversidad en la Caatinga del Noreste de Brasil

Resumen: *La Caatinga, con 735,000 km², es un mosaico arbustos espinosos y de bosques secos estacionalmente, con más de 2000 especies de plantas vasculares, peces, reptiles, anfibios, aves y mamíferos. El endemismo en estos grupos varía entre 7% y 57%. El uso inadecuado del suelo ha causado serios daños ambientales y acelerado la desertificación, que actualmente amenaza a 15% de la región. Más aun, la rica y diversificada biota de la Caatinga esta deficientemente protegida: solo 11 reservas (<1% de la región) son áreas estrictamente protegidas. Se debe diseñar una estrategia de conservación para la biota de la Caatinga para (1) evitar mayor pérdida de hábitat y desertificación; (2) mantener servicios ecológicos claves, necesarios para mejorar los estándares de vida y (3) promover el uso sustentable de los recursos naturales de la región. La instrumentación de una agenda de conservación efectiva para la Caatinga no es una tarea sencilla pero, con creatividad y apoyo financiero consistente, sería posible nutrir a este bioma único y garantizar la preservación de su rica y diversificada fauna y flora, y, con esto, el bienestar de sus poblaciones rurales.*

Introduction

The Caatinga is the mosaic of xerophytic, deciduous, semiarid thorn scrub and forest that covers much of north-

eastern Brazil and parts of northeastern Minas Gerais in the Jequitinhonha valley. It extends for about 735,000 km² and is surrounded by the mesic forested regions of Amazonia and the Atlantic Forest to the east and west

§email j.silva@conservation.org.br

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and the Cerrado savannas to the south. The Caatinga region is a flattened depression (300–500 m asl) dominated by Cretaceous sandstone on a basement of Pre-Cambrian crystalline rock (Ab'Saber 1977). Physiognomically it is similar to the arid regions of northern Colombia and Venezuela and Central America (Prance 1987). Average annual rainfall ranges from 240 to 1500 mm, with 50% of the region receiving <750 mm and some central areas receiving <500 mm (Sampaio 1995; Prado 2003). Most of the rainfall (50–70%) is concentrated in three consecutive months, although wide annual variations and long-lasting droughts are frequent (Nimer 1972). The number of dry months increases from the periphery to the center of the region, with some places experiencing 7- to 11-month-long periods of low water availability for plants (Prado 2003). The Caatinga is also characterized by high interannual variability in rainfall, with periodic severe drought (Krol et al. 2001; Chiang & Koutavas 2004). These droughts make life in the Caatinga difficult for the human inhabitants and provide adaptive challenges for the region's biota.

In the Tupi language of the Amerindians who once lived there, *Caatinga* means white forest and refers to the small-leaved, medium to tall, dry, light forests, dominated by woody genera such as *Tabebuia* (Bignoniaceae), *Cavallinesia* (Bombacaceae), *Schinopsis* (Anacardiaceae), *Myracrodruon* (Anacardiaceae), and *Aspidoderma* (Apocynaceae), which predominated in pre-Columbian times (Coimbra-Filho & Câmara 1996). As documented by Coimbra-Filho and Câmara (1996), these forests have been largely destroyed for timber and for cattle ranching, beginning soon after colonization in the early sixteenth century. Today the vegetation is mostly open scrub forest. Typical plant genera include *Bromelia* (Bromeliaceae), *Pilosocereus* (Cactaceae), *Caesalpinia* (Caesalpinaceae, Leguminosae), *Aspidoderma* (Apocynaceae), *Mimosa* (Mimosaceae, Leguminosae), and *Calliandra* (Fabaceae, Leguminosae). The tall Caatinga forests are now scarce, small, and fragmented (Prado 2003). Landscapes of profusely branched and spiny shrubs, succulents (especially Euphorbiaceae), bromeliads, and cacti predominate. Endemic Cactaceae genera include *Leocereus*, *Tacinga*, and *Zehntnerella* (Prance 1987). Leaves and flowers are produced during a short rainy season, and the Caatinga is leafless and dormant for much of the year. Herbs and grasses grow only during the sparse and unpredictable rains (Rizzini et al. 1988).

Tall dry forests are restricted to patches of nutrient-rich soils, and there are humid forests called *brejos* along the windward slopes of some of the raised sandstone plateaus (*chapadas*) and mountain ranges at elevations higher than 500 m that receive more than 1200 mm of orographic rainfall (Andrade-Lima 1982; Prado 2003). The *brejos* are present-day forest refuges. There are more than 30 of them, with floras that have Atlantic Forest and Amazonian affinities (Andrade-Lima 1982). The origin of the

Caatinga vegetation has been debated for many years, but results of recent studies suggest that Caatinga is part of what was a more widely distributed seasonal tropical dry forest that occupied large areas of South America in drier and cooler periods during the Pleistocene (Pennington et al. 2000, 2004).

Although entirely Brazilian, little attention has been given to the conservation of the Caatinga's remarkable and varied landscapes, and the contribution of its biota to Brazil's astonishingly high biodiversity has been consistently overlooked (Silva et al. 2004). The extent of this neglect is evident on examination of the investments in biodiversity research and conservation. From 1985 to 1996, approximately US\$135 million was spent by international, foreign, and national government organizations, state foundations, and nongovernmental organizations (NGOs) to finance 2439 biodiversity projects around the country. Only 4% were in the Caatinga (MMA 1999). We present an assessment of the biodiversity of the Caatinga, its current status and threats, and recent efforts to improve the protection of this island of aridity in the midst of the mesic tropics.

Biodiversity of the Caatinga

The Caatinga has been described as harboring relatively few species and having low numbers of endemic species (e.g., Vanzolini et al. 1980; Andrade-Lima 1982; Prance 1987). Some recent studies have challenged this, however, and demonstrated its importance for the conservation of an important component of Brazilian biodiversity (Leal et al. 2003a).

Inventories and assessments have, to date, recorded 932 vascular plant species (Giulietti et al. 2004), 187 bees (Zanella & Martins 2003), 240 fishes (Rosa et al. 2003), 167 reptiles and amphibians (Rodrigues 2003), 62 families and 510 species of birds (Silva et al. 2003), and 148 mammal species (Oliveira et al. 2003). Levels of endemism vary from about 7% for mammals (10 of 143 species; Universidade Federal de Pernambuco, Conservation International do Brasil, Fundação Biodiversitas, Semi-Árido, Fundação de Apoio ao Desenvolvimento da Universidade Federal de Pernambuco 2002; Oliveira et al. 2003) to 3% in birds (15 of 510 species; Silva et al. 2003) and 57% (136 of 240 species) in fishes (Rosa et al. 2003). Plant endemism is also quite high, although surveys are incomplete. Considering only succulents and woody plants, there are 18 genera and 318 (34% of the known flora) endemic species (Giulietti et al. 2004). These endemic genera and species are distributed among 42 families (Sampaio et al. 2002). These numbers are several times higher than those reported in previous assessments and publications (Pacheco 2004; Silva et al. 2004) and are equal to or higher than those recorded in other dry forests around

the globe (Leal et al. 2003a). The true numbers of species in the Caatinga, however, are potentially much greater because 41% of the region has never been surveyed by scientists and 80% of what has been surveyed poorly (Tabarelli & Vicente 2004). For example, in his work in the dune systems of the Rio São Francisco, Rodrigues (2003) found 4 endemic species of amphisbaenids, 16 lizards, 8 snakes, and 1 amphibian. These dune systems account for 37% of all the endemic lizards and amphisbaenids of the Caatinga, in an area of 7000 km² or 0.8% of the total area of this region (Rodrigues 2003).

Several Caatinga species are of special concern. The endemic Spix's Macaw (*Cyanopsitta spixii*) is believed to be extinct in the wild; it was last seen in 2000 (BirdLife International 2000). This monotypic genus was a habitat specialist on gallery forests of *Tabebuia caraiba*, now almost completely destroyed (Aguiar et al. 2002). Lear's Macaw (*Anodorhynchus leari*) is also a Caatinga endemic that is now restricted to two colonies in the state of Bahia. The total population is about 246 individuals (Nascimento et al. 2001). This species is also a habitat specialist, roosting and nesting in high sandstone cliffs and foraging in large groups on the fruits of the palm *Syagrus coronata* (Mart.) Becc. (BirdLife International 2000). The most conspicuous endemic mammal is the rock cavy, or mocó (*Kerodon rupestris*), which is closely related to the domestic guinea pig. It occupies rock outcrops within the Caatinga, is highly arboreal, and feeds on leaves and buds in the trees that tend to cluster in these mesic microhabitats (Lacher 1981). The rock cavy is also an interesting example of convergent evolution, sharing many ecological, morphological, and behavioral traits with the distantly related hyraxes of the kopjes in the African savannas (Mares & Lacher 1987). Finally, the Brazilian three-banded armadillo (*Tolypeutes tricinctus*) was thought to be extinct in the Caatinga until it was rediscovered in remnants of tropical, seasonally dry forest in the state of Bahia (Silva & Oren 1993; Santos et al. 1994).

The importance of the Caatinga lies not only in the listing of species and endemics, however. As a highly unpredictable arid region surrounded by tropical mesic biomes, the Caatinga is a climatic anomaly and functions as an important natural laboratory for the study of how plants, invertebrates, and vertebrates adapt to highly variable and stressful moisture regimes.

Current Status of the Caatinga Biome

The Caatinga is one of the world's 37 major wilderness areas (Aguiar et al. 2002) (i.e., large terrestrial regions covering more than 10,000 km² with more than 70% of their natural vegetation intact). There is some question as to whether the Caatinga actually meets those standards, given current levels of disturbance.

In 1993 the Brazilian Institute for Geography and Statistics (IBGE) calculated that 201,786 km², or 27.5%, of the Caatinga had been transformed into pasture, agricultural land, and other types of intensive land use (IBGE 1993). This is likely an underestimate because it does not include roads, small holdings, villages, or towns (Forman 2000). Castelletti et al. (2004) modeled the effects of roads on vegetation cover, added to this the area covered by agriculture and pasture, and estimated that the affected area (total habitat loss) in the Caatinga may range from 223,100 km² (with a road-effect zone 1 km wide [i.e., 500 m each side]) to 379,565 km² (with a road-effect zone of 10 km [5 km each side]). This indicates that between 30.4% and 51.7% of the Caatinga has been altered by human activities. The first estimate ranked the Caatinga as the third most degraded and destroyed ecosystem in Brazil after the Atlantic Forest and the Cerrado, but the second estimate gives the Caatinga a higher rank than the Cerrado. Even these numbers are likely underestimates because it is difficult to gauge the extent of damage and loss of the natural ecosystems and the fauna and flora of Brazil's northeast over the last 500 years. Historical records yield small but dramatic clues to the widespread destruction that has devastated the region since 1500 (Coimbra-Filho & Câmara 1996), and even the larger remaining forests have probably been altered since pre-Colombian times.

What remains of the natural ecosystems of the Caatinga is highly fragmented. The Castelletti et al. (2004) assessment of habitat loss and degradation showed that vegetation remnants were not distributed in a single, large block, but in many, different-sized fragments. In the road effect simulations with a 1-km effect width, 243 fragments were found with block size ranging from 0.03 km² to 41,212 km² and an average size of 2,104 km². Of these patches 28% were smaller than 50 km², and only 14 blocks were larger than 10,000 km². When a more realistic road effect of 10 km was used, the number of blocks decreased to 172 and the block size ranged from 0.10 km² to 22,767 km², with an average size of 2,063 km² and 30.2% of the patches smaller than 50 km². In this scenario, only 9 blocks were larger than 10,000 km².

Although these figures are disturbing, they offer guidance for selecting and placing new conservation units. Currently, the region has 47 protected areas of varying management regimes: 16 federal, 7 state, and 24 private reserves. They total 4,956 km², approximately 6.4% of the biome (The Nature Conservancy do Brasil & Associação Caatinga 2004). Eleven reserves covering <1% of the region are classified as national parks, ecological stations, and biological reserves. The Caatinga has the fewest protected areas, covering the smallest area, of any major Brazilian biome. They fail to protect the full range of biodiversity. Of the 13 major vegetation types (Prado 2003), four have no reserves or parks whatsoever (Tabarelli et al. 2000). None of the populations of 44 species of endemic and/or threatened passerine birds are

adequately protected by the current regional system of protected areas (Souza 2004). In addition, only half of the 16 federally protected areas contain exclusively Caatinga formations (The Nature Conservancy do Brasil & Associação Caatinga 2004). The Serra das Confuses National Park (502,411 ha) in Piauí, for example, includes areas of cerrado and dry forests and other vegetation formations besides Caatinga. Furthermore, several protected areas in the Caatinga have not been implemented fully, with landownership resolved, borders clearly demarcated, or management plans developed. The lack of even basic infrastructure and personnel makes these protected areas vulnerable to deforestation, fire, and poaching, and jeopardizes all efforts so far to create further protected areas.

There are nevertheless several significant protected areas that form the backbone of any future expansion of the protected area network in the Caatinga. They include the Chapada Diamantine National Park (152,000 ha) in Bahia, the Raso da Catalina Biological Reserve (99,772 ha) in Bahia, and the Serra da Capivara National Park (92,228 ha) in Piauí (Aguiar et al. 2002).

Major Threats: Present and Future

More than 25 million people, approximately 15% of the population of Brazil, live in the Caatinga (Mittermeier et al. 2002). The rural population is extremely poor, suffering greatly from the long droughts common in the region (Sampaio & Batista 2004). Widespread environmental impoverishment results from the slash-and-burn agriculture of the so-called *sertanejos* every year, which converts remnant vegetation to new and short-lived cropland; from the harvesting of firewood; from hunting; and from the continuous depredation of the vegetation by cattle and goat herds (now estimated to number more than 10 million animals; Medeiros et al. 2000). Cattle and goats, introduced by Europeans in the early 1500s, quickly devastated the native plant species that lacked resistance to intensive grazing (Leal et al. 2003b). Large areas, wherever soils were most productive, have been cleared for pasture and agriculture over the last 500 years. The gallery forests and dry forests have been largely replaced by open vegetation formations, which has affected local and regional rainfall and resulted in the siltation of even large rivers and streams (Coimbra-Filho & Câmara 1996). Large rivers, which were once navigable and allowed cattle to be transported and timber to be removed from the deep interior of the country, are now seasonally dry. Solutions to desertification, drought, and poverty over large parts of the Caatinga are now being sought through the use of powerful irrigation technology for fruit crops and soybean plantations. Inappropriate land use in recent decades has caused serious environmental damage—desertification currently threatens 15% of

the region (Universidade Federal de Pernambuco et al. 2002; Castelleti et al. 2004). Clearly, the conversion of the Caatinga for human occupation threatens its native biodiversity: 28 species in the region are threatened nationally or globally.

Major Conservation Initiatives

Because addressing human poverty is the primary challenge for political leaders in the Caatinga, biodiversity conservation has been consistently among the lowest investment priorities. Unfortunately, governments and NGOs have yet to adequately address the potential links between biodiversity protection and poverty reduction, even though the Serra das Capivara National Park offers one of the best examples for this in the entire country (FUMDHAM [Fundação Museu do Homem Americano] 1998). This 92,228-ha park is managed by the Brazilian Institute for the Environment (IBAMA) and the FUMDHAM, a local NGO. Considerable attention, both national and international, has been given to the park because of its importance as an archaeological site (it received World Heritage Site status in 1991) and to protect the region's natural landscape (IBAMA 1991). It is among the most visited of the national parks in all of Brazil. The ecotourism associated with this park has strengthened the local economy, generating jobs and opportunities in a hitherto impoverished area in Piauí, one of Brazil's poorest states. Much of the success of this initiative is the result of the strong leadership of Niede Guidon, a prominent Brazilian archaeologist, whose tireless efforts have received support from numerous national and international foundations and governments. The park also protects a number of threatened birds, including Illiger's Macaw (*Ara maracana*), Tawny Piculet (*Picumnus fulvescens*), Moustached Woodcreeper (*Xiphocolaptes falcirostris*), Gyalophylax bellmaryi, Great Xenops (*Megaxenops paraguayae*), and Northeastern Finch (*Carduellis yarrelli*), and large mammals (Universidade Federal de Pernambuco, Conservation International do Brasil, Fundação Biodiversitas, Semi-Árido, Fundação de Apoio ao Desenvolvimento da Universidade Federal de Pernambuco 2002).

In 2000 the MMA promoted a workshop, involving more than 150 scientists, conservationists, decision makers, and private-sector representatives, to select the most important areas and actions for conservation in the Caatinga (Universidade Federal de Pernambuco, Conservation International do Brasil, Fundação Biodiversitas, Semi-Árido, Fundação de Apoio ao Desenvolvimento da Universidade Federal de Pernambuco 2002). This effort was part of the National Biodiversity Program (PRONABIO), launched in 1996 by the ministry with support from the World Bank and the Global Environment Facility. The result was the delineation of 57 priority areas for

biodiversity conservation, 25 priority areas for scientific investigation, and the outline of a large biodiversity corridor along the Rio São Francisco. As part of this initiative, Silva et al. (2004) drew up guiding principles for the conservation of the region's biota. This joint effort resulted in the implementation of a number of new conservation initiatives on small and regional scales, and decision makers have considerably increased their awareness of the value of, and problems facing, the biodiversity of the Caatinga.

Despite the ever-growing pressures and the government development plans, the current climate and conditions are better now than they ever have been for the implementation of a regional conservation strategy for the Caatinga biota. The basic scientific information and conservation guidelines needed have been assembled and made available to all decision makers (Leal et al. 2003b; CNRBC 2004; Silva et al. 2004). The development of a regional conservation strategy should have three major goals: (1) avoidance of further biodiversity loss and desertification, (2) maintenance of key ecological services necessary for the rural people and their livelihoods, and (3) the promotion of sustainable use of the region's natural resources.

At the site level, the major task is the creation and implementation of protected areas in the 57 areas already identified as priorities. At subregional or regional scales, priority areas and the protected areas within them should be managed as part of the regional development program for the Caatinga in a manner consistent with biodiversity corridors (Sanderson et al. 2003). Such corridors have been established and tested in other Brazilian regions, including the Atlantic Forest (Sanderson et al. 2003). A first step toward the creation of a large and integrated network of protected areas in the region was the creation in 2001 of the Caatinga Biosphere Reserve, with a designated area of 19,899,000 ha. This initiative is expected to designate a network of 22 core areas (based on protected areas already decreed) and link them through buffer and transition zones. The whole network was designed by taking the Caatinga's priority areas into consideration and will encompass 40% of the entire region—19,905 km² into core areas and 268,874 km² as buffer and transitions zones (CNRBC 2004).

The bottleneck to implementing the major part of this conservation strategy is the almost complete lack of regulatory legislation, public policies, legal incentive mechanisms, economic instruments, and opportunities for biodiversity conservation specifically for the Caatinga region. There is also poor institutional capacity to deliver the conservation outcomes in a timely fashion. Biodiversity conservation and sustainable development in the Caatinga is still in its infancy compared with other Brazilian biomes.

Implementing a large-scale conservation agenda for the Caatinga will be especially difficult considering the human population density in many parts of the region, the degree of alteration of remaining habitats, and the long

history of local poverty and drought. It will require persistence, creativity, consistent financial and political support, and a strong and evident connection between the improvement of human livelihoods—the Caatinga epitomizes Brazil's worst rural poverty—and the conservation of natural landscapes.

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