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THE ECOLOGY OF A KEY AFRICAN MULTIPURPOSE TREE SPECIES *PARKIA BIGLOBOSA* (JACQ.) BENTH: THE CURRENT- STATE -OF- KNOWLEDGE

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ABSTRACT

Parkia biglobosa an important indigenous fruit tree of West African Sudanian woodlands was comprehensively reviewed and studied range-wide for its ecology. The review adopted a monographic style focusing on critical ecological attributes of the species. Records in herbaria and published information on the distribution of the species were assembled and summarised as a distribution map. Soil and vegetation maps of Africa, meteorological data and information on ecological accounts were used in the interpretation of the map. The origins and affinities indicated the species as an offshoot of Ingeae. Parkia demonstrates a broad regional ecological amplitude i.e from (Senegal to Uganda) covering 20 African countries. Elevation is from almost sea level to 1300m while mean annual rainfall ranges between 400 mm-1400 mm with 2-7 months of dry season. Temperature of 20℃ -30℃ is frequent, however frost is unknown in the range. Topographically, is a characteristic species of the hill slope crest underlain by crystalline basement complex/sand stone rock, with loam-sandy soil of variable texture. Well drained soil with a good moisture holding capacity typifies site and is probably sensitive to salinity. Due to selective protection it is prominent in farmlands, with varying stocking densities. Despite its positive effects on soil fertility maintenance it is a non-nodulating species. Attention is also drawn to various relationships with natural fauna and apart from man, bats appeared to be the oldest associates. The surviving gene pool is probably due to its heliophytic nature, coppice ability, deep tap root and tolerance to drought, pests and insects. Human disturbance continues to play significant roles in secondary invasion process. Definitive studies aimed at generating relevant data to aid husbandry action are outlined. Suggestions for future positive management prescriptions and domestication initiatives are also made

INTRODUCTION

Parkia biglobosa (Jacq.) Benth, named after Mungo Park by Robert Brown (1826), has long been widely recognised as an important indigenous fruit tree in many African countries south of the Sahara. It is commonly known as the locust bean tree in anglophone countries and néré in francophone range. Principally the range is the Sudanian woodlands of West Africa extending from Senegal in the west to Uganda to the east. As a result of age-long association with traditional agriculture and diverse usage, it has attained protective status in most agricultural systems (Keay, 1955; Hagos, 1962; Hopkins, 1983). It is a deciduous tree with a large spreading crown, producing indehiscent pods, and edible seeds (beans), which is the most valuable product of the tree (Keay, 1955; Irvine, 1962; Hopkins, 1983).

An array of multipurpose uses have been reported: including food, medicine, manure, gum, tannin, shade, wind-break, bee food, stabilisation of degraded environmental, livestock feed, fuel, fibre, fish poison among several others (Keay, 1955; Irvine, 1961, Campbell-Platt, 1980; Kater *et al.*, 1992; Kessler *et al.*, 1993; Hopkins, 1983). According to FAO (1988), the demand for the seed merits the establishment of plantations in a significant proportion of its range. *Parkia's* adaptation to its natural environment makes it more drought tolerant than many of the exotics grown as alternative tree resources (Ladipo & Soladoye, 1991; Oladele *et al.*, 1985; Fasheun & Osonubi, 1989; Otegbeye, 1995). As a result of the numerous usage the species was included in the Forest Genetic Resources Priority List of the FAO Panel of Experts on Forest Genetic Resources at their 4th meeting and was rated a priority species for industrial wood and food sources for genecological exploration, provenance trials, utilisation and conservation (FAO, 1988).

Despite the potential benefits, organised resource management was only in the last two decades, largely prompted by woodland disappearance in the region and the extended drought of 1968-1973 (Nichol, 1988; Baumer, 1990). However, like many other indigenous savanna fruit trees, the species is undergoing serious genetic depletion due to demographic pressure on land, uncontrolled bush burning, deforestation and extensive cattle grazing (Pullan 1977; 1977; Kio *et al.*, 1988; Kessler, 1992). Future management and conservation therefore requires an update of ecological information for in-situ conservation of the remaining germplasm and monitoring programmes for restorative intervention. The promotion of the tree as a component of agroforestry requires an updated ecological information for effective management. Extensive reviews of literature exist (Hopkins, 1983; Booth & Wickens, 1988; Sabiiti & Cobbina, 1992) nevertheless, even after their work additional information are still required on the species ecology particularly for Nigeria. This paper therefore provides an authoritative and integrated review of available information on the ecology of *Parkia biglobosa* across its range to further promote the tree and enhance germplasm conservation and improvement.

Origins and affinities

The *Parkieae* is suspected to be a specialised off-shoot of the *Ingeae* (Elias, 1981). The *Ingeae* is a relatively advanced group of the Mimosoideae, evolved from a more primitive base group represented today by the Mimoseae. Particular features of *Parkia*, taken as indicating an advanced state within the Mimosideae, are the pollen in polyads and a base chromosome number below 14. Reports of fossil *Parkia* from Africa do not indicate species (Hopkins, 1986) but reveal that *Parkia* or a very similar taxon, was present in Cameroun and Senegal during the Miocene (23-5 MYBP). Other reports (Salard-Chebaldaeff, 1978) indicate older pollen fossils in Cameroun (Mid and Upper Eocene: 50-35 MYBP). The fossil is known by the palynological name *Parkiidites microreticulatus* Guinet & Salard, but is a better match for Section

Sphaeroparkia than Section *Parkia* (Muller, 1981). *Sphaeroparkia* is not found in Africa today, but is thought to be the most primitive section of *Parkia* (Hopkins, 1986). The question raised by Hopkins (1986) of how Section *Parkia* comes to be present on both sides of the Atlantic, requires the assumption of long distance dispersal across the sea. It remains uncertain which side of the Atlantic the Section originally developed.

Present distribution and range

Parkia biglobosa occurs naturally in West Africa from Senegal in the west (14° 50'N, 17° 25'W-Thies, Berhaut 73, BR) to Uganda (3° 5'N, 11° 20' E -Mount Kei, Dale U 858, EA) in the east (Hopkins & White, 1984). It is believed to be endemic to the Sudanian Regional Centre of Endemism and the Guineo Congolian/Sudanian Regional Transition Zone of White (1983) while its spread to the Guinea-Congolian centre is probably due to invasion, following vegetation clearance and general land disturbance (White, 1983; Hopkins & White, 1984). The northern limit is however at the southern boundary of the Sahel (Hopkins & White, 1984).

Apart from Nigeria, it occurs naturally in Republic of Benin, Burkina Faso, Cameroun, Chad, Coté d'Ivoire, Central African Republic, Gambia, Ghana, Guinea, Guinea Bissau, Mali, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Togo, Uganda, and Zaire (Hopkins & White, 1984; Booth & Wickens, 1988; Sabiiti & Cobbina, 1992a). As an introduction however, it has been reported from the West Indies, Saó Tomé and Annobon (Exell, 1944; Hopkins, 1983). Using herbaria voucher specimens, with collector's comments and reported locations in published literature's it has been possible to prepare a range-wide distribution map for the species (Figure 1).

Relations with environmental factors

Elevation

Collating information range-wide indicates elevation of between 6m-1285m for *P. biglobosa,* however west of the range is most frequent at lower elevation (<400 m) but more associated with higher elevation (>400 m) eastwards (Oni, 1997). A summary of frequently reported elevations range-wide is indicated in Table 1.

Rainfall

P. biglobosa occurs principally in areas with mean a annual rainfall of 600 mm-1400 mm. The whole range of *P. biglobosa* broadly experiences 2-7 months main dry season, being those with rainfall <50 mm (Jackson, 1973, Hopkins & White, 1984; Booth & Wickens; 1988; Agbahungba & Depommier, 1993). *P biglobosa* demonstrates adaptations to drought and a prolonged dry season as a result of deep tap root systems and low leaf stomata conductance (Osonubi & Fasheun, 1987; Oladele *et al.*, 1985).

Temperature

The mean annual temperature is between 20°C-30°C range-wide (FAO, 1984). The mean monthly temperature often reaches 41°C at peak period, while in the coldest month, it often drops to about 11°C (FAO 1984; Carlowtiz, 1991). However frost is unknown range-wide (White, 1983b).

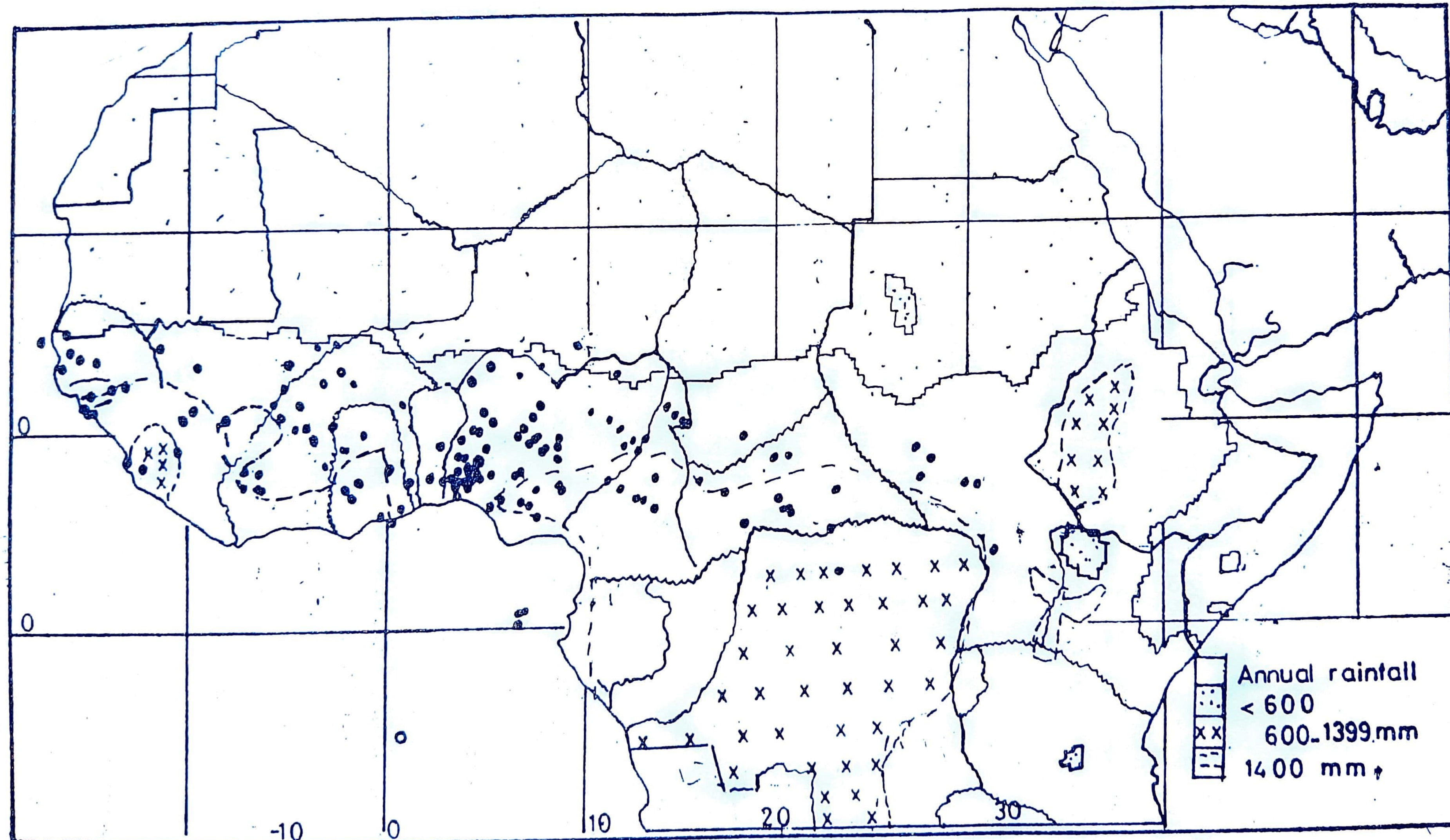


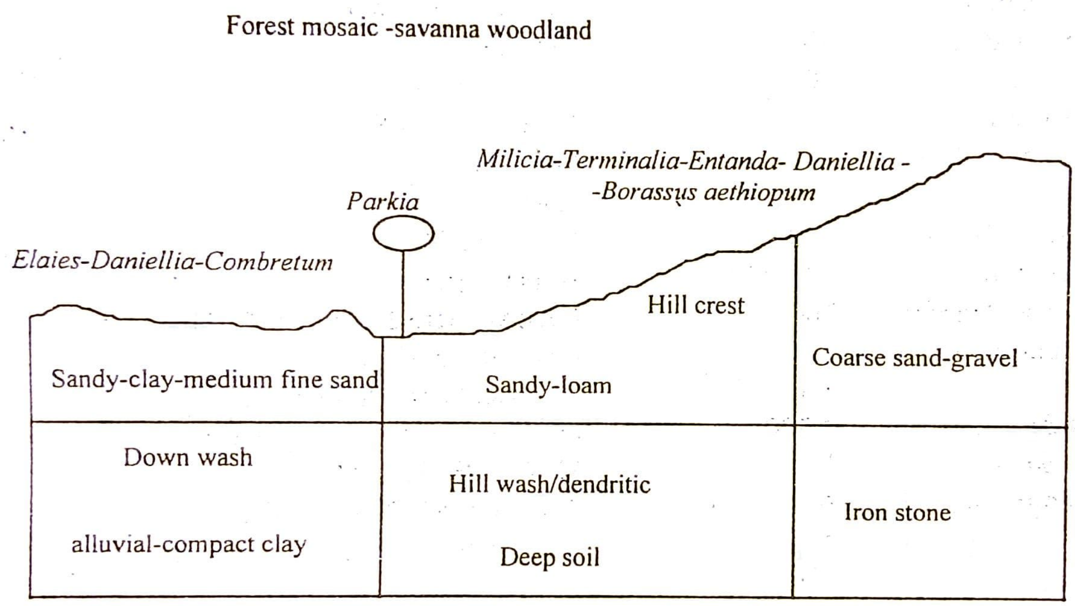
Fig. 1 . Distribution of Parkia biglobosa in relation to mean annual rainfall .

Table 1 Elevation of occurrence reported for *Parkia biglobosa* range-wide

Location	Altitude(metres)	Reference
Nigeria, Jos	1285	Batten-Pole 102 K
Cameroun, Wawa	1100	Leeuwenberg 7684, BR, K, MO
Nigeria, Gongola	750-800	Mildbread 9C03 BM
Nigeria, Katsina	450-700	Ahmed FHI 26212 BR, FHO, K
Central African Republic	400-600	Spinage 288 K
Niger Republic, Magaria	477	Fabregue 3016, P
Burkina Faso Dinderesso	432	Aubreville 2696, P
Sudan, Yirol-Dirgai	423	Andrews A 728, K
Togo, Sandboden	402	Ern 2961, K
Ghana, Ejura	400	Vigne FHI 1540
Guinea, Koroussa	377	Pobeguin 130 P
Chad Republic, Sarh	365	Foureau 3016, P
Mali, Sikasso	350	Kater *et al.*(1992)
Sierra Leone, Musaia	349	Deighton 5480 K
Benin, Parakou	300-400	Agbahungba & Depommier (1993)
Burkina Faso, Banfora	300	Leeuwenberg & Amshoff 4310, K P
Ghana, Achimota	300	Baker & Harris (1959)
Ivory Coast	300	Leeuwenberg 3263 BR, K
Range-wide	0-300	Derek *et al.* (1984), Hogg (1994)
Nigeria, Okene	300.	Maggs OK 31, BM
Cote d' Ivoire, Seguela	300	Leweenberg 3263, WAG
Senegal, Niokolo-Koba	200-300	Tutin 9, K
Nigeria, Kaura Namoda	300	Keay FHI 16205
Nigeria, Ilorin	200	Fagbemi (1994)
Benin, Abomey	167	Chevalier 23153, P
Nigeria, Olokemeji	100	Hopkins (1962)
Guinea Bissau,	21	Espirito Santo 1166, LISC
Senegal, Kaolack	6	Raichinger 77 P

Catena and Toposequence

Descriptions of the position of *P. biglobosa* in catenas are few and often difficult to interpret. However few reports exit; Morison *et al.* (1948) illustrate the toposequence position of *P biglobosa* in Aweil, Sudan (08° 42'N, 27° 20'E) at the colluvial-illuvial transition, where deposits of finer material of sandy-loam, washed down the slope crest of the elluvial region have accumulated. Here *Parkia* occurs with *Khaya senegalensis, Entada africana* and *Borassus eathiopum* (Figure 2). In Nigeria, Adejuwon (1971) also described the position of *P biglobosa* in a catena on the rock hill savanna forest in the Guineo-Congolian/Sudanian transition as a species occurring along the crest of the hill. In the Guineo-Congolian/Sudanian transition, Benue valley of Nigeria (Aliade Plains), *Parkia* was absent from the upper slope positions, dominated by a mixture of sandstone and shales as the parent materials, with a sandy surface horizon, but occurred at the lower crest region dominated by hill wash sandy-loam soil (Howard, 1976)



Morison *et al.* (1948) Sudan (08°42` N, 27° 20`E) Mean annual rainfall 1000 mm quaternary deposits, Howard (1976) Nigeria , Benue 7 28`N, 835`E Mean annual rainfall 1364 mm Cretaceous sand stone , Sand stone

Figure 2 The position of *P. biglobosa* in the catena.

Geology and soil

P. biglobosa occurs on a wide range of soil types, however it is most frequent in loamy-sand to loamy-clay of 1-4 m depth (Jackson, 1973; Hopkins & White, 1984; Fagbemi, 1989) Texturally, it varies from fine, medium or coarse in the surface 50 cm, while at a greater depth, good growth is generally where the texture is fine although individuals will survive even if the soil texture is medium to coarse (Howard, 1976; Hopkins & White, 1984; Sabiiti & Cobbina, 1992a; Kessler, 1992). Growth is restricted or less frequent where the soil is shallow (<50 cm) with very deep water table and prolonged dry season (Hopkins & White, 1984).

Geologically, the species occurs mainly on crystalline basement complex (FAO, 1977) however in Senegal it is one of the species retained during the formation of the unconsolidated sands (Giffard, 1974)) and has been widely reported from areas of sandstone rock (Hopkins & White, 1984). The general picture is one of concentration on various sandstone's and basement complex rocks and absence or scarce in areas of deep sand deposits and volcanic rocks.

Site

Relative abundance is where the soil is well drained and with good moisture holding capacity. Weathering of basement complex rocks leads to such soils. Where the soil is poor, stunted growth occurs and the species are of small sizes in these situations (Maydell, 1985). Poorly drained sites or saline soils are unsuitable and it is probably sensitive to high salinity levels. The toposequence positions where *P biglobosa* is most typical reflect these site requirements. As a savanna species in many parts of the range there are ironstone pavements which reflect quartenary fluctuations in climate. Within the toposequence, *P biglobosa* typically occurs on a level area where good soil depth is present above ironstone or on slopes.

PARKIA BIGLOBOSA AS VEGETATION COMPONENT

Chorology

Along with *Lophira lanceolata* and *Vitellaria paradoxa, P. biglobosa* is one of the typical Sudannian savanna tree species. None of these, or any member of these genera, occurs in savanna south of the equator. It has been suggested that *P. biglobosa* was part of the original vegetation in almost all parts of the Sudanian Regional Centre (Hopkins & White, 1984). In the Guinea-Congolian/Sudanian transition and Guinea-Congolian centre however, it is thought to have resulted from secondary invasion or planting (Keay 1959a; Hopkins & White 1984).

Vegetation type

The broad ecological spread of *P. biglobosa* in West Africa is matched by its occurrence in a wide range of vegetation communities. Nevertheless, most reports correspond to vegetation types of White (1983) terms `wooded grassland' and `wooded farmland'. Thus, in White's Sudanian Centre of Endemism, *P biglobosa* is frequently mentioned as a major vegetation component of undifferentiated Sudanian woodland (Taylor, 1960; Howard, 1976; Hopkins & White, 1984; Macmillan, 1991). This is the typical vegetation even at the eastern extreme of the range (Morison *et al.*, 1948; El-Amin, 1990). In the Guineo-Congolian/Sudanian transition zone, it is a component of Sudanian woodland with abundant *Isoberlinia* (Fagbemi, 1989; Ladipo *et al*., 1992), and towards the southern limit of the Guineo-Congolian/Sudanian transition it is a component of the mosaic of lowland rain forest and secondary grassland of White (1983).

Where *Parkia* is typical of wooded farmland, this reflects deliberate protection accorded the species, due to its economic importance (Savill & Fox, 1967; Kessler, 1992; Gakou *et al*., 1995). In most parklands, it is dominant in the woody vegetation and often forms a distinctive open *Vitellaria-Parkia* parkland, in association with smaller numbers of other protected woody tree species.

PROMINENCE, POPULATION LEVELS AND REPRESENTATION

Prominence

The deliberate clearing and cutting of other woody species has made *P biglobosa* prominent in many areas of the farmland in West Africa (Jones, 1963a; Pullan, 1974; Valette, 1973, Kessler, 1992; Gijsbers *et al*., 1994). *Parkia biglobosa* was used as a descriptor of the farmed parkland reflecting prominence where it was described as *Parkia-Vitellaria paradoxa* and *Faidherbia albida* (Gijsbers *et al*., 1994).

Population levels

Quantitative reports exist for *Parkia* population levels in some locations in the range, as listed in Table 2. However, the approaches adopted and parameters measured by different workers often complicate comparisons. Sampling areas and strategy are variable, and sometimes number of individuals are reported with no reference to minimum values for inclusion. Reported stocking for the species in the range is indicated in Table 2.

Representation

Information on *Parkia* representation in woodland and natural wooded grassland communities generally shows very low values below 5%, but in wooded farmland representation is higher, especially if only relatively large (≥10 cm dbh) woody species are considered. In Kontagora, Nigeria, *Parkia* accounts for upwards of 15% for individuals (dbh >10 cm) (Valette, 1973), and a larger representation of 20-30% was indicated as common for the species in most of the selected parklands of West Africa (Pullan, 1974; Kessler, 1992). Bennett *et al.* (1976) recorded representation of 38% on the Titiale series of Benue Valley in Nigeria.

INTERACTIONS WITH NATURAL OR SPONTANEOUS PLANT COMMUNITIES

Influence On Soil Environment

Quantitative reports on the extent to which *P. biglobosa* influences the soil environment is recent, most previous reports tend to have been casual comments. Current studies indicate increased soil fertility within the tree species vicinity and underneath its crown, compared with the open fields (Kessler,

Table 2 Stocking estimates of *Parkia biglobosa* in natural communities

Stocking trees ha^{-1} (representation)	Attribute	Minimum value for inclusion	Location	Basis	Source
0.19	individuals	not indicated	Southern Nigeria	Ecological survey	Forestry Dept (1986)
0.03	individuals	not indicated	Eastern Nigeria	Ecological survey	Forestry Dept (1986)
2	individuals	>10 cm	Kano (12° 05' N, 08°35' E) Nigeria	Ecological survey	Okpala (1989)
0.2 %	individuals	10 cm,	Olokemeji (7° 35'N, 3°25' E) Nigeria	formal inventory 0.25m² plot, >2m height	Hopkins (1962)
0.04 2.20%	stems	not specified	Badeggi (9°01' N,6°08'E) Nigeria	Ecological survey on 0.4 ha	Jones (1963)
1 individual 0.003%	individual tree	>9.5 cm, 1.30m height	Anara Forest Reserve (10 40' N,7°45'E) Nigeria	0-8 observations on each plot of fifteen 0.2 ha plots	Onochie (1961)
Stocking trees ha^{-1} (representation)	Attribute	Minimum value for inclusion	Location	Basis	Source
0.14 (9 individuals) 3.6%	trees	not specified	Kwara state (8° 30'N, 04°32' E) Nigeria	Ethnobotanical survey 64 hectares 100% enumeration	Soladoye *et al* (1989)
0.51 0.37%	individuals	>10 cm	Gambaga scarp (10°32'N, 0°2'5W) Ghana	91 observations on 177 ha	Taylor (1960)
3.75 (1.6 %)	trees	not specified	Northern Ghana	48 observations, on composite area 3.2 ha	Vigne (1953)
2-10	trees	>10 cm	Parakou (9°10'N,°2 20' E) Benin	formal inventory	Agbahungba & Depommier (1989)
1 (4%)	stems	>10 cm	Yundum (13°21' N, 16° 40' W) Gambia	formal inventory	Forster (1983)
10 47%	Individual	> 10 cm	Burkina Faso (12°21'N, 01°31'W)	CNSF. harvest inventory	Nikiema (1993)
0.09 3.1 %	sapling	>5 cm and >3m height	Petit Samba (12°45'N, 02°15'W) Burkina Faso	Vegetation survey on 100 ha	Gijsbers *et al.* (1994)

2	Trees	10 cm and 11.7-13 m	Oula (12°20'N, 03°05'W) B/Faso	Field survey	Kessler (1992); 1994
12	Trees	> 15 cm	(Sapone) (12°30'N, 03°10'W) B/Faso	Field survey	Nikiema (1993)
3	individuals	> 10 cm, 11.8 m height	Sikasso (11°21'N 05° 45'W) B/Faso	Agroforestry study	Kater *et al.* (1992)
1-14	individuals	>10 cm	Zaria (11°05'N, 07°42'E) Nigeria	Field survey	Pullan (1974)

Kater *et al.*, 1992; Sabiiti & Cobbina, 1992b; Tomlinson *et al.*, 1995). However contrary to previous reports (Allen & Allen, 1981) the species do not nodulate (Tomlinson *et al.*, 1995). Recently, in Mali, Kater *et al.* (1992) indicated that the average carbon content, available magnesium, potassium and calcium were higher in the soil in the zone covered by *Parkia's* crown compared with open field conditions. There were significant differences for the 0-20 cm soil layer but not in the 20-40 cm layer. *Parkia* tree is also reported to increase the soil organic matter and soil carbon, while soil moisture infiltration is improved compared with the open field in both Burkina Faso and Mali (Kater *et al.*, 1992; Kessler, 1992; Breman & Kessler, 1995).

5.2 Relations with the natural fauna

Interaction with the natural fauna is most noticeable during the reproductive phase, when potential pollinators and pollen thieves are more frequent on the tree (Baker & Harris, 1957; Hopkins & White, 1984). Interactions generally with the natural fauna are diverse in terms of the visiting time and pattern. The fruit-eating bats (*Megachiroptera: Pteropodidae* is the predominant nocturnal visitor (Baker & Harris, 1957, 1959; Hopkins, 1983). Pettet (1977) also indicated sun birds (*Nectariinidae*) and several other species of birds roosting and nesting on the tree during the day. Other frequent visitors to *Parkia* inflorescence are crepuscular, honey bees (*Apis mellifica* Linn), feeding mainly on the pollen. The fruit also attract various ungulates, including ground squirrel (*Xerus erythropus*), Anubis baboon (*Papio anubis)* and wart-hog (*Phacochoerus aethiopicus*), red-flanked duiker (*Cephalophus rufilatus*) and bushbuck (*Tragelaphus scriptus*), tree-climbing mammals, chimpanzees and large birds acting as dispersal (Hopkins, 1983, Soladoye *et al.*, 1989). However where the tree occurs around villages domesticated animals including (sheep, donkeys, horses, bush fowl and goats) are frequent, often browsing the seedlings, eating aborted capitula and dropped fruits (Bayer, 1990; Kessler, 1992; Nikiéma, 1993);

Forsyth (1966) and Wagner *et al.* (1991) reported arthropods frequently observed feeding on various parts of the tree in Ghana and Nigeria. In Burkina Faso, bruchid larvae feed on the pulp of pods left un-harvested (Varaigne & Labeyrie, 1981). Fagbemi (1989) and Sabiiti & Cobbina (1992b) observed weevils and Lepidoptera from five families feeding on the fruits, and pyralid and sucking bugs feeding on the leaves in Nigeria. *Parkia,* as an agroforestry species, associates with corn ear-worms and butterflies (*Eurema hercabae* Linn.) from the adjacent maize crop (*Zea mays*), with the larvae feeding on the leaves (Fagbemi, 1989). At the seedling stage in Burkina Faso, rodents and rats (*Malacomys longipes*) bite through the young stalks and consume the leaves (Nikiéma, 1993). Ants are reported frequently especially on pods, possibly feeding on the exuded gum (Hopkins, 1983).

Loranthaceous hemi-parasite associated with *Parkia*

Tapinathus dodoneifolius(DC.) DANSER infests *P biglobosa*, particularly in derived savanna areas such as Saki, Nigeria (Oni, 1997).

Casual relations with man-including fire

The relative abundance, frequency and distribution patterns of *Parkia* in parklands and farmed/fallow lands are indications of its age-long association with man (Bennett *et al.*, 1976; Pullan, 1974; Kessler, 1992; Gijsbers *et al.*, 1994; Gakou *et al.*, 1995). According to Valette (1973) and Pullan (1974), the presence of a mature *Parkia* tree indicates a long history of human settlement and cultivation, whilst its presence away from existing settlements indicate abandoned land. Regular occurrence of *Parkia* seedlings along cattle tracks and pedestrian routes are further indications of interactions with man (Oni, 1997). *P. biglobosa* is a fire resistant heliophyte, although apparently to lesser extent than *Lophira lanceolata* and *Crossopteryx febrifuga* (Unwin, 1920; Hopkins & White, 1984). Ogigirigi & Igboanuago (1985) indicated that the deep tap roots, thick bark, and high coppice shoot re-growth are various adaptation strategies to fire. Bush fires largely from intentional human activities are features of savanna woodlands in West Africa (Hopkins, 1962; Fatubarin, 1987). *Parkia* is seasonally exposed to both early and late burning, often coinciding with the flowering, fruiting and regeneration regimes of the species (Oni, 1997). Mature *Parkia* trees and seedlings suffer greatly from seasonal bush fires (Gijsbers *et al.*, 1994; Breman & Kessler 1995). Nevertheless the same fire promotes coppice shoot re-growth and pre-rain flushing (Fatubarin, 1987).

***Parkia Biglobosa* In Successional Vegetation Change.**

P biglobosa has remained edaphically adapted and resistant to seasonal bush fires, especially in Sudanian wooded grassland savanna (Fairbran, 1939; Murdoch *et al.*, 1976; Blair *et al.*, 1977; Hopkins & White, 1984). In the Guinéo-Congolian/Sudanian transition zone of White (1983), *Parkia* has invaded and persisted. In this zone it has thrived, favoured by the intensive cultivation, reduced fuel loads and fires intensity, and the selective cutting of competing woody species with less economic values. Clayton (1958) reports that the end-product of retrogression can be a park-like landscape dominated by *Parkia* (carefully preserved for its edible seeds). In most anthropic vegetation replacing earlier forest cover, *Parkia* occurs with seral species as a result of secondary succession, probably spreading further over time through planting or dispersal by man (Keay, 1959b; Hopkins & White, 1984).

DISCUSSION - A CONSERVATION PERSPECTIVE

The economic importance of *Parkia biglobosa* arises from its role as an important indigenous fruit tree range-wide, providing food, medicinal services, and an alternative income source and employment for the rural population (Agbahungba & Depommier, 1993). The availability of the fruit towards the end of the dry season and to several months of the rains is also significant in dietary values during the time of lean food period. It is a tree of well drained soil, thriving mostly in moderately fertile soil, and at an elevation of almost sea level to 1300 m altitude, and dry season lasting 2-7 months with bimodal rainfall of 600-1400 mm. Temperature generally from 20°C-30°C are appropriate, however frost has not been reported anywhere in the range. The rarity of *Parkia biglobosa* where mean annual rainfall is below 400 mm is noteworthy which further confirms the Sudano-sahelian range limit (Hopkins & White, 1983; Rocheleau *et al.*, 1988). The typical toposequence position of the species correspond to site conditions favourable for crop growing explaining the prominence in farmed areas, despite limited deliberate planting. The species-site preferences offer guidance in the development of appropriate management protocols for future provenance collections and selection for plantation establishment.

The distribution map for *P biglobosa* (Figure 1) in this review is more comprehensive than that of Hopkins (1983) and Hopkins & White (1984) because it has not been limited to herbaria voucher specimens. Use has been made of ecological literature which has the advantage of giving better indications of areas where the tree is most frequent and those where it occurs only sporadically. It remains the case that the map is not finally definitive- there are parts of the range, especially in Tchad, the Central Africa Republic, Zaire and Sudan for which little information seems to have been reported. There are increasing threats to the existing populations from demographic pressure on land, illegal felling, deforestation for large scale mechanised farming, and prevalent annual bush fire (Kio *et al.*, 1987; Ladipo *et al.*, 1990). Despite the slow growth rate compared with many exotic species, interest continues to grow, among the farmers, in the silvicultural and integration of *Parkia* in agroforestry projects and farms (Douglas & Hart, 1985; Popoola & Maisanu, 1995). Currently, in Nigeria, and several other parts of the range, various action programmes are being put in place to preserve the remaining genepool. In Nigeria, the Federal Government initiated action within the Third National Development Plan (1975-1980), which included a special programme to appraise the indigenous fruit trees, including *P. biglobosa* while the currently the World Bank assisted project under the National Agricultural Research Project gives priority to the species. The level of awareness has steadily increased in both research institutions and in the forestry arms of the government. Unfortunately, however, the global recession and the drastic economic reforms introduced in recent times have had a significant effect on the level of in-situ conservation. Local people have eliminated several stands of *Parkia* because of un-affordable cost of other fuel energy sources (Kerosene and domestic gas).

The distribution range to the Guinea-Congolian centre, associated with higher soil moisture, proves very encouraging for in-situ conservation work, as the current population is not threatened by drought and intensive grazing limiting regeneration in these areas (Oni, 1997). Almost all *P biglobosa* is still in a wild state in unselected populations that can be presumed to exhibit wide natural variability. By selective retention of trees with the most valued characteristics, some influence will have been executed on the farmland populations, of course, but this has been an essentially opportunistic process and further positive selection and breeding should be manifested in great increases in yield and adaptability to sites and farming systems. Forms of intervention are needed which local people will be able to adopt, even in these difficult circumstances. Renewable resources professionals, linked to farmers through extension staff, will help in this drive. Both enhanced protection of naturally established seedlings and planting actions could have significant positive effects.

In the Guinea-Conglian/Sudanian transition zone, the land degradation is less severe while available soil moisture is higher, but the problem of deforestation, particularly for large scale mechanised farming, is noteworthy. Therefore, the need to identify areas of dense *Parkia* population, which can be modified to restricted natural reserves, will be desirable. Fire plays significant roles in depleting the current genepool of *Parkia* in the range, while at the same time it promotes seed germination (Menaut, 1983; Fatubarin, 1987). However, early burning is less destructive, while late burning has serious, devastating effects on woody species. Management policies, therefore, require some level of direct government protection of wild species, while at the same time increasing awareness on the implications of late burning to the maintenance of existing *Parkia* populations. Enrichment planting is an option available where there is doubt as to the ability of natural seedling to sustain the population. Local community action that will promote and encourage rehabilitation of depleted sites through natural regeneration could be achieved with strict fire, especially where there are relict living rootstocks. In reality, such action will often be impracticable and there is need to aim at management that will promote and maintain natural conditions where fuel accumulation is minimal.

Success with direct seeding on the field has not been encouraging and establishment rates have been poor (Bonkoungou, 1987; Popoola & Maishanu, 1995). Until nursery raising of *Parkia biglobosa* becomes wide-spread, the obvious option will be to use wildlings from better stock for enriching and rejuvenating deteriorating stands. Vigorous stock of known origin are needed for supplying to farmers as a better alternatives than wildlings, and development of efficient and in-expensive silvicultural methods for breaking seed dormancy and raising vigorous seedlings in village conditions are needed. The availability of improved seedlings with more vigour and selected desirable characters will encourage farmers involvement in the development of this resource, and ensure the preservation of existing seedlings under in-situ conservation. Species multiplication through cuttings, layering, budding and suckers have proved very promising in the current research on *P biglobosa* (Okafor, 1987, Oni *et al.*, 1995). What is now required is perfection of the techniques and production. Farmer's perceptions of stock quality indicates a preference for stock which matures early and fruits heavily.

Selection of these traits within existing populations on farmers' fields will involve farmers directly in seed raising and transplanting for improvement of the species.

On the national and regional scale, genetic evaluation and improvement of *P biglobosa* requires adequate information on variation between and within populations from different ecozones under different levels of land use intensity. An in-situ conservation approach for *Parkia,* that aims at establishing plots close to settlement rather than in isolated/more distant fields, should be viable. Within the context of attaining effective in-situ conservation of *Parkia biglobosa* as a resource for the future, the need to adopt a joint forest management programme, in which local communities participate effectively with the Forestry Department and share responsibilities and benefits from the forest, would be desirable. Nevertheless, unless access and the current existing land user rights decree in Nigeria is modified, there is little incentive to manage woodlands sustainably. Success depends upon the clarity and practicality of policies, and positive action from institutions assigned the responsibility for implementation. Management efforts will require assessment of the cropping systems and crops desired most frequently by farmers on *Parkia biglobosa* farmlands. These cropping systems are the framework in which an appropriate spatial organisation must be put in place for *Parkia* trees. Where *Parkia* trees are planted in a defined spatial arrangement, the effect on competition with associated food crops could be reduced, while at the same time effective gene flow within the population could be enhanced and high fruit production favoured. Extension activities will require strengthening. Effective co-operation with local people would, more than any other step, increase awareness of the value of *Parkia biglobosa* as a resource, and secure its involvement in rational utilisation. Achieving this would involve a systematic and comprehensive inventory of the existing populations of *Parkia biglobosa* in the natural woodlands, farmlands, near settlement and in forest communities. This aspect has recently been completed for Nigeria (Oni, 1997). Inventories will need to be followed by implementation of a monitoring scheme on the rate of population depletion and the extraction rates for fruits under different ecozone and land use intensity situations. Finally the industrial sector should be involved in the conservation through research efforts development in the commercial utilisation of the beans, pulp, tannins, gums and other components parts of the tree.

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