

Description and Ecology of *Pterocarpus angolensis* in Namibia

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Abstract

The tree Pterocarpus angolensis is an important component of the dry woodland savanna of northern Namibia. Its timber provides the basic resource for much of the carvings in Namibia. Unfortunately little management, particularly regeneration, has been implemented in the country and current exploitation practices amount to mining of the species.

Keywords: Dry woodland savanna, Namibia, *Pterocarpus angolensis*

Introduction

Pterocarpus angolensis is a leguminous tree which belongs to a genus comprised of about 100 species (Dyer 1975). Four of these species occur in the northern and eastern parts of southern Africa.

The species provides a very valuable timber used for carpentry and for carving by the tourism industry. While commercial exploitation is controlled, it is uncertain how much of the wood is harvested illegally. Since the tree is extremely slow growing, it is important to implement conservation measures to insure sustainable utilization of the species.

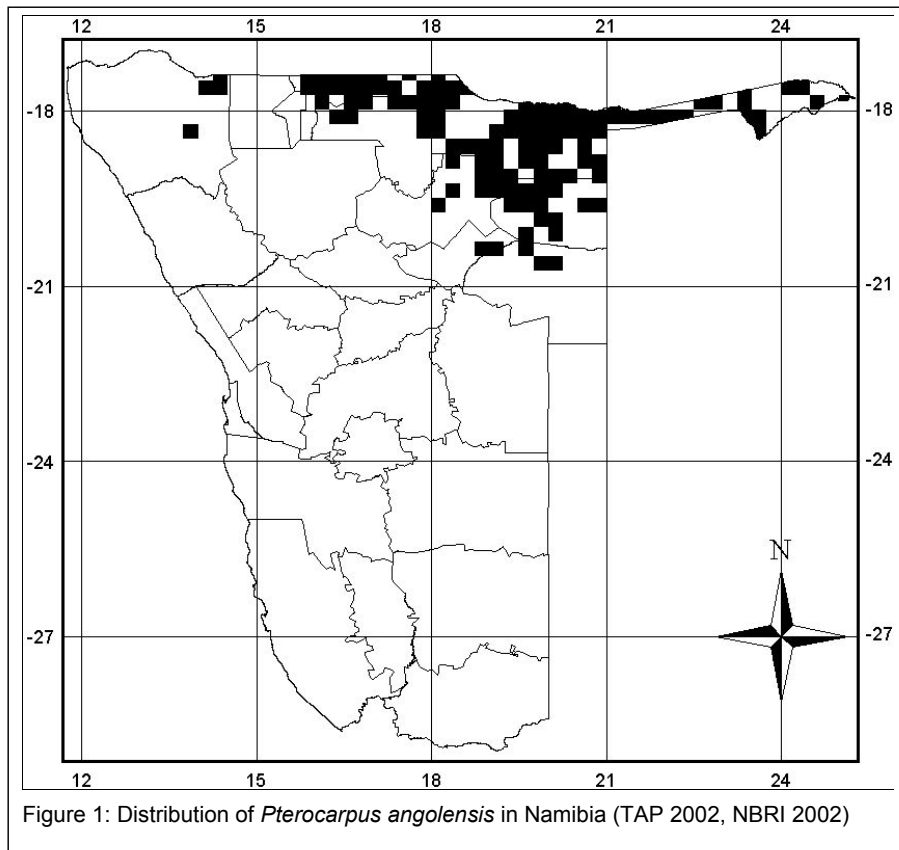
This monograph aims to consolidate available information. While a very comprehensive review was compiled by Vermeulen (1990) some research results obtained after that date need to be taken into account.

Distribution and Occurrence

Distribution

P. angolensis occurs in the dry woodland savanna in southern Africa. The countries in which the species occurs include Zambia (Trapnell 1959), Malawi (P. Hardcastle pers. com.), Mozambique, Tanzania (Groome *et al.* 1957b), Angola, Namibia,

Botswana, South Africa, Zimbabwe (Coates Palgrave 1983) and Swaziland (Dyer 1975).



Within Namibia, the species is found in the dry woodland savanna areas of western and eastern Caprivi, Okavango, Otjozondjupa, Omaheke, Ohangwena and Otjikoto regions.

In the Otjozondjupa region the species is frequently found in conjunction with *Burkea africana*, sometimes with *Terminalia sericea*. In the Okavango region *P. angolensis* may be found together with *Guibourtia coleosperma*, *Lonchocarpus nelsii* and *Schinziophyton rautanenii*. Although the different species occur together, it is probable that *P. angolensis* established first given its sensitivity to competition; the other species would have followed later.

Growth Requirements and Preferences

Soil

Within its distribution range *P. angolensis* occurs mostly on deep sands, with the biggest trees on well-drained soils with a sandy or loamy texture (Vermeulen 1990). Personal observations and discussions with local forestry staff indicate, that seedlings were able to establish themselves on the slightly heavier soils of a dry river bed near Kanovlei, Namibia. None of the plants observed had developed beyond the suffrutex stage (see later in text) and assumptions about long term survival cannot be made.

Water

P. angolensis occurs in areas that are characterized by well-defined wet and dry seasons. Rainfall may be as low as 500mm per annum (Vermeulen 1990, Groome *et al.* 1957b), although precipitation in parts of its range is somewhat less in Namibia, and a water table of around 70m (Vermeulen 1990).

The soil conditions favored by the species together with the rooting strategy described by von Breitenbach (1973) and Vermeulen (1990) indicate that precipitation rather than a permanent subterranean water supply meet the species' water requirements. This brings the tree into competition for water with the remaining vegetation. Under conditions of exceptional competition for ephemeral water resources *P. angolensis* is not successful (von Breitenbach 1973).

Light

According to Groome *et al.* (1957b) and Vermeulen (1990) *P. angolensis* is a light demanding species. Although it may persist in moderate shade it is likely to stagnate. Other authors consider that *P. angolensis* may survive as a suffrutex in shade conditions for a number of years and is able to form a permanent shoot once conditions improve (Boaler and Schiwale 1966)

Frost

While high temperature may cause *P. angolensis* to produce leaves early, frost may have detrimental effects. Low temperatures appear to affect younger plants in particular, causing them to die-back. Older growth does not seem to be affected as severely, although periodic damage may occur (Groome *et al.* 1957b).

Description

Growth form

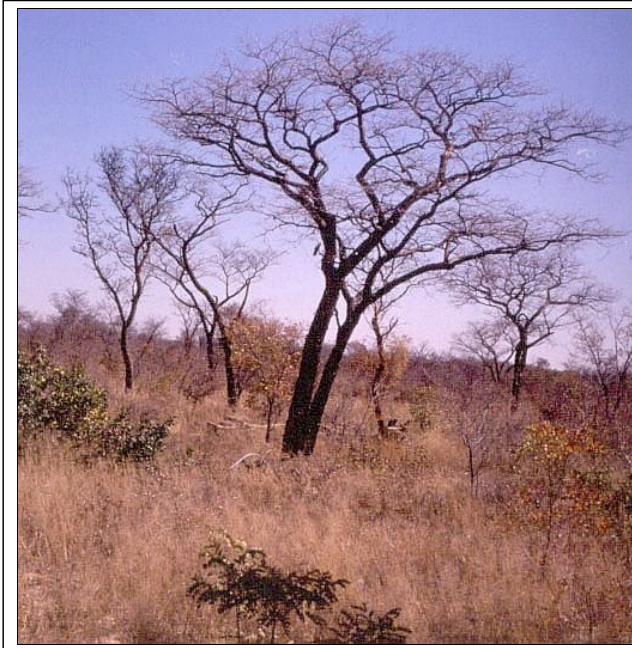


Figure 2: *Pterocarpus angolensis* tree on dune near Kanovlei Forest Research Station (photo F.P. Graz, June 1994).

P. angolensis, figure 2, is a medium sized tree with a short trunk and a flat topped crown. Tree height is usually between 10 and 12 m, although it may grow to 20m (Orpen 1982).

Growth rate and ultimate tree size are strongly genetically controlled (Vermeulen 1990), although development is otherwise highly dependent on environmental factors, with final tree height directly related to the productivity of the site (Vermeulen 1990).

Generally, a tree will reach its full crown diameter in the third or fourth decade (von Breitenbach 1973). It is not clear if von Breitenbach calculates from year of germination or from the year in which the permanent shoot was formed. No clear relationship between age and crown diameter has been established thus far (Vermeulen 1990).

Leaves

The leaves are imparipinnate (Dyer 1975) and alternately arranged (Coates Palgrave 1983). Minute glands are often found on the underside of leaflets. Young leaves are often densely, silky-pubescent (von Breitenbach 1973).

Childes (1989) and Vermeulen (1990) report that the first rains of the season cue leaf-flush. It seems, however, that trees will flower and produce before the onset of the rains near Kanovlei (pers obs). This is also the case for a number of other woodland savanna and savanna species.

Leaf fall is early, at the start of the dry season (Coates Palgrave 1983, Childes 1989) and is probably in response to moisture stress (Childes 1989).

To enable the tree to flush prior to the first rains nutrients are stored from around March and April (Vermeulen 1990), rather than used for growth.

Flowers

Flowers are orange to yellow and occur in large, branched sprays about 10 to 20cm long, from August to December (Coates Palgrave 1983). Flowers are produced before leaves flush. Since flowering is markedly synchronized it is probably induced by temperature or photoperiod (Childes 1989).

Flowers are pollinated by insects (Childes 1989) to produce one to six pods in a raceme.

Fruit

The fruit of *P. angolensis* is a pod that is covered with spiny bristles and surrounded by an orbicular, slightly lobed wing. The entire fruit is between 50-150mm in diameter (Vermeulen 1990), and carried on a stalk about 10mm in length.

Pods generally contain a single seed although this may change with location (Vermeulen 1990).

The wing provides the fruit with an excellent gliding ability; dust-devils may carry them up to 3km (Groome *et al.* 1957a), while the spiny centre helps the fruit to stick to the fur of animals (epizoochoric dispersal).

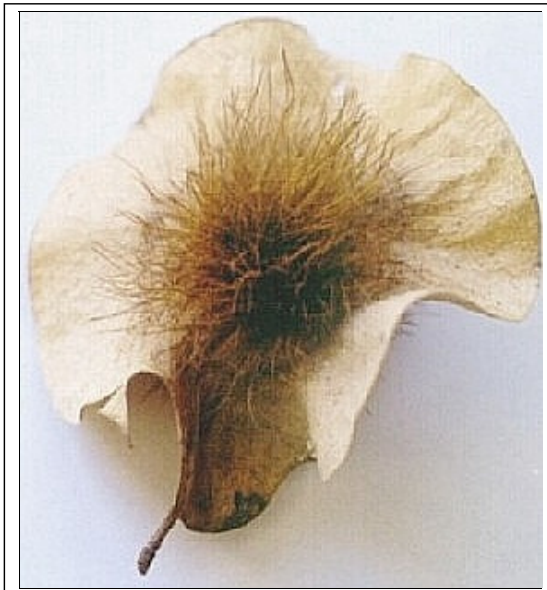


Figure 3: *Pterocarpus angolensis* fruit

The fruit may therefore be dispersed by one or a combination of mechanisms, i.e. anemochory (dispersal by wind) or by means of its barbed fruits. In addition, fruits may sometimes be seen rolling along the ground on their wings ("Bodenroller").

Most fruit, however, do not travel more than about 30m from the parent tree (Vermeulen 1990), so that the heaviest fruit deposits occur around the trees with the largest crops (von Breitenbach 1973).

Generally, pods are detached from the parent tree in the late dry season or early wet season (von Breitenbach 1973) by wind (Vermeulen 1990), but may also be beaten down by rain (Groome *et al.* 1957b). At this time of year dispersal is enhanced by the absence of leaves on the surrounding vegetation (Childes 1989), although the fruit may snag in dry grasses.

Bark and Wood

The heartwood is generally reddish to reddish-brown, while the sapwood is a pale yellow to almost white. The transition between heartwood and sapwood is very sharp. This is often exploited by the carving industry to achieve pleasing contrasts. If the wood is left too long the sapwood will discolor to a blue. Chemical treatment against such discoloration is possible.

Demography

Fruit Production

Trees produce fruit after 20 years (Vermeulen 1990). This delay is possibly influenced by the suffrutex stage (see later in text) through which the species passes before it produces its first permanent shoot. It is, however, not clear if Vermeulen calculates the age of the tree from time of germination of the seed, or as the age of the permanent shoot.

The size of fruit crops is correlated with the degree of openness of the stand. Trees established on recently abandoned cultivated lands bear particularly heavy crops (Vermeulen 1990). (Von Breitenbach (1973) considers 200-400 fruit per tree to be a heavy crop.)

The large crops produced in open areas not only emphasize the light requirements of the species, but also have other important ecological implications. These will become evident later in the text.

Seed Release and Germination

Fire is known to remove the wing and hairs and to bring the fruit into contact with the ground if it has been lodged in brush or grass (van Daalen 1991).

The opening of the pod appears to be induced by repeated wetting and drying in the later part of the rainy season, or in the wet season following the production of the fruit (von Breitenbach 1973). Groome *et al.* (1957b) also suggest that the moisture is

conserved below pods detached by rain that would attract termites that would then crack the hull. Vermeulen (1990) on the other hand assumes that termites merely remove the wing and bristles but do not open the fruit.

Germination of the seed is epigeal (Vermeulen 1990) and is estimated to require two weeks (Geldenhuis 1975) immediately after the pod has opened (Vermeulen 1990).

Fire has been found to enhance germination under natural conditions (Geldenhuis 1975, van Daalen 1991), although this influence is dependent on fire intensity. Very intense fires have been found to reduce the viability of the seed, whereas 'cool' fires have very little influence on germination at all (van Daalen 1991).

Once the pod is detached from the parent tree the seed rapidly loses its viability (Groome *et al.* 1957a, Vermeulen 1990). Although Geldenhuis (1975) estimates the limit of viability of the seed at 1 to 2 years, Hilbert (pers. com.) has successfully germinated five-year-old seed. He did not indicate how the seed was stored.

Nursery observations indicate that *P. angolensis* germinates best without shade (Groome *et al.* 1957b). Together with the observations reported by von Breitenbach (1973) and Vermeulen (1990) - regarding the relationship between fruit crop and stand density - the heavy fruit crops produced in open areas would provide the species with a greater chance to persist in open stands.

Competition for water will also be less between woody plants in open stands once the seedlings are established.

Establishment

Seedlings are subject to a high degree of mortality that may be caused by a variety of factors. These include fire, nutrient deficiencies, damage by animals, intra- and interspecific competition (Vermeulen 1990) and drought (Groome *et al.* 1957b).

In the establishment phase the seedling develops a tap root of between 45 and 90cm within the first growing season (von Breitenbach 1973). This taproot then thickens to a depth of 60cm and then tapers off rapidly.

Seedlings quickly enter a suffrutex stage that usually continues for a number of years. During this period the plant produces shoots that may reach a height of between one and three meters each growing season. These die back in the subsequent dry season to a depth of about 2-3cm below the surface (von Breitenbach 1973), thus effectively protecting the plant against dry season fires.

This period of annual die-back continues for a period of around 10 years although it may be prolonged by high fire frequencies. During this time the root-system develops to an extent where it may collect sufficient water and nutrients to support a permanent shoot through the dry season (von Breitenbach 1973, Vermeulen 1990).

The lateral roots of a fully-grown canopy tree will spread over an area greater than the reach of the crown, to a diameter of 15 to 20m, in the upper 30 to 60cm of the soil. Numerous 'sinkers' are sent down to a depth of about 2m (Vermeulen 1990).



Figure 4: *Pterocarpus angolensis* suffrutex in the 1994 felling area (photo F.P. Graz, June 1994)

Mortality

While the plant is in the seedling stage it is most prone to damage by animals. Large mammals browse on the young leaves and wild pigs have been known to dig up entire plants to reach the fleshy tap-root (von Breitenbach 1973). Van Daalen (1991) also indicates that grazing pressure can have detrimental effects on seedling survival. It is not clear from his text how this is caused, i.e. through physical damage or indirect causes. Later, trees may be damaged by elephant that have been reported to chew the bark (Groome *et al.* 1957b).

Trees and Fire

While the strategy of annual die-back and re-growth may protect the seedling from fire damage, annual burning retards the development of plants from the suffrutex to sapling stage (Vermeulen 1990). Only once it has reached the sapling stage may the species benefit from its higher fire resistance.

The saplings themselves may tolerate fire temperatures of between 400°C and 450°C; most other woodland species die off at lower temperatures. The removal of competitors will allow saplings to obtain greater benefit from the subsequent ash-bed effect (Vermeulen 1990, von Breitenbach 1973) as well as from reduced competition for water.

Geldenhuis (1992) observed a high stem density of smaller classes of *P. angolensis* (as well as *Burkea africana*) in Kavango, northern Namibia. This he attributed to the high frequency of moderate fires in the region.

The superior fire tolerance also assists the species during the colonization of open areas. The development of herbaceous vegetation is favored in such areas, leading to a correspondingly higher fire frequency (Heikkilä *et al.* 1993), and intensity (Graz 1996). The large fruit crops that von Breitenbach and Vermeulen associate with trees in such areas also increase the likelihood of recruitment.

On the other hand, fire also seems to be the main factor that prevents the re-establishment of felled areas from coppice regrowth (Vermeulen 1990). The thinning of the canopy as a result of felling may lead to an increase in the herbaceous vegetation with a subsequent increase in fire intensity. In addition, dry material, such as leaves, may accumulate between coppice shoots providing fast burning fuel directly next to the shoots.

Vermeulen (1990) reports that shoot growth is enhanced if the herbaceous vegetation is removed by fire. This may be due to reduced competition for water (after Walker and Noy-Meir 1982), or due to changes in nutrient status of the soil such as found by Knoop (1982).

Although the trees are generally fire resistant, damage to the bark or cambium may nevertheless provide fire with entry into the trunk. Zimmermann (pers com) observed damage at the base of many adult *P. angolensis* trees in parts of northern Namibia. The damage had been caused by cattle herders who used small sections of the trunk to protect themselves or their belongings against rain.

Management Issues

Vermeulen's review of the species provides a summary of management strategies that have been proposed by various authors. It is not evident if any of these strategies have been implemented or tested successfully; the silvicultural treatments presented by Vermeulen generally refer to countries with higher rainfall.

While *P. angolensis* is reputed to have a life expectancy of 90-100 years (Vermeulen 1990), the difficulty of determining the age of the trees presents one of the most

important limitations to the development of management programs. According to Van Daalen *et al.* (1992) the tree forms false growth rings that limit the usefulness of ring counts. (Stahle *et al.* 1999) on the other hand have been able to establish tree age using growth rings, although the authors needed to cross check with other woody plant species. Additionally, a large proportion of the trees in Namibia are hollow (pers. obs.) making aging by conventional means almost impossible.

Observations of in sample plots in Tanzania and Mozambique indicate that stands are probably even aged (Groome *et al.* 1957b). Considering the site requirements of *P. angolensis*, as well as the difficulty with which the species is able to establish itself under other trees this is probable.

The (re-) establishment of felled areas provides further difficulties for active management. Vermeulen (1990) reports that propagation of seedlings or cuttings in nurseries is extremely difficult, and survival rates of seedlings that have been planted out are low. He speculates that this is probably due to the development requirements of the root system. Vermeulen does not indicate any association with mycorrhiza, although such a relationship has been reported by the National Tree Seed Programme (NTSP), Tanzania (NTSP 1995)

Coppicing may be an alternative to regenerate the species in the field since *P. angolensis* is a persistent coppicer especially in the seedling and establishment stages. However, this regeneration strategy is not reliable enough for timber production unless fire control is implemented (Groome *et al.* 1957b).

The management proposals presented by Vermeulen (1990) indicate that management should concentrate on coppice and suffrutex management. Such management could include fire protection, protection from animal damage, or transplanting suffrutex plants in the field.

Also, conditions that provide the species with a means to seed out in the field should be encouraged. Such management may need to concentrate on fire control, but would also need to consider the thinning or clearing of areas to reduce competition and benefit the establishment of seedlings (Erkkila and Siiskonen 1992).

Management of *Pterocarpus angolensis* in Namibia.

None of the silvicultural practices cited by Vermeulen (1990) have been implemented in Namibia. Research on the development of coppice shoots near Kanovlei and northern Omaheke had been initiated in the late 1980's but was terminated in 1994.

There is no current information on the growing stock of *P. angolensis* in Namibia, or an estimate of the population structure, although some approximations have been made in the past.

In 1995/96 a total of about 7000m³ of roundwood was harvested annually for sawtimber in Caprivi, Kavango and Bushmanland (unpublished data). On average recovery to sawn wood is about 40% (v.d. Berg pers. com. 1992, Orr pers. com. 1992). Further quantities were harvested for carving and carpentry for the tourist industry. The amount of illegal exploitation cannot be quantified but is assumed to be high.

Volume estimates based on a reconnaissance survey in some parts of Bushmanland in 1989 indicated a periodic allowable cut of 600m³ per 100km² (Hilbert pers. com.). However, the distribution of *P. angolensis* is patchy (pers. obs.) and quotas must be adjusted accordingly. Hilbert (pers. com.) suggests a rotation of 50 years.

Felling quotas for the informal sector are granted in numbers of trees, and volumes are not recorded.

Trees are felled selectively based on diameter rather than age. This system was first implemented in the 1960's (Hilbert pers. com.). In accordance with the specified procedures only trees with a diameter exceeding 45cm may be cut. Where multi-stemmed trees are encountered, fellers were required to leave at least half of the stems standing.

It is not clear on what criteria the minimum diameter was based (Hilbert pers. com.). The ease with which the system may be implemented and controlled has made it very attractive.

However, this selection system may result in the equivalent of local clearfelling, as was seen in parts of Bushmanland. This is consistent with the findings of von Breitenbach (1973) in Caprivi and with regard to site dependent growth rate and ultimate size of trees, and the diameter distributions reported by Groome *et al.* (1957b).

Conclusion

While some knowledge exists, and research into the artificial establishment of *P. angolensis* has been carried out in neighboring countries, it is unsure how effective these techniques are in Namibia. Further research is therefore required to support the management of the species.

The increasing demand for the carving industry coupled with the lack of re-establishment amounts to the equivalent of mining of the species.

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