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State-of-Knowledge on *Didymopanax morototoni* (Aublet) Decne. and Planch. (ARALIACEAE) for Genetic Conservation in Brazil

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Abstract: This study explores the basis for conservation action on *Didymopanax morototoni* (Aublet) Decne. and Planch. (Araliaceae), a wide-ranging forest species occurring in Central and South Americas. In Brazil, it is mostly found in Amazonia-but also in the gallery forests of the Cerrado region and to a less extent in other South American countries. It offers insight into the taxon through structured reviews of knowledge of its biology, ecology, silviculture and management. Widely scattered published reports are critically considered and efforts made to highlight and resolve contradictions and inconsistencies therein. Information about this species is scanty and scattered, particularly in respect to its biology and ecology. Some effort has been applied to its domestication and improvement, yet knowledge of its silviculture and management is insufficient. Gaps in current knowledge relevant for conservation are identified and steps to fill them proposed. Where *in situ* conservation proved to be more appropriate, recommendations are made for the location of additional protected areas. *Ex situ* and enrichment conservation action is highly recommended for specific parts of the range where resource losses are already so extensive that *in situ* measures alone are inadvisable. Provision for refining the limited management and conservation knowledge is made through highlighting priorities for study of the taxon. Finally, future action is discussed in the context of the infrastructure of the national conservation sector.

Key words: Amazonia, Cerrado, Atlantic coast forest, conservation, forest genetic resources research

INTRODUCTION

Conservation operating through in situ channels has, understandably, been ecosystem focused. There is, however, need to complement this with attention directed at particular target species. Here, this approach is developed for *Didymopanax morototoni* (Aublet) Decne. and Planch., a forest species, which occurs in a distinctive but threatened habitat in central Brazil, the Cerrado. This taxon is included in the listing of 23 priority species for Brazil drawn up by the Brazilian Agricultural Research Organisation through its Genetic Resources and Biotechnology Research National Centre (Embrapa-Cenargen, 1988) for the Brazilian Government in connection with the national conservation strategy. Criteria for selection were those recommended by the FAO Panel of Experts on Forest Gene Resources: restricted ecological distribution, low population densities, heavy exploitation for wood and other products, unknown or deficient silviculture and threatened habitat (Roche, 1987).

Efforts to trace a robust but flexible standard system for acquiring, collating and organising information on named neotropical tree species were not successful. The reasons always reside in problems of standardisation of taxonomic and systematic nomenclature and regional peculiarities of (and particularly for wide-ranging) woody species, as well as the generally scattered nature of the acquired knowledge on these species. For example, in the *Forestry compendium* of CAB International

(2000) *D. morototoni* is only briefly treated as an outline data sheet. However, Lorenzi (2000) provides an instructive account, including figures, of this species. Reference to World Conservation Monitoring Centre (WCMC-Kew, 1990) indicated that for other tropical areas the situation was no different. Since species are the targets of gene resource conservation, a structured review of existing knowledge has great appeal when conservation strategies are to be formulated. Accordingly, this study offers a framework for such action, with *D. morototoni* serving as a case study.

The form and distribution of knowledge about tropical tree species introduce complications in information retrieval. Un-processed raw data (for example, those recovered from herbarium holdings, ecological literature and species listings) need to be especially reviewed and critically incorporated into the progressing study. In an uncollated state, published information is often very dispersed, much (notably early references) being in obscure or poorly circulated documents. Various languages may be involved and reference may be made under obsolete names, which may reflect broader or narrower concepts of the species than those accepted today. For many wide-ranging species these problems are acute, making the preparation of a unifying account taxing, time-consuming and sometimes laborious. The exercise is nevertheless important as the basis of an authoritative conservation plan.

Few can claim familiarity with all aspects of the existing knowledge of a wide-ranging species: existing information about a species can be allocated in many fields, each the line of a different group of specialists: foresters, ecologists, geographers, botanists. Geographical spread complicates matters greatly. Much concern with species is at national rather than range-wide level. Differences in the circumscription and in the nomenclature of species need to be recognised (and perhaps reconciled) and taken into account as the information is integrated. Whether or not this can be achieved in a single step depends on the quantity of published and archival information (including herbarium material), on the species, as well as on the resources and time available to the investigator.

Aimed at producing a current state-of-knowledge account for the species to support genetic conservation programmes in Brazil, the present study has three objectives (1) to review available information on the biology, ecology, silviculture and management of *D. morototoni* relevant to its genetic conservation as a sustainable resource (2) to create a comprehensive and authoritative monographic account of the species by a critical analysis of available information, highlighting in the process unresolved misinterpretations and inconsistencies which need clarification and (3) to identify the major gaps in current knowledge of the taxon and recommend positive research actions to fill them.

MATERIALS AND METHODS

This study is devoted to an in-depth account of the target taxon included in the programme of conservation of forest genetic resources in Brazil, which occurs in the Central Brazilian Cerrado region. Consequently, it has copious monographic content for the species. Comprehensiveness and authority have been sought by means of the extensive, though scattered information accessed and the scope of the review has enabled a clear picture of the species throughout the neotropics. Comprehensive comments on taxonomic and morphological aspects-at times addressing exposed contradictions and misinterpretations-are given, along with résumés of what is known of the reproductive biology and associated phenology. Distribution and ecology are aspects dealt within the context of the overall taxon range. Silvicultural and management experience was revealed but the information retrieved was inconsistent, scattered, incomplete and seldom widely circulated. As expected utilisation of the resource was particularly related to wood properties, but a variety of comments on alternative non-timber usage for the species were located. Lastly, information on genetic conservation status and priorities was supplied as general introductory statements, which were linked to conservation action to be taken and presented later in the article.

The approach followed has been adapted from that used by Hall and Walker (1991) for *Balanites aegyptiaca* and the schemes of Mondal (1986) for *Maesopsis eminii* and Irozuru (1986) for *Nauclea diderrichii* and the approach followed by Morse (1981) to report the conservation status of an endangered North American shrub species.

The species is considered sequentially with a subdivision allocated for each main aspect. The first subdivision outlines the systematic position and circumscription of the taxon. The nomenclatural history in each case is presented as a tabular chronological summary. The second subdivision is descriptive, covering, in turn, the seedling phase and the mature tree with, for the latter, details of habit, size and form, foliage, flowers and fruits and, where known, systematic anatomy. The third subdivision is in three sections covering the reproductive biology of the taxon with respect to phenology, pollination and dispersal and seed biology in natural conditions. The fourth subdivision is in two sections: distribution and ecology. The distribution covers, as far as possible the whole natural range. The ecology is treated first by factor: Elevation, climate and soils and then in the phytosociological context (associated species, relations with the natural fauna and with forest disturbance). The fifth subdivision addresses the silviculture and management of the species. In terms of artificial regeneration, experience involving propagation and outplanting and establishment and the performance of planted individuals is reported. On the management side, an account of attention in forest stands is given. The sixth subdivision deals with utilisation. There are three subsections-a description of the wood properties regarding macro- and microscopic, as well as physical and mechanical features; use as timber in terms of seasoning and preservation, durability and workability and final uses; other uses, based on the Booth and Wickens (1988) scheme of non-timber uses for African species. The seventh and final subdivision is concerned with the conservation status of the species.

The fragmented and unsatisfactory species information for many species in the neotropics requires today's monographers to invest more thought, effort and time to taxonomic circumscriptions and their geographical implications than their counterparts in Africa, Asia or Australia.

In the present research, a retrospective picture of the taxonomic chronology was a necessary preliminary to an overview of the knowledge base.

More specific comments on the importance of knowledge of the different aspects of a species have been given by Hall (1993 and 1994). Hall reports the general need for monographic accounts rather than only lists, brief profiles, data-sheets and bibliographies on both multipurpose tree species and traditional forestry trees. Monographs can be the most authoritative and comprehensive documents of the state of knowledge on any species. However, it is important that they are based as a sound framework in the form of a set of headings covering all aspects of the tree's biology and resource potential: taxonomy/morphology, distribution, ecology and silviculture/management. Critical assessment of the information gathered is important, especially resolving or explaining nomenclatural contradictions and differences of opinion as far as possible. Hall (1993 and 1994) stress the prominent role distribution maps should play among those headings. This is an exercise, which depends on information from five distinct sources-herbaria, taxonomic literature (basically in the form of floras), inventories, ecological literature and personal observations. Complementary data sets can cover terrain, climate and soil allowing occurrences to be related to these factors. Hall (1994) also discusses the potential combined role of such information sets in distinguishing genetically determined variation from ecologically determined variation in a wide-ranging species once mapped using all relevant available information. A critical approach to these issues is essential if conservation programmes are to be successful.

Unification of information on a species into a structured and authoritative monograph has been achieved for the African dry zone tree *B. aegyptiaca* (L.) Delile (Balanitaceae) by Hall and Walker (1991). This study serves as a useful model for a monograph but adaptations will be appropriate for other species. In the present case, prominence has been given to the conservation aspect, which has

been excluded by Hall and Walker (1991) although separately considered at some length elsewhere (Hall, 1992). This conservation aspect is also covered in more recent monographs such as those presented by Hall *et al*. (2000) for *Prunus africana* and Pasiecznik *et al*. (2001) in a *Prosopis juliflora-Prosopis pallida* complex account. The present study involves diverse sources of information. For Brazil these are published and unpublished material at Embrapa and Cenargen, National Parks management plans and lists and maps of current protected areas at the Brazilian Institute for the Environment and Renewable Natural Resources-Ibama. Paraguayan Conservation Data Centre data sheets on the target taxa were also obtained. In Britain, WCMC's database information on protected areas and assessment of conservation status of the target species were consulted and information assembled through visits to and correspondence with the Royal Botanic Garden, Kew (both herbarium and library). Electronic (Web of Science, CABI TreeCD) and traditional abstracting facilities (Forestry and Biological Abstracts) and a range of periodical publications but particularly Forest Ecology and Management, Forest Genetic Resources Information, Threatened Plants Newsletter and Silvae Genetica were also consulted. For less readily available recent documents Inter Library loans were used. Further information was collected in discussions and correspondence with experts-both in Britain and abroad (Brazil, Paraguay, Switzerland). This review has been done as complementary to field studies carried out with four target species occurring in the gallery forests of the central Brazilian Cerrado -a savanna-like vegetation physiognomy- in the early nineties.

RESULTS

Vernacular Names of *Didymopanax morototoni*

Portuguese: morototó, mucututú, matataúba, pará-pará, sambaquim, sambacuim, mandiocí, mandiocaí, mandiocão, mandioqueira, marapaúba, marupá-uba-falso, pixixica, imbaubão, pé-de-galinha, pau-caixeta, marupá, caixeta, cacheta (Loureiro and Silva, 1968; FAO, 1986; López, 1987; Salomão, 1990).

Spanish: Sacha-uva, anonillo, guitarrero, yarumero, yrumero, yagrume, yarumo-de-savana, yarumo-macho, yagrumo-macho, orumo-macho, sun-sun, higuereto, tinajero, amba'y guasu, ambay gusu, ambay-guazú (Williams, 1936; Chudnoff, 1984; FAO, 1986; López, 1987).

Dutch: Cassavehout, bigi boesie, papajahoedoe, kasabahoedoe, kassavehout (FAO, 1986; Loureiro and Silva, 1968).

French: Córdovan, bois de mai, bois de Saint Jean (FAO, 1986).

English: Karohoro, matchwood (FAO, 1986).

Systematic Position and Circumscription

The binomial for this species, *Didymopanax morototoni* (Aublet) Decne. and Planch., in this study, is the one proposed by Decaisne and Planchon (1854) when they revised the species previously referred to *Panax*, among them *P. morototoni* Aublet (1775).

In the past it was considered that *Didymopanax* could be separated from *Schefflera* on the basis that *Didymopanax* had a narrower geographical distribution, a calyx with five persistent teeth, a stylopodium (with two partly free, recurved, stylar branches) and, especially, a two-locular ovary and bilaterally symmetrical fruit, features pronounced in the type species.

The species known to Decaisne and Planchon could be readily separated into two groups using these criteria but many more species have since been discovered which undoubtedly relate very closely to those described up to and including 1854. The extra species have revealed that what was thought a well-characterized distinction between *Schefflera* and *Didymopanax* does not exist in reality: instead there is a continuum of variation with a range of taxa combining features separately associated with each of the genera as originally defined.

Frodin (1975 and 1989) and Maguire *et al*. (1984) re-examined species of Araliaceae in connection with a programme for the Flora of Guiana and it became clear that no reliable distinction could be made between those referred to *Schefflera* and *Didymopanax* and that all should be treated as species of *Schefflera*, the generic name with priority. The number of *Schefflera* species resulting from this interpretation is of the order of 150, mostly in the tropics of the Western Hemisphere (Maguire *et al*., 1984).

However, this relatively recent development is not so familiar in Brazilian forestry circles where the name *Didymopanax* continues to be used in silvicultural and conservation literature. The name *Didymopanax morototoni* has therefore been retained for this study, as one of those 11 taxa recognized as worthy of specific rank by Frodin (1989) which had until then been known by binomials under *Didymopanax*:

D. acuminatum March.
D. allocotanthus Harms
D. anomalus Taubert
D. glabratus (Kunth) Planch. and Decne. ex Linden
D. hitchcockii Lasser and Maguire
D. longipetiolatum March.
D. macrocarpum Seem.
D. morototoni (Aubl.) Decne. and Planch.
D. psilophyllus Harms
D. reticulatus Gleason
D. weberbaueri Harms

Table 1 shows the taxonomic history, including synonymy of *D. morototoni*.

Description

Seedling

Information on the morphology of the seedlings of *D. morototoni* is given by Duke (1965). They are phanerocotylar (epigeal) on germination. There are two phanerocotylar cotyledons 15-23 mm long and 11-13 mm broad (Hladik, 1970). The cotyledons are subsessile and are not punctate nor plicate or dentate. The eophylls are pilose, usually with more than 14 teeth. These are longer than broad and sometimes ciliate. The indumentum of the lower surface is not arachnoid (Fig. 1). There are no stipules on the first eophylls, which are simple. Latex is absent.

Table 1: Taxonomic history: *Didymopanax morototoni* (Aubl.) Decne. and Planch

Authority	Event
Linnaeus (1753)	Description of *Panax* with *P. quinquefolium* as type species
Aublet (1775)	Description of *P. morototoni* and *P. undulata*
Forster and Forster (1775)	Description of *Schefflera, S. digitata* being the type species
Vahl (1796	Description of *P. chrysophyllum*
Willd (1806)	Description of *P. speciosum*
Poiret (1811)	Description of *P. spinosa*
Decaisne and Planchon (1854)	Description of *Didymopanax*, *D. morototoni* being the type species together with five other species formerly of *Panax*, constituting genus *Didymopanax*, (contrary to *Panax*, *Didymopanax* contains a group of neotropical species with pedicels without joints)
Decaisne and Planchon (1878)	Description of *D. calophyllum*
Frodin (1975)	Proposal to combine *Didymopanax* with *Schefflera*
Maguire *et al*. (1984)	Incorporation of *Didymopanax* within *Schefflera* and consequent redesignation of *D. morototoni* as *S. morototoni*. *P. undulate* brought under synonymy of *S. morototoni*
FAO (1986)	*P. chrysophyllum*, *P. speciosum*, *P. spinosa*, *D. calophyllum*, *D.chrysophyllum*, *D. speciosum* and *Schefflera morototoni* treated as synonyms of *Didymopanax morototoni*

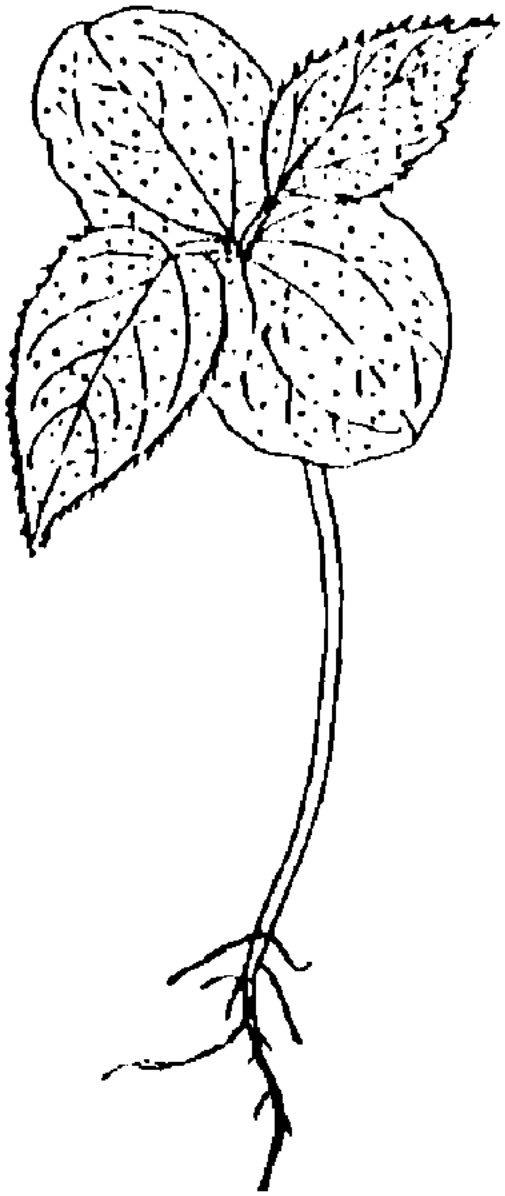

Fig. 1: Seedling of *Didymopanax morototoni*, actual size (Duke, 1965)

Mature Tree

Habit, Size and Form

Didymopanax morototoni is a handsome medium- to large-sized evergreen tree, 8 to 30 m in height and up to 80 cm in diameter. The bole is straight and cylindrical without branches to 12 m (Hladik, 1970). The butt is sometimes swollen. The little-branched crown is small and umbrella-shaped, with ramifications only at the summit. The leaves, on abscission, leave conspicuous scars where previously attached to the trunk. The outer bark is thin (1-2 mm), smooth and cream, greenish-white to grey or light brown in colour with dark spots. The large lenticels form a columnar pattern. The

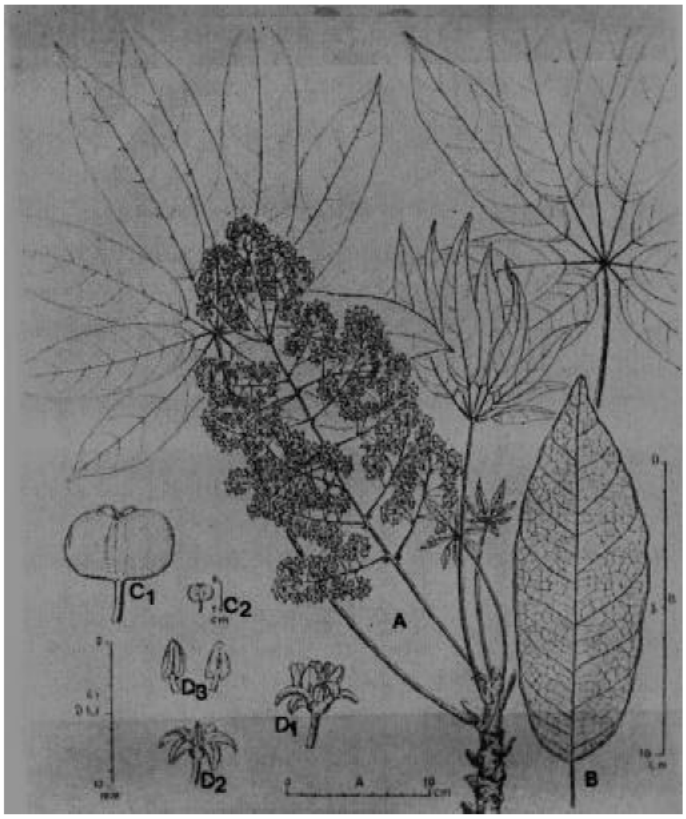

Fig. 2: Branchlet of *Didymopanax morototoni* with inflorescence (A) leaflet, (B) fruit, (C) staminate flower, (D1) pistillate flower, (D2) anthers, (D3) (Loureiro and Silva, 1968)

blaze is cream to whitish, the inner bark revealed as a golden band and rather thicker (10-15 mm) than the outer (Williams, 1936; Chudnoff, 1984; FAO, 1986; López, 1987). It contains a principle giving a bitter taste.

Foliage

The leaves are digitately compound, 15-40 cm long and altemate, with the leaflets grouped at the end of the long (30-60 cm) petiole, at the base of which are well developed stipules. In each leaf there are 9-13 acuminate leaflets, each 8-30 cm long and 4-12 cm broad. The lamina is semi-coriaceous in texture and dark-green in colour on the abaxial and reddish-brown on the adaxial side. Pubescence is limited to the adaxial surface. The venation of each leaflet is of 7-12 ascending veins, prominent on the abaxial surface (Fig. 2). Young individuals have juvenile foliage, with fewer (ca 7) leaflets, with short petiolules, thick and green on both surfaces with a reddish pilosity (Loureiro and Silva, 1968; Yared *et al*., 1980; Leão, 1984; FAO, 1986; López, 1987; Salomão, 1990).

Flowers and Fruits

The inflorescence is a racemose terminal panicle of umbels 20-40 cm long. In each umbel there are ca 30 small, 3-6 mm long, white to greenish-white, pedicellate or sessile flowers with apical styles. FAO (1986) and Hladik (1970) report the presence of three different groupings of umbels (1) on tertiary branches of the inflorescence with solitary flowers below on the same axis (2) formed on

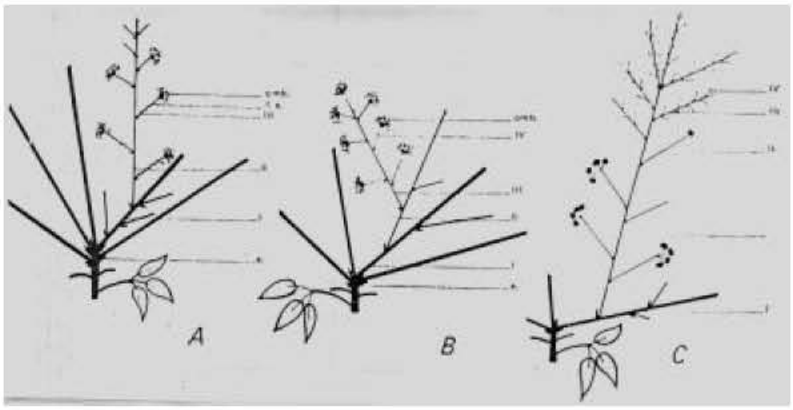

Fig. 3: The inflorescence of *Didymopanax morototoni*. (A) ordinary case, umbels of third order, (B) special case, umbels of fourth order and (C) special case, mixed umbels of third and fourth order Omb. = umbels, f.s. = solitary flower, I = primary peduncle, II = secondary peduncle, III = tertiary peduncle, IV = quaternary peduncle, a = main axis of the inflorescence, reduced or elongated (Hladik, 1970)

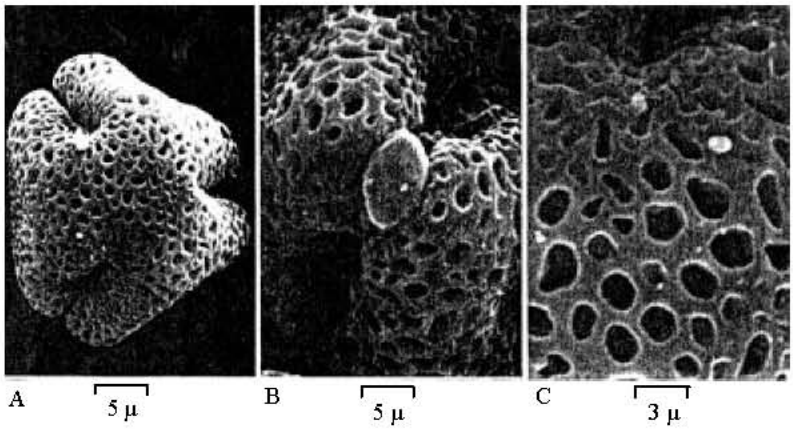

Fig. 4: Photomicrographs of *Didymopanax morototoni* pollen showing a polar view, (A) (x3000); an equatorial view, (B) (x6000) and an enlarged polar view, (C) (x10000). Modified from Maguire *et al*. (1984)

quaternary branches and (3) formed as an intermediate condition with some umbels directly on a tertiary branch but others (usually with aborted flowers) on quaternary branches subtended from the upper half of the same tertiary axis (Fig. 3). The calyx is of 5 slightly pubescent sepals. The corolla is of 5 petals. The fruit is a small, greyish, transversely elliptical, slightly keeled drupe, 7-12 mm long and 4-9 mm in transverse diameter, normally bearing two seeds. However, it had been reported taking 3-5 seeds as shown in Fig. 2 (Williams, 1936; Loureiro and Silva, 1968; López, 1987; Salomão, 1990).

Systematic Anatomy

Details of pollen morphology are given by Maguire *et al*. (1984) as shown in Fig. 4 although no description of their features is made.

Table 2: Phenology of *Didymopanax morototoni*

Locality	Event	Period	Season
Amazonia	Flower	Jun-Jul	Dry
	Fruit	Jun-Nov	Dry/Wet
	Dispersal	Sep-Nov	Wet
Northeast	Flower	May-Jun	Dry
	Fruit	Sep	Wet
	Dispersal	Sep-Jul	Dry/Wet/Dry
South	Flower	Feb	Wet
	Fruit	Apr-Dec	Wet/Dry
Centre	Flower	Feb-Apr	Wet
	Fruit	Jun-Aug	Dry
	Leaf fall	Jul-Sep	Dry
Brazil	Flower	Nov-Jan	Wet/Dry/Wet
	Fruit	Nov-Dec	Wet
Peru	Fruit	Nov-Dec	Wet

Sources: Cavallari and Gripp (1990), FAO (1986), Salomão (1990), Silva *et al.* (1990) and Williams (1936)

Reproductive Biology

Phenology

Flowering and fruiting vary with location (Table 2). This behaviour should be explained in terms of the wide-ranging distribution of the species. Associated climate conditions range from ever-humid, in Amazonia, to semi-arid, in the northeast of Brazil. However, the dry season, even in places where it is at its shortest, relates well with flowering patterns, the same happening in the semi-arid northeast. Moves towards a flowering period matching with the wet season are more pronounced in the central and southern locations in Brazil. Fruiting could be less clear-cut but still a weak association with the wet season in northern latitudes, both in Brazil and Peru, could be detected.

Pollination and Dispersal

The reproductive state is reached at an age of about 10 years: thereafter flowering is annual. It is believed pollination is mainly by insects, including wasps. Hladik (1970) reports visits by various insects, though notably the bees *Trigona* and *Mellipona*. The dispersal of seeds is reported to be ornithochorous (Hladik, 1970; FAO, 1986; Roth, 1987; Salomão, 1990).

Seed Biology in Natural Conditions

FAO (1986) reports 59,000 seeds per kilogram; Salomão reports just under 71,500 seeds per kilogram. Hladik (1970) considered the viability of *D. morototoni* seeds relatively high when compared with other species she studied.

FAO (1986) and Salomão (1990) report a long period for germination to occur and fire resistance of seeds which still germinate after the burning of vegetation, suggesting a dormancy mechanism operates.

Distribution and Ecology

Distribution

Present Distribution

The species occurs in Argentina, Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Surinam and Venezuela in South America (Fig. 5). Although the range extends to Central America countries: Costa Rica, Guatemala, Honduras, Nicaragua, Panama, including Antillean islands of Cuba, Dominican Republic, Puerto Rico, Trinidad and Tobago and reaches Mexico, in North America, these extra-South American occurrences will not be dealt with in this study.

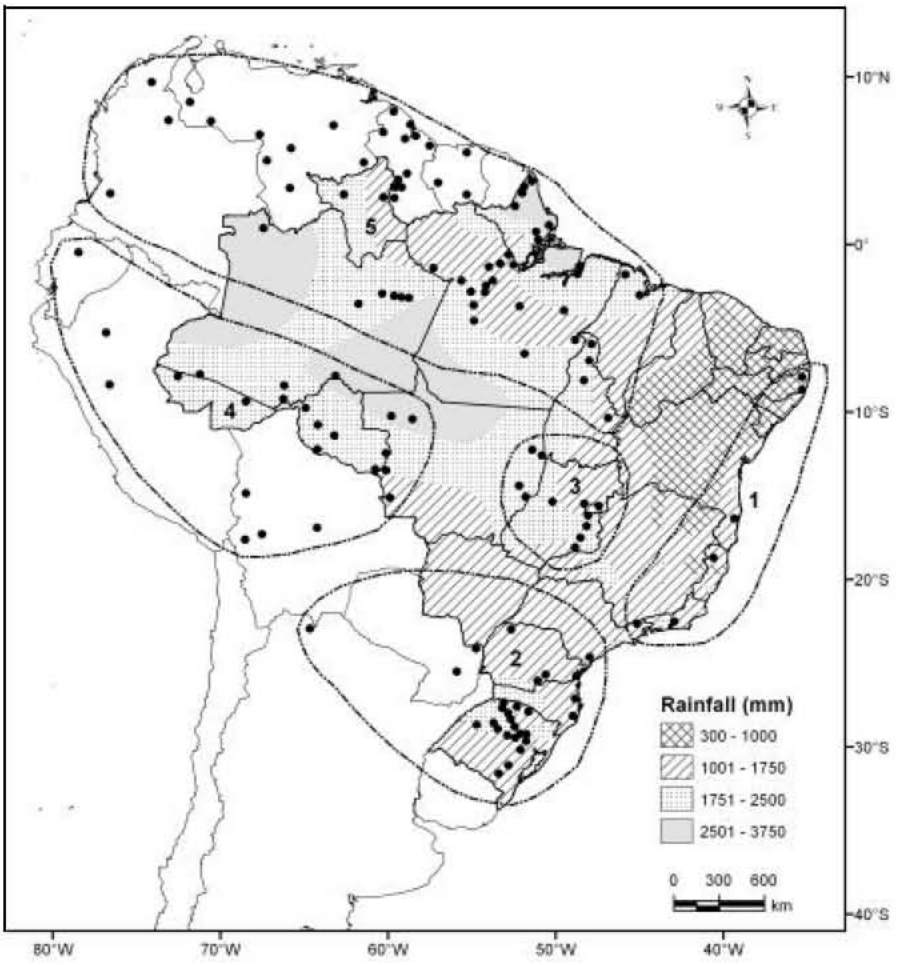

Fig. 5: Distribution of *D. morototoni* in S. America. Numbers denote sub-regions and countries as follows (1) Northeastern and Eastern Brazil;(2) Southern Brazil, Paraguay and Argentina;(3) Central Brazil (4) Western Brazil, Bolivia, Peru and Ecuador and (5) Brazilian Amazonia, French Guiana, Guyana, Surinam, Colombia and Venezuela

Range

Didymopanax morototoni is mostly found in Amazonia, particularly in the Amazonian and Guyanan basins which constitute the two core areas of the range in South America. The species is also prominent in Central American countries, particularly in the Antilles.

Many occurrences have been reported from the southernmost Brazilian state of Rio Grande do Sul though none, surprisingly, from neighbouring Uruguay. *D. morototoni* occurs also in other southern Brazilian states along the Tropic of Capricorn, in a few places in Paraguay and in Argentina.

The sparse distribution of the species in the centre-south, centre-west, northeast and Atlantic coast forest of Brazil, extends to Bolivia, Peru, Colombia and Venezuela (particularly west-of-the-Andes occurrences) and Ecuador (Maguire *et al*., 1984; FAO, 1986; López, 1987; Salomão, 1990).

Ecology

Environment

Elevation

Most reports are from low altitude forests but material has been collected from as high as ca 1,350 m (Maguire *et al*., 1984). Other reviewers such as FAO (1986) reported the species as frequent in upland forests. Williams (1936) reported occurrences from below 500 m to over 1,000 m in Peru. Ratter (1985) found the species in low numbers at altitudes of ca 200 m in the National Park of Araguaia, in the State of Mato Grosso, Brazil and there is herbarium material confirming the presence of *D. morototoni* from sea level (in Guyana) to ca 1,500 m (north of La Paz, Bolivia).

Soils

López (1987) describes soils for the ideal development of *D. morototoni* in Paraguay as deep and semi-humid. However, the species cannot be considered prominent in such areas having acrisols. Prominence is more associated with flat terrain, as those found in Amazonian (acid clayey soils - FAO, 1986) lowlands and southern Brazil pampas and to a less extent, landscapes in central Brazil. Prominence of the species is also observed in steeper landscapes as those in the Guianas, bordering Amazonian territory. Here the ferralsols are characteristically poor soils also.

Climate

Following the mean annual rainfall map for South America (WMO *et al*., 1975) and association with distribution (Fig. 5), the central, eastern and southern occurrences are associated with mean annual rainfall ≥ 1,200 mm and usually < 1,600 mm. Isolated occurrences in Argentina where continental scale rainfall maps show mean annual rainfall < 800 mm. In southern Amazonia where there is a wider mean annual rainfall range, occurrences under mean annual rainfall > 1,600 mm are more frequent (under up to ca 2,000 mm mean annual rainfall). In northern Amazonia there are a number of reports from areas subject to mean annual rainfall as high as 2,500 mm.

Site

Williams (1936), Record and Hess (1972), Chudnoff (1984) and FAO (1986) reported occurrence of *D. morototoni* in tropical South America, in open forests, abandoned clearings and at the forest/savanna boundary. The most important requirement for the development of the seedlings is abundant sunlight, rather than fertile soils.

Stocking

There is negligible information on stocking - only Salomão (Table 3) indicates per hectare numbers in relation to dbh. In this case among the individuals of *D. morototoni* > 15 cm dbh 56% were > 25 cm dbh and FAO (1986) give a broadly similar proportion of individuals (61%) in another report for Amazonia. Unfortunately FAO do not indicate what 100% relates to and do not indicate values in per hectare terms. Other reports are also vague: 5 and 7 individuals ha^{-1} (no sizes mentioned) by Salomão (1990) and Hladik (1970), respectively. In secondary forest the frequency of the species is higher (Yared and Carpanezzi, 1981; Roth, 1987).

Didymopanax Morototoni in a Phytosociological Context

Associated Species

Table 4 shows the association of *D. morototoni* with a number of species in various parts of its range in Brazil: Cerrado (C), the transition between Cerrado and the Amazonian forest (CA), the Amazonian forests (A), the Atlantic coast forest (AF) and the southern Brazil rainforests (RF).

Table 3: Stocking levels of *Didymopanax morototoni* in Amazonia (Salomão, 1990)

DBH (cm) classes	>15	>25	>35	>45	>55	>65	>75
Individuals ha^{-1}	9	5	4	3	3	2	0

Table 4: Species associated with *Didymopanax morototoni* in Brazil

Species	C	CA	A	AF	RF
Astronium fraxinifolium	*	*		*	
A. gracile			*	*	
Apuleia leiocarpa	*			*	*
A. molaris		*			
Cariniana estrellensis	*				
C. legalis				*	
Copaifera langsdorffii	*				
C. multijuga		*			
Hymenaea courbaril var. *courbaril*		*			
H. courbaril var. *stilbocarpa*	*				
H. intermedia var. *intermedia*		*	*		
Virola sebifera	*				
V. melinonii			*		
V. gardneri				*	
V. officinalis				*	
Britoa rugosa		*			*
Bagassa guianensis		*	*		
Cordia bicolor		*	*		
C. trichotoma				*	*
C. magnoliaefolia				*	
Manilkara huberi		*	*		
M. salzmannii				*	
M. bella				*	
M. longifolia				*	
Tabebuia rigida		*			
T. impetiginosa		*			
T. ochracea			*		
T. serratifolia				*	
T. avellanedae					*
T. alba					*
Dipteryx odorata		*	*		
Cedrela odorata			*	*	
C. fissilis					*
C. angustifolia				*	
Jacaranda copaia			*		
J. micrantha					*
J. puberula					*
Clarisia racemosa			*	*	
Terminalia argentea			*		
T. brasiliensis				*	
Parkia multijuga			*		
P. pendula				*	
Lecythis pisonis				*	
L. lurida				*	
L. usitata var. *paraensis*			*		
Ocotea costata			*		
O. costulata			*		
O. organensis				*	
O. porosa					*
O. puberula					*
O. odorifera					*
O. odorata					*
Simaruba amara			*	*	
S. cedron				*	
Nectandra miranda			*		
N. megapotamica					*

Table 4: Continued

Species	C	CA	A	AF	RF
N. saligna					*
N. lanceolata					*
Qualea paraensis			*		
Q. parviflora				*	
Q. magna				*	
Hydrogaster trinervis				*	
Emotum nitens					*
Balfourodendron riedelianum					*
Ilex paraguayensis					*
I. brevicuspis					*
I. dumosa					*
I. theezans					*
Araucaria angustifolia					*
Matayba elaeagnoides					*
Sebastiania klotzschiana					*
S. brasiliensis					*
Machaerium stipitatum					*
Allophylus edulis					*
Cabralea glaberrima					*
Parapiptadenia rigida					*

*Association of *D. morototoni* with a number of species in various parts of its range in Brazil: Cerrado (C), the transition between Cerrado and the Amazonian forest (CA), the Amazonian forests (A), the Atlantic coast forest (AF) and the southern Brazil rainforests (RF), Source: Salomão, 1990

Relations with the Natural Fauna

Hladik (1970), FAO (1986), Roth (1987) and Salomão (1990) report that birds disperse the seeds. Hladik draws attention to an association with *Crematogaster* ants which pierce the flowers and favour autogamy.

Relations with Forest Disturbance

The species thrives in secondary vegetation and is shade intolerant (Hladik, 1970; Yared *et al*., 1980; Yared and Carpanezzi, 1981; Roth, 1987; Salomão, 1990), accounting for abundance in disturbed forests, forest openings and at road sides throughout its range. Such areas are prone to fire in dry periods, (FAO, 1986), which favours the species because it has more fire resistant seeds than most of its associates. The seeds germinate quickly on fire-cleared soil.

Silviculture and Management

Experience with Artificial Regeneration

Propagation

Leão (1984) examined experimentally the viability of stored *D. morototoni* seeds, concluding that it was advisable to store seed at a temperature of 8°C and an ambient relative humidity of 50%, rather than in dry or humid conditions: to achieve this, permeable paper containers were preferable to plastic bags. After 11 months storage in cold (8°C) conditions, percentage germination was 33% compared 48.5% for fresh seed (the lots used were of low, 9.2%, moisture content at the end of the test period). Salomão(1990) reported that Carvalho (1976) estimated 68 days were required for the seed to germinate. Hladik (1970) obtained exactly the same results - 68 days elapsed for seed to germinate in Petri dishes under laboratory conditions at 22°C.

Montero and Estevez (1983) tested 83 pre-germinative treatments involving immersion of the seeds in sulphuric acid for different time intervals. It was concluded that germination energy level was very low and that immersion in concentrated acid does not favour germination However, the seed used was contaminated by fungi, especially *Aspergillus* sp., *Fusarium* sp. and *Curvularia* sp. and the results may have been affected by this.

For germination it is recommended that seed be allowed to imbibe water before being sown. After sowing, protection from direct sunlight is required.

Marques and Yared (1984) investigated treatments for accelerated nursery seedling production testing 10 soil mixtures, each with and without fertilizer. Seeds were sown on the seed beds of a 1:1 silt and sand medium. Seedlings were transplanted from the seed beds to plastic bags on reaching 3 cm height. Four months after transplanting, survival, root collar diameter and height attained were assessed. The best performance was from seedlings grown on a mix of local soil (rich in silt), sand and organic compost at a 3:1:1 ratio. This mixture promoted survival and growth and generated the most homogeneous crop of seedlings. Addition of mineral fertilizer enhanced growth (the period for seedling production was reduced from ten to six months) but prejudiced survival.

It is normal to transplant seedlings grown on seed beds into plastic bags 70 days after sowing. Outplanting is from stock in the plastic bags (Marques and Yared, 1984; Salomão, 1990).

Salomão (1990) reports that the species can be propagated by cuttings.

Outplanting and Establishment

Record and Hess (1972) draw attention to the accommodation of transplanting by the seedlings and their quick resumption of vigorous growth once plentiful sunlight is available.

Performance of Planted Individuals

This is one of the fastest growing native Amazonian species known and consequently it has been subjected to several silvicultural trials. Dubois (1971), cited by Yared and Carpanezzi (1981), set up experiments to test potential as a fast growing species for commercial plantations. Yared and Carpanezzi (1981) tested suitability of the recrû method for this and nine other native species in secondary forest in Pará State, Brazil. At an age in excess of ten years, for *D. morototoni* they found over 90% survival of the planted trees and growth in both diameter and height exceeded that of any other species tested. Yared *et al*. (1980) had earlier included the species in a silvicultural trial with 16 species. At 32 months, *D. morototoni* was the third tallest (just over 6 m) and the most sturdy (7.32 cm diameter) and the survival rate was in excess of 75%. The authors recommended proceeding with pilot plantations to test production and economic aspects more thoroughly. FAO (1986) report results of experimentation with the species in Amazonia. In three years-old plantations the best performance in height growth (over 4.6 m) was achieved from a 3×2 m spacing. The best diameter growth was for 4×4 m spacing (over 9 cm). Projected production was 15-18 m^3 ha^{-1} $year^{-1}$ in even-aged stands. No information on rotation period was given.

Management Attention in Forest Stands

Didymopanax morototoni is grown for commercial purposes in the State of Pará where stands are over ten years old (Leão, 1984). Native stocks of the species, although abundantly available, are not being exploited by the forest companies, who are supposedly more interested in reforestation with the species due to its good potential of growth and form (FAO, 1986).

Utilization

Wood Properties

Macro- and Microscopic Features

Williams (1936) described the wood of the species as pale or greyish brown, occasionally with a yellowish tinge. López (1987) extends this range of colour to light brown or somewhat pinkish. There is no distinction between heartwood and sapwood and no distinctive odour or taste. The grain is straight or fairly straight and the texture rather coarse - although Loureiro and Silva (1968), Record and Hess (1972), Chudnoff (1984), FAO (1986) and López (1987) reported a medium to rather fine

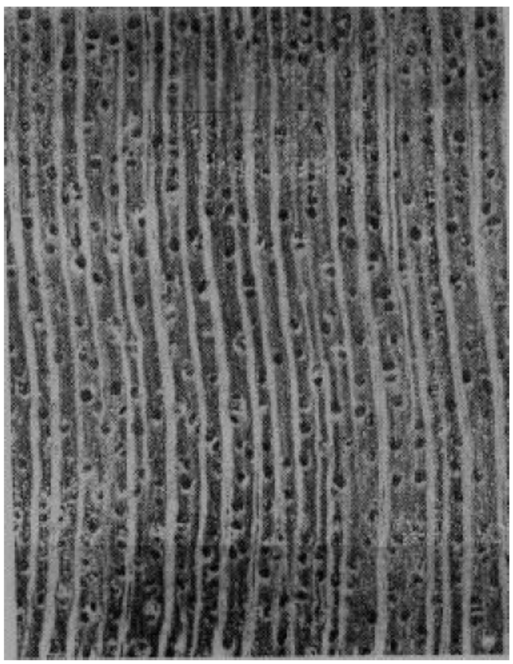

Fig. 6: Wood parenchyma of *Didymopanax morototoni*, (Loureiro and Silva, 1968)

texture. Lustre is medium, with a shiny and smooth cut surface (Loureiro and Silva, 1968; Record and Hess, 1972; FAO, 1986) without any figure (Williams, 1936). Williams (1936) and Loureiro and Silva (1968) add that (Fig. 6) the growth rings are indistinct and that the parenchyma is organized in indistinct, scattered cells. The pores are small (0.1-2.0 mm), scarce (4-7 mm-2) to numerous and evenly distributed, solitary or in radial multiples of 2-4 (seldom in small clusters). Vessel lines are moderately fine and inconspicuous with tyloses sometimes present. The rays are broad and uniform in cross section, numerous and distinct on all cut surfaces, especially radial. The rays are homogeneous or with a tendency to be heterogeneous and up to five cells wide - the marginal cells usually being larger than those within. Small radial canals occur at the margin of the pith and are common in the rays. Vessel perforations are simple, scalariform with several bars, reticulate, or composite. Vessel pits are large, irregular and with conspicuous borders. The fibres are septate and 1.62 mm in length and 0.034 mm in diameter (Salomão, 1990).

Physical and Mechanical Features

The wood of *D. morototoni* is described as rather light to light by Record and Hess (1972), Williams (1936) and López (1978), but as moderately heavy by Loureiro and Silva (1968) and FAO (1986).

The average weight (air-dry) is 497 kg m^{-3} within a range of 449-641 kg m^{-3} (Record and Hess, 1972; Chudnoff, 1984). Salomão (1990) reports of an average weight of 400 kg m^{-3}.

Chudnoff (1984) and Salomão (1990) reported mechanical properties (Table 5) for the species.

Use as Timber

Seasoning and Preservation

The wood air seasons quickly but with considerable degeneration. Warping is moderate to severe but checking and end splitting is reported absent or only moderate (Chudnoff, 1984).

Table 5: Mechanical properties of *Didymopanax morototoni*

Moisture content (%)	Bending strength	Modulus of elasticity	Compression strength	Tensile strength	Shear strength
	----------	----------	(N mm^{-2})	----------	----------
12 (1)	82.8	1247980	47.6	-	-
12 (2)	90.3	16134.3	-	-	
Green	39.3	883	17.1 //	2.8 ⊥	6.3
Dry	71.1*	1110	39.8 //	10.2 ⊥	10.2
Green	-	-	2.1 ⊥	-	-
Dry	-	-	4.2 ⊥	-	-
Other properties					
Hardness			2958-4070 N		
Load (green)		2578 N //	2042 N ⊥		
Load (dry)		4760 N //	3443 N ⊥		
FPL toughness			0.993 kJ		
	Radial		5.9-6.4%		
Shrinkage	Tangential		9.2-10.3%		
	Volumetric		14.8%		

*15% moisture; Load parallel (//) or perpendicular (⊥) to the fibres. (1), (2): First and second data sets based on the 2.5 and 5.0 cm standards, respectively

Absorption and penetration of treating solutions are fair for open tank and pressure-vacuum systems but there is good end grain penetration and the process can be enhanced by incising (Chudnoff, 1984).

Durability and Workability

Reports are consistent in indicating that the wood is not durable, being poorly resistant to decay (Record and Hess, 1972) and subject to blue stain (Williams, 1936). It is also very susceptible to dry rot (Chudnoff, 1984).

Williams (1936), Record and Hess (1972) and Loureiro and Silva (1968) report good workability. FAO (1986) also notes good and smooth finishing. Chudnoff (1984) recounts the good working features of the species with hand and machine tools but points out that the wood has a tendency to produce fuzzy and torn grain in planing and gives only fair surfaces in most other operations. It holds screws and nails very well, is easy to glue and can be cut into utility grade veneer.

Uses

Williams (1936) and Record and Hess (1972) report the use of this light and soft wood, especially on a local scale, for general carpentry protected from the weather, for match splints, boxes and crates. Loureiro and Silva (1968), Chudnoff (1984), FAO (1986) and Salomão (1990) added interior and general construction, ceilings, veneer, utility plywood, particle board, corestock, pencils, doors, trim and toys. López (1987) reported the use of the wood for making guitars, although it has been little used in his country, Paraguay. Salomão (1990) points out the good yield of cellulose, 52.5%, indicative of a role as a potential source of pulp for the paper industry.

Various authors report the selling and exporting of the species as Marupá (*Simaruba amara*) which it resembles (Loureiro and Silva, 1968; Record and Hess, 1972; FAO, 1986).

Other Uses

Medicinal

Loureiro and Silva (1968) report local use of the leaves as medicine, in Amazonia.

Ornamental

The handsome habit and rapid growth signify potential use in urban forestry (Loureiro and Silva, 1968; Salomão, 1990).

Conservation Status

Present Conservation Status

WCMC (personal communication, 1992)) assign no Red Data Book category of threat to this species due to lack of data from any part of its range and FAO (1986) report non-immediate genetic decline of *D. morototoni*, good provenances surviving throughout its range. However, this could be misleading. Roche (1987), presenting the FAO Panel of Experts list of forest genetic resources priorities for Brazil, included the species as a target for the national programme of genetic conservation focussed on Amazonia and the eastern parts of Brazil. This recommendation reflects concern to quickly develop what initial experience showed was a silviculturally amenable tree species and to implement measures to take into account provenance variation over the very wide range before land use changes seriously eroded the gene pool.

Present Conservation Priorities

Apart from international recognition of the priority status of the species by FAO (Roche, 1987) at national level in Brazil, Cenargen stresses the need for more silvicultural studies on the species and ecological assessments and collation of knowledge of the genetic diversity to allow preparation of a satisfactory genetic resources conservation programme (Salomão, 1990).

FAO (1986) highlight the wood as potentially a source of pulp for the paper industry describing as urgent the need for in-depth studies on the management of its natural regeneration and on its silviculture. FAO (1986) urge, in addition, establishment of base populations for ex situ conservation and the study of genetic variability among and within populations.

DISCUSSION

This study deals with the conservation issue seen from a species-oriented viewpoint rather than the more commonly seen community-centred strategies. The approach followed draws on current conservation theory adapted to the circumstances peculiar to the reviewed taxon. Biological and genetic conservation frameworks for the species are then presented together with suggestions of priority conservation action.

Success in conserving the genetic variation of widely-distributed taxa depends upon sampling enough of the overall genetic diversity inherent to such taxa. This means that the protected populations must include a sufficient spectrum of genetic variability and therefore also an adequate spectrum of ecological variability. The importance of clinal variation, common in wide-ranging tropical species, has become increasingly understood through comparative provenance trials (Roche, 1984). For species-oriented programmes of genetic conservation it is essential that intraspecific genetic variation takes precedence over interspecific variation (Roche, 1984).

For successful implementation of genetic conservation, there must be a clear strategy reflecting the character of the species. Tropical woody species, such as *D. morototoni* have long life cycles, are normally allogamous, have large individuals and mostly survive in a wild state. Consequently, relevant objectives for the strategy are refinement of biological knowledge and development of capability to introduce and breed the species where and as required. Such objectives also define which method of conservation suits a given species and, theoretically, dictates the size of population that must be conserved.

In view of our chronic lack of knowledge of many aspects of tropical species biology and ecology, *in situ* conservation measures merit the greatest investment of effort. This is because the *in situ* approach provides for maintenance of dynamic genetic variability more effectively than ex situ. Whilst a level of management intervention may be needed to 'stabilize' populations, our ability to achieve this is usually greater than our ability to create ex situ stands containing an adequate representation of the gene pool.

The appeal of *ex situ* conservation in recent years has been heavily based on theoretical considerations which do not apply for most tropical high forest species. Implementation of this approach appears most practicable for species which are not part of climax forests; this includes species of more open tropical formations and particularly those which are aggressive, light demanding and widely distributed (e.g., *Balanites aegyptiaca*-Hall, 1992). For the majority of species from the most humid tropical environments, however, very little has been achieved on the development of reliable methods of storage because of seed recalcitrance (FAO, 1990). Additionally, lack of research restricts our understanding of the extent to which seed storage is a safe method of conserving tropical woody species (Roche, 1975). Alternative approaches such as tissue culture remain unproven as realistic practical methods facilitating *ex situ* conservation.

Efforts have been made to link key genetic conservation research areas presented by Roche (1975) and National Research Council (1991) with knowledge on the target taxon. Gaps in our knowledge, such as those revealed in this study, were given particular attention. Despite these gaps, the available information can be used as a foundation for offering practical suggestions on potentially rewarding conservation approaches, following Hall's (1992) model for *Balanites aegyptiaca*.

The types of information needed to develop a conservation strategy are presented in Table 6, together with the appropriate data for *D. morototoni*. A good deal is known about the wood properties, taxonomy and morphology of *D. morototoni*. The available information about the distribution of the species could be used as a basis for locating potential in situ conservation areas or for planning germplasm collections for provenance trials. However, to pinpoint precise locations to conserve the genetic variability of this taxon requires further refining of the maps this must be based on visits to previous collection points as well as to new areas, in order to assess more fully the level of infraspecific variation. The species should also be considered in relation to its total range - a level of attention not feasible in the present study. Present ecological knowledge about the species, despite the relatively high number of sources, is inconsistent and incomplete. Our present information on reproductive biology of the taxon is also unsatisfactory.

Comparison of the distribution of the taxon with major soil units was made using the FAO-Unesco (1971) soil map. *D. morototoni* showed weaker relationships with fertile soils, while only patchy occurrences of the species are associated with richer soils.

Didymopanax morototoni have received great consideration in terms of silviculture and management. It stands out as a taxon well-known silviculturally, particularly in Brazilian eastern Amazonia, where already it is being grown commercially.

Information on the conservation status is very little. A major source of reference was the IUCN Red Data Book (WCMC, Personal Communication, 1992).

More noteworthy, however, is the consistent association with several other target taxa on the FAO Panel of Experts on Forest Gene Resources list (Roche, 1987). This was the basic document used by Cenargen to choose target species for the national programme of genetic conservation in Brazil. The main priorities of this programme are the establishment of genetic reserves wherever possible and particularly in existing protected areas. Additionally, *ex situ* conservation is sought through setting up germplasm banks and provenance and progeny trials. *In situ* genetic reserves should, however, be as large as possible to alleviate problems of genetic drift and consequent depression of genetic variability that can be expected in the existing small reserves. Both *in situ* and *ex situ* methods require management. Comments on non-immediate threat to *D. morototoni* as resource should be treated with particular caution.

In summary, despite our limited knowledge about *D. morototoni*, we conclude that is typical of many thinly dispersed, outcrossing, tropical forest trees which are at risk as forest disturbance levels increase and individuals become increasingly isolated. The species displays several features generally associated with pioneer species which warrant it a special consideration. Although this account deals

Table 6: Type of information required for conservation

Type of information	Current knowledge relevant to the conservation of *D. morototoni*
1. Population status and structure	
Reflect mainly levels of stocking (individuals ha^{-1}) prominence, represents distinctiveness of the species among constituents of the habitat.	Stocking levels lower (reports of 4 trees but less than 1 tree (this study) ≥15 cm dbh ha^{-1}) in less disturbed forest than and in secondary vegetation. Prominence in South America in northern Amazonian and Guyanan basins and rather sparse elsewhere, except in the south of Brazil.
2. Resilience	
(a) Physical	
The importance of resilience to physical disturbance agents, normally natural browsing, drought) or management activities (selective logging, clear-felling, girdling) is in the definition of methods of protection and intervention to favour the species.	Aggressive pioneer species which withstands fire.
(b) Herbivores and/or pathogens	
The role of herbivores and/or pathogens is important to consider when com-mercial species are involved.	Seeds attacked by fungi
3. Level of exploitation	
Exploitation of the resource relates to the degree to which the species is seen as economically important and under pressure in the current context.	Wide-ranging internal use of the timber but still only of local importance. Potential for pulp production may change trend.
4. Level of rehabilitation	
Level of rehabilitation and resource creation cover capability in securing regen-eration as desired and in controlling agents antagonistic to establishment.	Colonizing ability favours planting in commercial stands. Native stocks abundantly available in the north but southwards occurrences demand enrichment plantations. Several silvicultural trials in Amazonia
5. Quantification and characterization of genetic variability	
Quantification and characterization of genetic variability are achieved through careful examination of collected material within the range of the species looking for variation at an infraspecific level, mainly by observation of phenotypic traits such as shape and size of leaves, fruits, seeds, bark.	Infraspecific variation not known but worth investigating for the remaining of the very wide range. No information about formal attempts to establish different provenance trials within the range.
6. Ecological amplitude	
(a) Site	
Site represents the small-scale environmental variation (e.g., soil texture and composition and topographic features).	Gap conditions in the habitat favour development (sunlight rather than fertile soils appears main factor in growth).
(b) Vegetation formations	
Relates to the various phytogeographic forest formations present in the range of the distribution.	Extremely variable, from tropical ombrophilous lowland forest in Amazonia to drought deciduous lowland woodland in Argentina. Notably, absent from Brazil's northeastern Caatinga.
7. Breeding system and reproductive biology	
(a) Sexual system	
Breeding systems and reproductive biology are important to ascertain by which type of reproductive system species populations are perpetuated.	Reproductive age reached at ten years with subsequent annual flowering. Autogamy favoured by ants piercing flowers in this monoecious species
(b) Pollination and dispersal	
Important is insight into agents responsible for pollination and seed dispersal	Entomophily and ornithochory observed.
8. Seed biology	
Seed biology knowledge, involving knowledge of phases subsequent to ferti-lization (seed crop, pre-dispersal predation and dormancy patterns) is important for prediction of how much is produced and the proportion likely to germinate successfully.	
(a) Seed crop	Little information on seed crop but variation in seed weight fairly wide: 59,000-71,500 seeds kg^{-1}.
(b) Seed pre-dispersal predation	No reported predation of seed.
(c) Seed dormancy	Suggested dormancy mechanism involved, with fire triggering germination.

Table 6: Continued

9. Nursery technology	
Nursery technology, involving raising planting stock both as selected seedlings and as cuttings, is important for enrichment planting and intervention in a management scheme.	
(a) Seedling production	Several accounts of seed storage (cold conditions), germination (slow) and handling of seedlings.
(b) Clonal production	Very little information available.
10. Forest policy	
The forest policy aspect relates to the extent of involvement of the legal authority and how actively it promotes law enforcement regarding conservation matters for the species and how threats to it are curbed.	Provenances beyond Amazonia are at highest risk. Studies of these are needed, particularly for eastern parts of Brazil and non-studied Centre-American populations.

with the whole natural range of the species, including Argentina, Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Surinam and Venezuela in South America, emphasis, on this occasion, is given exclusively to Brazil, for this was the primary objective of the study regarding assessment of the resource in protected areas and further actions to conserve it.

Of the recognized protected areas (Sharpe, WCMC, Personal Communication, 1992) in Brazil, theoretical conservation suggests few qualify as effective both in size and legal status for the long term conservation goals of forest genetic resources. A more practical listing of potentially viable protected areas is one according with Ibama's definition (Gonchorosky, Personal Communication, 1992) of conservation units of indirect use national parks, biological reserves, ecological stations) and direct use (national forests and extractive reserves).

Consideration of the species and its distribution within Brazil in relation to the WCMC map of protected areas (Sharpe, Personal Communication, 1992) can be done only on a very tentative basis at present. Nevertheless, it is appropriate to associate occurrences of the taxon with the protected areas to the extent possible.

This was done by showing the distribution of protected areas which have had some more attention regarding their floristic composition, enabling, therefore, to have a picture of the occurrence of the species in such areas (IBGE, 1993). Figure 7 shows a map where these areas are located.

Didymopanax morototoni, due to its wide distribution and resilience, can be assumed represented in many protected areas, particularly in Amazonia (National Parks of Amazonia, Cabo Orange, Pacaás Novos, Jari Ecological Station), but also in the Cerrado (National Parks of Araguaia and Brasília). There is need for enhanced protection in a number of areas throughout the range of the taxon (Fig. 7). *D. morototoni* lacks provision for conservation in the central Cerrado (particularly in the parts north of Brasília) and in the southern Pampas of Rio Grande do Sul State.

Protection of outlying populations is important due to the likely genetic variability existent in them when compared to the core of the range populations.

Basically, there are three practical options for tackling the conservation problem: traditional *in situ* reserves, normally in existing protected areas or specifically designated genetic conservation reserves traditional *ex situ* stands, mostly provenance and progeny-sometimes silvicultural- rials a compromise approach which is based on enrichment action to favour the targeted species (Table 6).

Considering the current situation of protected areas in Brazil, the geographical distribution patterns of the taxon and the little that is known of its population structure, some recommendations can be put forward for genetic conservation programmes. *D. morototoni* is at less risk because of its aggressive pioneer status. It is, in contrast, well-suited to *ex situ* and compromise conservation approaches, approaches allowing stocking levels in excess of the highest developed in unmanaged secondary forest (7 adult individuals ha^{-1}) and far above that (< 1 adult individual ha^{-}) of less disturbed areas, such as the gallery forests of the central Cerrado. Spontaneous regeneration could be stimulated by judicious use of fire or alternative chemical and physical breaking of dormancy.

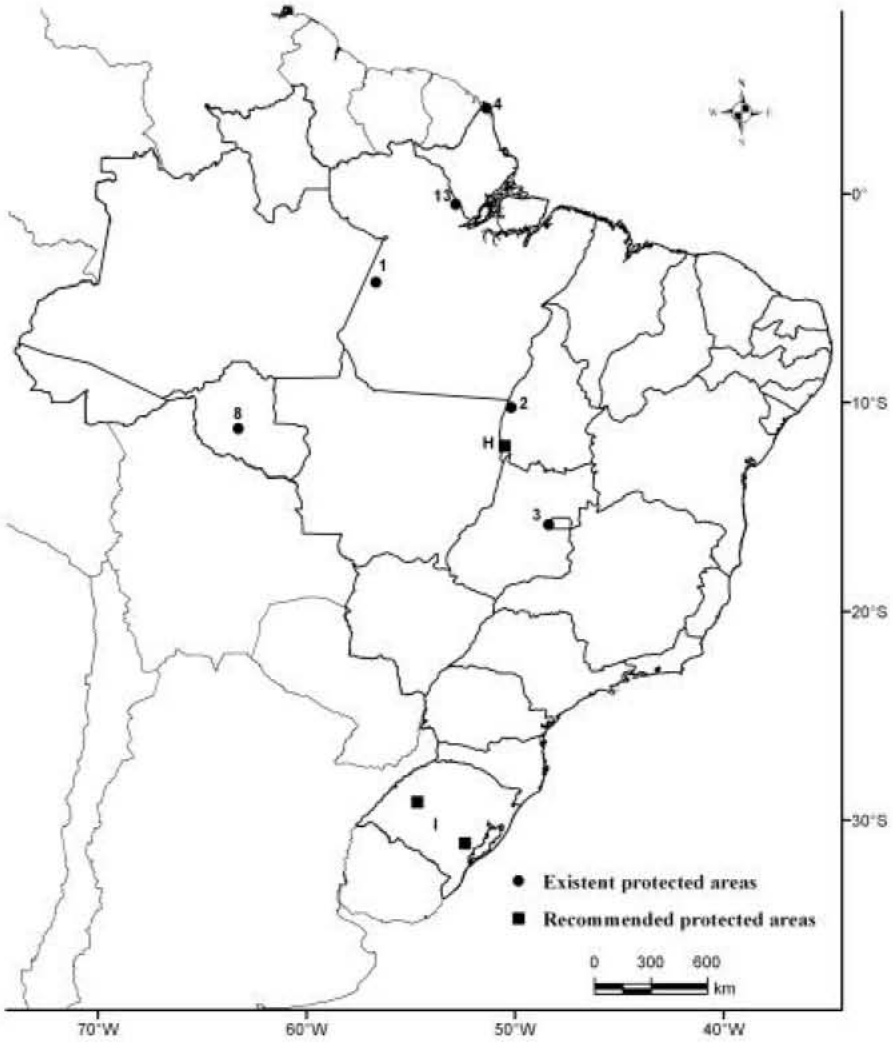

Fig. 7: Distribution of existent protected areas: The National Parks of Amazonia (1), Cabo Orange (4) and Pacaás Novos (8), the Jari Ecological Station (13), in Amazonia; and the National Parks of Araguaia (2), Brasília (3), in the Cerrado; Recommended potential protected areas in Brazil in the central Cerrado -particularly in the parts north of Brasília- (H) and in the southern Pampas of Rio Grande do Sul State (I). Current protected areas based on IBGE's (1993) map

With so many gaps in the silvicultural/management/conservation picture it is important that new initiatives should be on a planned and focused basis centred on identified priorities and not merely opportunistic. For *Didymopanax morototoni*, the priorities centre on seed technology-notably procedures to break dormancy and achieve quick nursery production of seedlings. Fire management in protected areas containing the species is an option worth exploring as a means of speeding up the germination of seed dormant in soil banks.

The organizations with a mandate to advise on national conservation policy need to make a convincing case to the legal authorities and decision-makers of the implications of neglecting to declare

the additional protected areas needed to secure a viable gene pool of the resources considered in this study and pinpointed in Fig. 7. One vital area of experience is in seed collection expeditions: already there has been successful collecting of other target species seed and, additionally, extending activities to storage and testing and nursery establishment would constitute logical extension of the work done on those species to others requiring similar action. Longer-term, more involvement in provenance and progeny trials - as has already started with other species - can be foreseen for other taxa. Teams dealing with reconnaissance surveys or inventories to identify areas (protected or with potential) containing the target taxon should also pay special attention to assessing population structure aiming at future rehabilitation (compromise) action. A major role is played by the Instituto Florestal (Forestry Institute) of the State of São Paulo in forest genetic conservation in Brazil. Because most of the actions utilizing ex situ and the compromise (enrichment) approaches are concentrated in a region around that State, it is wise to have their collaboration in these programmes. It is clear, after what has been discussed in this study, that despite the dearth of current knowledge, technical solutions for the conservation of forest genetic resources followed by action (breaking away the notorious verbosity generally encountered in the subject) are possible. Hopefully, scientific advice will be followed by political will to fulfil expectations.

CONCLUSIONS

The background level of effectiveness and versatility of the system of protected areas in Brazil is still poor, as far as conservation of forest genetic resources is concerned. Few examples of the main categories of protected areas with a bearing on conservation and management (national forest and extractive reserve) of the resource, through intervention, contain the species (Fig. 7). Indeed, the majority of existing areas containing *Didymopanax morototoni* are 'indirect use' categories (national park, biological reserve, ecological station), as shown in Fig. 7 and no management actions are expected to favour the species studied here due to the non-intervention policy followed by Ibama. Such management actions are better directed to the conservation problem, in genetic reserves (*in situ* conservation) and formal planted stands (ex situ conservation) established by the scientific authority, as can be shown in Fig. 7. There is no initiative concentrating on alternative conservation approaches, such as enrichment planting, to complement traditional ones.

There has also been little implementation in the country of conservation options developed over the last few years from the increasing ecological understanding of tropical forest ecosystems. Much current activity takes insufficient account of the high diversity and low population densities of neotropical forest tree species. The vulnerability of the Cerrado formations to conversion for other land use makes application of effective conservation an urgent need.

Didymopanax morototoni differs from the other target taxa in being better known silviculturally than biologically. Information is very limited with respect to aspects of the reproductive biology (notably the pollination process) and conservation schedules for this apparently large pioneer species in the secondary forest vegetation, where it is most abundant. Vital aspects important for traditional in situ and ex situ conservation are lacking and, additionally, there is poor legal protection in established areas. Compromise measures, basically through enrichment (e.g., mixture) with local seed source, are therefore urged to compensate for this. As conservation target, the taxon requires measures suited to a resilient species well-adapted to forests subject to disturbance.

RECOMMENDATIONS

The following recommendations are made, with respect to the conclusions above, to assist the national conservation programme.

The patchy characteristics of forest formations in central Brazil Cerrado and the increasing fragmentation of more populated areas in the northeast and the centre-south, require that tackling the conservation problem should take into account the island-like nature of the habitats-habitats where conditions favour high rates of inbreeding, progressive loss of genetic diversity and, in the long run, extinction of species. To curb this, a network of local or, ideally, regional protected areas has to be established containing preferably direct categories, but not disregarding the possibility of creating indirect categories when the opportunity arises. A significant increase in the number of even small protected areas contributing to a larger network would increase chances of survival of species for long term purposes. This network has to be supported by complementary approaches to favour thinly dispersed forest species by including sites which serve as links between more widely separated areas. This could involve the use of enrichment techniques with germplasm from nearby sources.

Didymopanax morototoni is recommended for development of conservation schedules formalized into routine management actions together with conjugation of effort to link the information from Brazil with that from the rest of the range. This would allow ascertaining the overall extent of variability and its possible causes.

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