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Full Length Research Paper

Conserving species of the *Manilkara* spp. threatened with extinction in vegetation fragments in Ecotone zones

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Ecosystem fragmentation has become one of the most striking aspects of human-driven environmental change in North-eastern Brazil, and this modification of natural habitats, in turn, has become one of the principal causes of species extinction. In light of these observations, the question arises as to whether floristic studies and botanical collections can help save species threatened with extinction. The present study is based on collections of species of the genus *Manilkara* (Sapotaceae) in areas of "restinga" (coastal vegetation) in the municipalities of Ilha Grande, Parnaíba, and Luiz Correia, Piauí State, Brazil, and on examinations of botanical material housed in the country's principal herbaria. Four native species of *Manilkara* have been observed to occur in Piauí State: *Manilkara cavalcantei*, *Manilkara rufula*, *Manilkara salzmannii* and *Manilkara triflora*. The former two species are listed by the IUCN as threatened with extinction. Although these species have been collected in "Delta of Parnaíba" environmental protection area, effective measures are still needed to protect this conservation area from advancing anthropogenic environmental degradation.

Key words: Extinction, fragmentation, *Manilkara*, Northeastern Brazil, Sapotaceae.

INTRODUCTION

The Brazilian Atlantic Forest is internationally known as a biodiversity hotspot because of its exceptional species richness and its many endemic species (Myers et al., 2000). These forests, however have been highly fragmented and reduced to only 7% of their original cover, and their fauna and flora are becoming highly threatened even before they have been fully studied (Moura, 2006).

Ecosystem fragmentation in North-eastern Brazil represents one of the most striking examples of extensive environmental alteration caused by humans in recent centuries. The modification of the Atlantic Forest habitat has been one of the principal causes of species extinction and the consequent loss of biodiversity in Brazil (Schaffer and Prochnow, 2002). Pernambuco State, for example, retains less than 5% of its original forest cover (Tabarelli et al., 2005).

Due to the high degree of fragmentation and isolation of Atlantic Forest remnants, many plant populations have become locally extinct, while others have suffered significant losses of genetic variability due to isolation of their populations (Siqueira-Filho and Tabarelli, 2006).

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This shows the need for more ecological research around the world (Koh and Sodhi, 2010).

Notably, most Brazilian species that are threatened with extinction are endemic to this coastal forest ecosystem (Schaffer and Prochnow, 2002). On the positive side, Brazil is one of the 25 nations that have ratified the IUCN/WWF proposal to quickly protect at least 10% of their remaining natural areas (Peres, 2005).

The reduction of forested areas may induce further marginalisation of the smallest fragments by causing them to be considered unworthy of detailed floristic studies. However, in analyzing the seed rain in small forest fragments, Pivello et al. (2006) have determined that small and/or isolated fragments are often little disturbed. These authors urged that greater attention be given to these fragmented areas. Even if a forest fragment is quite isolated in the landscape, it can still serve as an important seed source for recovery of the degraded area around it. Likewise, Pollito et al. (2004) have pointed out the necessity of actively protecting these remnant areas for conservation purposes.

Among the species to be considered for proactive conservation measures are many belonging to the genus *Manilkara*, a taxon that comprises approximately 30 species with tropical distributions (Pennington, 1990). Approximately 19 species of this genus have been identified in Brazil; 11 occur in the Atlantic Forest (Almeida Jr et al., 2009), 7 occur in the Amazon Forest, and 1 species is found in the “caatinga” (dryland) and “cerrado” (savannah) vegetation regions (Pennington, 1990).

Manilkara is well represented in the coastal vegetation areas in North-eastern Brazil, and its representatives are usually among the ten species with the largest importance values in surveys undertaken in the region (Santos-Filho, 2009). Based on the species of *Manilkara* (Sapotaceae) cited on lists of plants threatened with extinction, the present study evaluates the importance of floristic studies undertaken in small and isolated forest fragments along the coast of Piauí State (Brazil). Our results help to indicate priority areas for conservation.

MATERIALS AND METHODS

Study area

The coastline of Piauí State (Brazil) has many estuaries, including those of the Parnaíba, Portinho, Camurupim and Ubatuba/Timonha Rivers (Baptista, 1981; IBGE, 1996). The regional vegetation is composed of a mosaic of areas influenced by the Amazonian, Northeastern, and Central Highlands domains, with a wide diversity of ecosystems that vary from sub-deciduous broadleaf forest to mixed sub-deciduous forest, non-spiny deciduous broadleaf forest, and transitional areas of *babaçu*/*cerrado* forest, dry forest/*cerrado*, and *cerrado*/dryland (CEPRO, 1996a). This intersection of domains is exemplified by the presence of species typical of the Amazonian region in association with plants typical of generally drier regional ecosystems, such as the *Cerrado* and *Caatinga*, or transition zones (Santos-Filho, 2009).

Approximately 37% of the ecotonal zone of South-eastern Piauí is occupied by *Caatinga* vegetation with arboreal, arboreal-shrub, and shrub habits (Emperaire, 1989; CEPRO, 1996b; Oliveira et al., 1997), while 33% falls within the *Cerrado* domain (Castro, 2000; Castro et al., 1998; Farias and Castro, 2004).

Surveys and conservation status

The floristic inventory reported here is based on botanical collections undertaken from 2007 to 2008 in the coastal *Restinga* of Piauí State in the municipalities of Ilha Grande, Parnaíba, and Luiz Correia (Figure 1). This area is part of the “Delta of Parnaíba” Environmental Protection Area in Piauí, Brazil (located between the geographical coordinates of 2°50’34"S / 41°47’41"W and 2°55’52"S / 41°30’14"W). Field data were complemented by herbarium surveys. The principal herbaria consulted were ALCB, ASE, CEPEC, EAC, HB, HST, HUESF, INPA, IPA, JPB, MAC, MBM, MBML, PEUFR, R, RB, SP, SPSF, TEPB, UEC, UFP, UFRN, and UFPR (acronyms according to Holmgren and Holmgren, 1998). Based on plant surveys undertaken by Santos-Filho (2009), four species of the genus *Manilkara* that are listed as threatened with extinction were chosen as the principal focus of the present study (IUCN, 2009). The classifications of the conservation statuses of the species cited here follow the IUCN listing (2004; 2006; 2009).

RESULTS AND DISCUSSION

Among the many native species of Sapotaceae, a common taxon in the Amazonian region (Pennington, 1990), *Manilkara cavalcantei* Pires & Rodrigues ex T.D. Penn., *Manilkara rufula* (Miq.) Lam, *Manilkara salzmannii* (A.DC.) H.J. Lam and *Manilkara triflora* (Allemão) Monach were encountered in Piauí State. Of these four species, three were collected in the coastal vegetation of Piauí state: *Manilkara cavalcantei*, classified as threatened with extinction (IUCN, 2009); *Manilkara salzmannii* and *Manilkara triflora*, not listed as threatened because they are widely distributed within the Atlantic florest provinces and in the Amazonian region (IUCN, 2009).

Although not belong to the official lists of threatened extinction (IUCN, 2009), few individuals of *M. salzmannii* and *M. triflora* are found in coastal areas of Piaui state. However, if they are not developed conservation actions at the local level, *M. salzmannii* and *M. triflora* may in future occupy a category of threat of extinction.

The IUCN (1998) lists approximately 34,000 vascular plant species worldwide (12.5% of the estimated total) as being threatened with extinction; 1,380 of these species (2.4%) occur in Brazil. These numbers probably underestimate the true situation because the world’s (and Brazil’s) flora is far from completely documented. Other estimates indicate that from 22% to 47% of the world’s plant species are threatened with extinction among a total

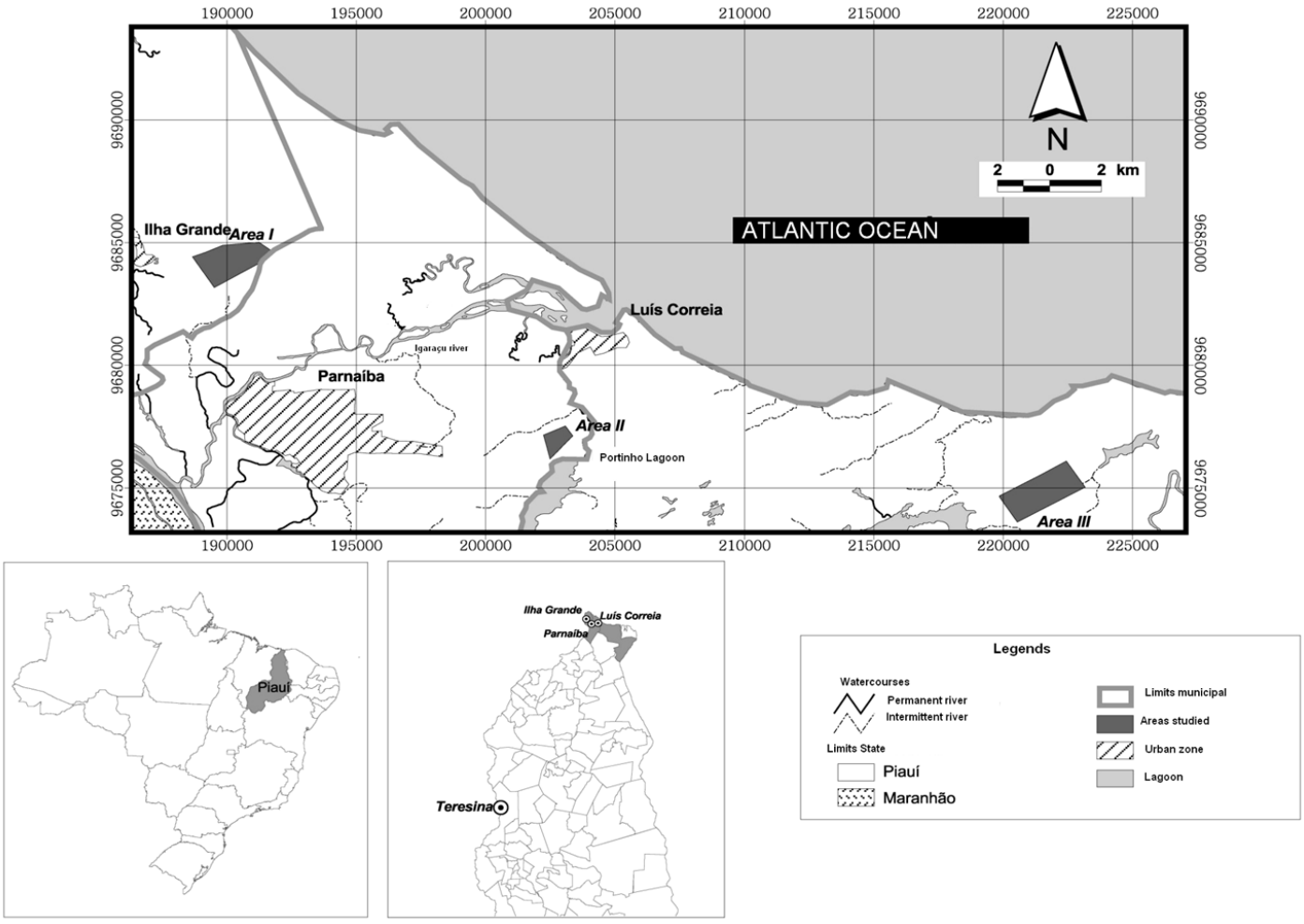

Figure 1. Map indicating the location of the different areas of restinga vegetation in the "Delta of Parnaíba" environmental protection area, Piauí State, Brazil.

of 310 to 422 thousand species growing mostly at tropical and subtropical latitudes (Pitman and Jorgensen, 2002).

Floristic and structural data from research in coastal areas of Piauí State (Santos-Filho, 2009), in conjunction with new collections, have increased our knowledge about development of *Manilkara* and will aid in constructing ecological corridors to facilitate genetic flux among the species found there. Thus, the records of threatened species in protected areas should base decisions on these priority conservation areas (Laumonier et al., 2010).

Piauí State is located in a transition zone between the Amazonian domain and the semi-arid region of North-eastern Brazil that is known as the Middle-North or Western Northeast Region. The distributions of the vegetative formations in these transitional areas are principally linked to climatic regimes, although geomorphological and edaphic factors are often determinants (Emperaire, 1989).

The position of this transition zone allows many species from adjacent ecosystems (such as the Amazonian Forest) to colonise areas with appropriate edaphic characteristics. For example, *M. cavalcantei* (which was previously known as a strictly Amazonian species) has recently been collected for the first time in Piauí State (Almeida Jr. et al., 2011). The occurrence of this species in this region points to the value of conserving and studying vegetation fragments, whether they be composed of *Cerrado*, *Caatinga* or Amazonian Forest remnants and independent of their shapes or sizes (Scariot et al., 2005).

Fragmentation provokes substantial alterations in any ecosystem, resulting in the creation of habitats that are inhospitable (negative) to many native species (Western,

2001). These inhospitable conditions diminish the probability that individuals can survive and reproduce effectively. As a result, many species demonstrate reduced abundances that are directly proportional to the reduction of favourable (positive) habitats (Cerqueira et al., 2005).

The largest remnant vegetation fragments have generally benefited from some level of institutional protection, and they are usually zoned with more restrictive controls; smaller fragments, on the other hand are usually zoned less restrictively (even when effectively annexed to conservation areas) and are subsequently subjected to additional degradation and fragmentation that reduces their long-term viability. Although secondary forests represent a large fraction of the remaining forested areas in the world today (Gómez-Pompa and Vázquez-Yanes, 1971), they are not usually targets for floristic studies and conservation proposals. Wiechers and Gómez-Pompa (1979) have noted that most of the vegetation in tropical zones throughout the world is secondary. This fact in itself is sufficient to justify further studies on the regeneration of tropical ecosystems. Floristic studies and botanical collections in these secondary vegetation areas may be able to identify new plant species before they arrive at the point of imminent extinction.

Coastal zones require special attention at the present time because a large part of the fragmentation that is taking place in these regions is related to the commercial development of shorefront areas (and their occupation by hotels, roads, residences and related infrastructure) (Fiszon et al., 2005) and the commercial extraction of plant products. The indiscriminate cutting of the most valuable species diminishes the quality of those forests, compromises their structural composition, and interferes with the maintenance of the local fauna and flora (Fiszon et al., 2005).

Another important conservation consideration is related to the genetic consequences of fragmentation. These consequences, which result from reduced population sizes and the spatial isolation (Conte 2004), include the loss of diversity, increasing levels of endogamy, alterations in the genetic structure of remnant populations, and extinction. For example, an examination of a population of *Cedrela fissilis* (a species threatened with extinction) has demonstrated very low genetic diversity in small forest fragments (Schneider et al., 2005).

Primack and Rodrigues (2001) have noted that detailed data are absolutely necessary to determine the stability of plant populations and to plan conservation activities in areas affected by human activities. Although *M. cavalcantei*, *M. salzmannii* and *M. triflora* were collected in “Delta of Parnaíba” Environmental Preservation Area (APA) (Santos-Filho, 2009), more effective actions are needed to protect these species because human activities are only loosely controlled in APAs (which are considered sustainable-use areas).

In view of the necessity of preserving what still remains of coastal forest ecosystems in Brazil, greater political investments in conservation are needed. The creation of more ecological stations and reserves as well as federal, state and municipal parks (full-protection areas) is a way of maintaining and protecting forested areas and guaranteeing better environmental monitoring. This strategy has been implemented for the Atlantic Forest and *Restinga* ecosystems in the Biodiversity Corridors of the Serra do Mar Range in São Paulo State (Rocha et al., 2003). Actions such as the creation of natural reserves will help to guarantee the survival of plant populations. However, such actions will be effective only if the reserves have workable management plans that can reduce anthropogenic impacts and assure the sustainable use of forest resources, particularly for taxa threatened with extinction, such as *Manilkara* species in forest fragments in Piauí State.

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