

MIOMBO BIBLIOGRAPHY WITH ABSTRACTS

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1. Avery, D.M. 1992. The environment of early modern humans at Border Cave, South Africa: Micromammalian evidence. *Palaeogeogr.* 91:71-87.
Keywords: palaeoecology/environmental conditions/human/Mammalia/South Africa, Border Cave/Pleistocene/South Africa/Africa/Brachystegia/rainfall
Abstract: An enlarged sample of micromammalian remains from Border Cave has permitted re-evaluation of vegetational and climatic conditions at the site from its earliest occupation, apparently about 130 kyr B.P. The indication is that vegetation in the region was initially woodland analogous to miombo (Brachystegia) woodland which today occurs a minimum of 3 degree latitude north of the site. Rainfall would have been 25-100% higher than it is today and more seasonal, with drier winters. Mean annual temperature may have been similar to or slightly higher than it is today. Thereafter, perhaps in delta super(18)O stage 5b onwards from around 96 kyr B.P., vegetation and, consequently, rainfall appear to have become much as they are today, namely bush savanna with forest patches supported by rainfall around 800 mm. Temperatures, on the other hand, may have been rather lower than they are today, and it is possible that delta super(18)O stage 4 is represented during this period. Subsequently, during delta super(18)O stage 3, the vegetation appears to have been open *Acacia nigrescens*-*Sclerocarpa* savanna, perhaps preceded by mopane (*Colophospherum mopane*), such vegetation types today being found at lower altitudes in neighbouring Swaziland and into the northeastern Transvaal
2. Barnes, R.W. and I. Douglas-Hamilton. 1982. The numbers and distribution patterns of large mammals in the Ruaha-Rungwa area of southern Tanzania. *J.Appl.Ecol.* 19:411-425.
Keywords: Tanzania, Ruaha-Rungwa/Mammalia /surveys/population levels/Tanzania/miombo/miombo woodlands/miombo woodland/Africa/human/rainfall
Abstract: An aerial census of Ruaha National Park, Rungwa and Kizigo Game Reserves, and part of the proposed Mloa-Ilambi Game Controlled Area is described. Zebra, eland, sable, and hartebeest were virtually restricted to the miombo woodlands. Impala and kudu were most common in the rift valley sector of the census zone. Elephants, buffalo, and giraffe occurred throughout the entire area. The 31,500 km super(2) census zone carried one of the largest elephant populations in Africa, an estimated 43,685 plus or minus 9,254 elephants, of which 24,625 plus or minus 7,132 were estimated to occur within Ruaha National Park (10,200 km super(2) in area). Within the National Park, comparisons with earlier counts showed an apparent increase in elephant density of 8-10% per annum since 1965. Of the large herbivores, elephants alone showed a significant increase since the 1972 census and only elephant distribution was significantly affected by the distribution of human settlement and hunting. The increase in elephant numbers within the National Park is probably the result of the change in human distribution in the region and a period of higher rainfall
3. Beaver, R.A. and K. Loeytyniemi. 1991. Annual flight patterns and diversity of bark and ambrosia beetles (Col., Scolytidae and Platypodidae) attracted to bait logs in Zambia. *J.Appl.Entomol.* 112:505-511.
Keywords: Scolytidae/Platypodidae/flight activity/baiting/trapping/Zambia/Coleoptera/Brachystegia/Julbernardia
Abstract: The annual flight patterns and diversity of scolytid and platypodid beetles in miombo woodland in Zambia were observed by year-round trapping in 1979-80 and 1983-84. In the former year, window traps were baited with Brachystegia and Julbernardia logs, in the latter with Pterocarpus logs. Both families and some species of beetles are present throughout the year, but the major flight period for most species coincides with the onset of heavy rains in October or November. Numbers of individuals and species caught were significantly lower in 1983-84 for both families of beetles. This can probably be related in part to the greater resistance of Pterocarpus logs to attacks by the beetles. Despite the variation in numbers and species, the species-abundance relationships of the two beetle families were very similar in both years

4. Bennett, N.C., J.M. Jarvis, and F.D. Cotterill. 1994. The colony structure and reproductive biology of the afro-tropical Mashona mole-rat, *Cryptomys darlingi*. *J.Zool.* 234:477-487.
Keywords: *Cryptomys darlingi* /colonies/community structure/reproduction/life history/Zimbabwe
Abstract: *Cryptomys darlingi* occurs in the mesic Miombo woodland of north-eastern Zimbabwe. It occurs in colonies of up to nine individuals, in which reproduction is limited to one of the largest males and the largest female in the colony. Reproduction and details of colony size and number of breeding animals in a colony are described for five complete field-captured colonies. In captivity, mating is not confined to a particular season, and up to three litters of pups are born per annum. The reproductive female initiates the pre-copulatory behaviour. The gestation length is 56-61 days (n = 2). The new-born pups are altricial and litter size is small $x = 1 \text{ times } 7 \text{ plus or minus } 0 \text{ times } 5$ (n = 6). In this case, the pups first left the nest 10 days after birth, began to eat solids when 14 days old, and were fully weaned at five weeks. They began to spar with each other when 36-40 days old, but did not disperse and were incorporated into the colony. This suggests that the Mashona mole-rat colonies are composed of a founding pair and at least three successive litters of pups
5. Chidumayo, E.N. 1987. Species structure in Zambian miombo woodland. *J.Trop.Ecol.* 3:109-118.
Keywords: Zambia/forests/community structure/species richness/species diversity/regeneration/rainfall/conservation
Abstract: Miombo woodland in Zambia is divided into wetter and drier types by the 1100 mm mean rainfall isohyet. In the present study two wetter (Northern, Northwestern) and three drier (Central, Eastern, Western) miombo subtypes were recognized. A survey of the woody flora of 94 old-growth and 58 coppice stands in the five miombo subtypes revealed some significant differences in species diversity among them. The floristic differentiation of miombo subtypes was best achieved by the use of the Shannon species diversity index (H') and species density (number of species 0.1 ha super(-1) or 0.4 ha super(-1)). Results indicate lower species diversity in regenerating miombo. The dynamic aspects of species structure should therefore be considered in the future conservation of biological diversity in miombo woodland
6. Chidumayo, E.N. 1988. Estimating fuelwood production and yield in regrowth dry miombo woodland in Zambia. *For.Ecol.Manage.* 24:59-66.
Keywords: fuels/wood/dry forests/Zambia/production/yield/models/regrowth/miombo/management/growth/regeneration
Abstract: A combination of destructive and non-destructive samples was used to develop regression models for estimating fuelwood production and yield in regrowth dry miombo stands aged 6-34 years. Fuelwood yield from understorey species was estimated from girth at stump height (GSH) data while GSH and stem height data were necessary for estimating yield from canopy species. Mean fuelwood production was estimated at 1.93 m super(3) ha super(-1) year super(-1). It was found that canopy species had a greater sustained stem growth than understorey species. Enhancement of regeneration of canopy species is therefore recommended for the management of miombo woodland for fuelwood production
7. Chidumayo, E.N. 1988. A re-assessment of effects of fire on miombo regeneration in the Zambian Copperbelt. *J.Trop.Ecol.* 4:361-372.
Keywords: deforestation/tropical environment/fires/regeneration/Zambia/effects on/miombo/species diversity
Abstract: In 1933/34 eight coppice plots were established in *Brachystegia-Julbernardia* (miombo) woodland at Ndola in the Copperbelt area of Zambia by the Forestry Department. The density of stems over 20.0 cm girth in the 13-year-old coppice at Chitwi was 2.5 times that in an adjacent shelterbelt woodland. The stem density in the fire protected plot at Ndola in 1982 was 86% of the pre-felling density while in one of the early burnt plots it was 95% of the pre-felling density. The protected plot had the lowest species diversity after 49 years, largely because of the loss of 11 understorey species that were present before felling

8. Chidumayo, E.N. 1990. Above-ground woody biomass structure and productivity in a Zambebian woodland. *For.Ecol.Manage.* 36:33-46.
Keywords: productivity/forests/Brachystegia/Julbernardia/biomass/Zambia/models
Abstract: A survey of standing woody (leaf and wood) biomass was made in a Zambebian Brachystegia/Julbernardia (miombo) woodland in the Copperbelt area of Zambia during 1988. Woody biomass data obtained from destructive stem samples from Central and Copperbelt areas of Zambia were used to develop regression models for estimating dry weights of woody biomass components from stem-diameter data. These models were then applied to stem census data collected during 1982-1988 from 45 coppiced and old-growth plots to determine the structure of woody biomass in miombo woodland in the Copperbelt area. Mean wood biomass of 234.7 t/ha on small (0.02 ha) sample plots was significantly higher than that of 89.2 t/ha on large (> 0.10 ha) sample plots in old-growth woodland. The overall mean woody biomass of 92.5 t/ha on large old-growth woodland plots was made up of 3.6% leaf and 96.4% wood
9. Chidumayo, E.N. 1992. Seedling ecology of two miombo woodland trees. *Vegetatio.* 103:51-58.
Keywords: seedlings/biomass/growth/mortality/seed germination/Brachystegia spiciformis/Julbernardia paniculata/Zambia/trees
Abstract: The development of seedlings of two miombo trees, Brachystegia spiciformis Benth. and Julbernardia paniculata (Benth.) Troupin, was studied during two growing seasons (December 1989-April 1991) at a Zambian grassland site. Leaf production was confined to the rainy season. Leaf fall occurred during the dry season and in J. paniculata this was followed by shoot die-back during the hot dry period (August-November). Two-thirds of B. spiciformis seedlings experienced shoot die-back but shoot die-back did not necessarily result in seedling mortality. Shoot growth was negligible during the second growing season. These results suggest that shoot die-back in seedlings of miombo trees is caused by drought and that the slow shoot growth is the result of allocating most of the biomass to root growth during seedling development
10. Chidumayo, E.N. 1994. Effects of wood carbonization on soil and initial development of seedlings in miombo woodland, Zambia. *For.Ecol.Manage.* 70:353-357.
Keywords: Zambia/forests/soil/seedlings/Brachystegia/Julbernardia/charcoal/soil nutrients/growth/seed germination/plants
Abstract: An assessment of the effects of wood carbonization by the traditional earth kiln method in Brachystegia-Julbernardia (miombo) woodland on soil nutrients in the field and seedling growth under laboratory conditions was made from August 1992 to March 1993. Wood carbonization increased soil pH and exchangeable P and K. Generally seed germination was better in charcoal soil than in undisturbed soil among the seven indigenous woody plants studied. Seedling growth in charcoal soil was good, except for Isoberlinia angolensis which had lower growth rate than in undisturbed soil
11. Chidumayo, E.N. 1997. Annual and spatial variation in herbaceous biomass production in a Zambian dry miombo woodland. *S.Afr.J.Bot.* 63:74-81.
Keywords: vegetation/primary production/soil/nutrient content/seasonal variations/dry forests/Zambia/biomass/fires/phosphorus/leaves/nitrogen
Abstract: Herbaceous biomass production was studied for six years (1991-1996) at four dry miombo woodland sites (two on hillsides and two on interfluves) in central Zambia by methods of harvest and nutrient analysis. Frequent man-made fires at the study sites destroyed most of the necromass by the end of the dry season; the residual necromass disappeared by the middle of the rainy season through decomposition. Production was confined to the wet season (November-April). Above-ground total biomass peaked in March or April but this varied from year to year over the six-year period. The hillside sites produced a lower mean biomass (<100 g m⁻² yr⁻¹) than interfluve sites (100-200 g m⁻² yr⁻¹). When mass loss due to decomposition of necromass and nutrient leaching from live biomass was taken into account, the peak above-ground total biomass estimates represented 64-92% of actual production. The effect of woodland clearing on above-ground herbaceous biomass production was most significant at the hillside sites and

production was negatively correlated with soil extractable phosphorus. Tree basal area, stem density and height, leaf biomass in cut plots, soil cation exchange capacity and mineral nitrogen had no significant effect on herbaceous biomass production. Annual variations in herbaceous biomass production appeared to be linked to variations in soil moisture availability. The nutrient content of herbaceous biomass changed throughout the growing season. Nitrogen concentration in biomass was highest at the beginning of the rainy season while phosphorus concentration was highest during the latter half of the season. The concentration of potassium increased from the beginning of the rainy season and peaked in mid-season before declining to low dry season levels

12. CHOINSKI, J.J. and J.M. JOHNSON. 1993. The Mysteries of Zimbabwe's Flushing Trees. *Biology Digest* 19:11-15.

Keywords: MIOMBI

WOODLANDS/Zimbabwe/ANTHOCYANINS/PHOTOSYNTHESIS/FLUSHING TREES/UB-V/ANTI-FUNGAL AGENTS/HERBICI COLORATION/trees/leaves/miombo/miombo woodlands/miombo

woodland/woodlands/growth/plants/climate/Brachystegia/Julbernardia/Julbernardia globiflora/forests/DNA/production/carbon /fungi

Abstract: In the Northern Hemisphere, brightly colored red leaves are a sure sign that autumn is in full bloom. However, within the miombo woodlands of the semi-humid south African upland tropics, red leaves are not indicative of fall, but spring. Although the foliage will eventually turn green, this initial display of red and pink leaf hues is known as the spring "flush." The flush has become of particular interest to biologists in their studies of leaf expansion and photosynthesis sequences. Anthocyanins, water-soluble pigments, are what give both miombo and temperate region deciduous forest foliage their redness. Anthocyanins also create the pink, mauve, red and blue flower petals and flushing leaves in the humid tropics. That the synthesis of anthocyanins induces these colors in both spring, during the start of new growth, and in fall, as plants are beginning to die, while in such different climates, is an unusual phenomenon. In the more moist areas of Zimbabwe, the dominant tree species is *Brachystegia speciformis*, known as the msasa, while in drier regions, *munondo* (*Julbernardia globiflora*) are abundant. Anthocyanin synthesis begins in these trees almost in tandem with the sprouting of new foliage. This synthesis peaks 2 to 2 1/2 wk. after bud burst, and after 5 wk. the anthocyanin pigments are at visually undetectable levels. Color variation is attributed to varying amounts of green chlorophylls and red anthocyanins, as well as to altering quantities of pH. The biological reasons for the synthesis of anthocyanins are not fully understood. A well-accepted consensus is that young red leaves confer ecological or selective advantages to trees which produce them. Another theory purports that anthocyanins act as a protective mechanism against the high intensity UB-V (280-320 nm) radiation to which plant cells are exposed in the high altitude miombo forests. Investigations have provided data that suggest anthocyanins might absorb the UV-B that would otherwise damage plant DNA. Early experiments are also looking at anthocyanins as possible natural anti-fungal or even anti-herbivore agents. Biologists also have not completely resolved the effect of anthocyanins on the food production of msasa and *munondo* trees. Because anthocyanins do not trap sunlight, they cannot provide the energy for carbon fixation (photosynthesis) and are thus reliant on the tree's chlorophyll, which can harvest light. The question arises as to how needed carbon levels are obtained. One explanation could be that the mother plant provides the glucose needed to make anthocyanin molecules, while also utilizing this glucose during anthocyanin breakdown. Further studies have tentatively identified a three-phase msasa leaf development cycle in which the carbon levels and peak food production times rise as the anthocyanin levels drop. Thus, the presence of anthocyanins in the south African high altitude miombo forests may aid trees in keeping fungi and insect herbivores at bay, while also acting as a "sun screen" against damaging UB-V rays. As ozone concerns grow and man continues to search for environmentally-safe pesticides, anthocyanins may become increasingly valuable

13. Dangerfield, J.M. 1990. Abundance, biomass and diversity of soil macrofauna in savanna woodland and associated managed habitats. *Pedobiologia*. 34:141-150.

Keywords: biomass/species diversity/soil

fauna/savannahs/habitat/heterogeneity/Arthropoda/abundance/miombo woodlands/soil/Zimbabwe/miombo/cultivation

Abstract: Soil macrofauna were sampled from natural savanna woodland (miombo) and four managed habitat types: a maize field, fallow, disturbed miombo and beneath mature *Eucalyptus grandis*. Millipedes and beetle larvae had the largest biomass and were most abundant within the natural woodland. Canopy structure significantly influenced overall population density and biomass of soil fauna with litter dwelling groups most affected by spatial heterogeneity. Abundance and biomass beneath *Eucalyptus grandis* were comparable with estimates for the natural woodland. Diversity was highest under a small stand of disturbed miombo woodland. Maize cultivation significantly reduced the populations of all groups with beetle larvae the only abundant taxa. Habitat heterogeneity on a small scale can affect the abundance and composition of the soil fauna community. Retaining some heterogeneity in managed systems would keep areas of favourable habitat and maintain the abundance and diversity of soil fauna

14. Dangerfield, J.M. 1990. The distribution and abundance of *Cubitermes sankurensis* (Wassmann) (Isoptera; Termitidae) within a Miombo woodland site in Zimbabwe. *Afr.J.Ecol.* 28:15-20.
Keywords: Isoptera/Termitidae/Zimbabwe,Marondera/spatial distribution/abundance/forests/*Cubitermes sankurensis*/miombo/miombo woodland/Zimbabwe/ecology/mounds/vegetation/habitat/heterogeneity
Abstract: The distribution of epigeal mounds of the humus feeding termite *Cubitermes sankurensis* (Wassmann) was studied in relation to small-scale variation in vegetation pattern on three permanent transects within a 5 ha stand of miombo woodland. The composition of vegetation did not have a significant effect on the abundance of *C. sankurensis*. There was an effect of habitat structure on mound distribution with increased aggregation in areas of open canopy. Factors such as colonization potential and the history of termite activity may be more important in determining the distribution of mounds than the heterogeneity of the vegetation
15. Dangerfield, J.M. 1991. Soil modification by *Cubitermes sankurensis* (Wassmann) (Isoptera: Termitidae) within a Miombo woodland site in Zimbabwe. *Afr.J.Ecol.* 29:267-269.
Keywords: nitrogen/phosphorus/carbon/*Cubitermes sankurensis*/Zimbabwe/Termitidae/Isoptera/soil nutrients/mounds
Abstract: In the present study chemical analyses of soil from mounds of *Cubitermes sankurensis* were undertaken to assess the change in soil organic carbon, total nitrogen and total phosphorus compared to background soil in a miombo woodland site where the overall nutrient status of the soil is poor
16. Dangerfield, J.M. and S.R. Telford. 1992. Species diversity of julid millipedes: Between habitat comparisons within the seasonal tropics. *Pedobiologia.* 36:321-329.
Keywords: species diversity/habitat/tropical environment/Julida/Diplopoda/Africa/soil/species composition
Abstract: The species diversity of julid millipedes was compared between several habitat types within the seasonal tropics using log-abundance species rank plots and standard diversity indices calculated from hand collections and trap samples of animals. The number of species per site ranged from 1 to 8 and most habitats were species poor. There was considerable variation in diversity and dominance of species between habitats. Relatively homogeneous habitats (riparian forest, pine and *Eucalyptus* plantations) contained few species and were dominated by the first rank species *Alloporus uncinatus*, whilst more heterogeneous habitats (for example, natural miombo woodland) were relatively species rich. A resource preemption hypothesis is suggested as a possible explanation for these between habitat differences in species diversity. Variation in species composition and diversity is noted as a possible factor influencing the effect of millipede assemblages on nutrient dynamics
17. Desanker, P.V. and I.C. Prentice. 1994. MIOMBO - A vegetation dynamics model for the miombo woodlands of Zambezi Africa. *For.Ecol.Manage.* 69:87-95.

Keywords: Africa/tropical environment/forests/vegetation changes/droughts/fires

Abstract: The gap model FORSKA was modified to develop MIOMBO, a model to simulate productivity and succession in the miombo tropical dry woodlands of Central Africa. A few measured parameters of the miombo were used to establish suitable ranges of the rest of the parameters in the model by simulation to form a 'base case'. This base case does not represent any specific site, however; deviations from the base case under hypothesized fire and drought regimes can be used to study the response of the miombo to fire and drought in a general way. The MIOMBO model can be used as a starting point for more detailed parameterization for specific sites. In this paper, we emphasize the changes made to FORSKA

18. Desanker, P.V. 1996. Development of a miombo woodland dynamics model in Zambebian Africa using Malawi as a case study. *Clim.Change* 34:279-288.

Keywords: Malawi/models/dry forests/succession/climate/Africa/forests

Abstract: A patch model was developed to characterize the effects of climate on succession of miombo dry forests of Zambebian Africa using Malawi as a case study. The model, called MIOMBO, is based on the FORSKA Version 1 gap model of forest succession by Prentice and Leemans (1990). The FORSKA model was modified to include the effects of moisture and fire; and how these affect processes of establishment, survival, growth and development. The impacts that four different GCM scenarios for a CO₂ doubling might have on dynamics of a number of miombo species were analyzed. Preliminary results show a gradual increase in the basal area of the more mesic species. This result is consistent with what might be expected with increased precipitation. Tree growth and development data with associated detailed climatic data are lacking and severely limit the ability to define quantitatively how species are influenced by given levels of environmental factors (such as climate and nutrient factors), and how they might respond to seasonal changes in climate variability

19. Ernst, W.O. 1988. Seed and seedling ecology of *Brachystegia spiciformis*, a predominant tree component in miombo woodlands in south central Africa. *For.Ecol.Manage.* 25:195-210.

Keywords: seedlings/ecology/Africa,Southcentral/ecophysiology/*Brachystegia spiciformis*/seeds/*Brachystegia*/miombo/miombo woodlands/miombo woodland/Africa/growth/nitrogen/phosphorus

Abstract: Seed crop and seed weight of the dominant deciduous tree species in African miombo woodland, *Brachystegia spiciformis*, varied between years. Seeds possessed no dormancy and germinated completely after imbibition. First phase of seedling growth is completely based on energy and nutrients allocated in the large cotyledons. Low seed weight gave slow-growing seedlings. Optimum temperature for photosynthesis was at 30 degree C; photosynthesis at higher temperature interfered with the closing movements of the leaflets. At the time of abscission of the cotyledons nearly 80% of nitrogen and potassium, 65% of magnesium, and 50% of phosphorus and copper had been exported from the cotyledons to the seedling

20. Ernst, W.O. 1993. Food consumption, life history and determinants of host range in the bruchid beetle *Specularius impressithorax* (Coleoptera: Bruchidae). *Journal of stored products research*. Mar 1993.v.29 (1) p.53-62 53-622.

Keywords: *Erythrina*/seeds/storage/bruchidae/feeding behavior/host range/host specificity/larvae/life history/stored products pests /Coleoptera/leguminosae/miombo/miombo woodland/trees/*Brachystegia*/*Brachystegia spiciformis*/forest trees

Abstract: The bruchid beetle *Specularius impressithorax*, a multivoltine species, feeds on seeds of *Erythrina abyssinica* (Leguminosae) affecting them in storage. Larval development was indicated by weight loss of infested seeds and five larval instars were detected. Breaking through the emergence disk demands much energy, and was registered by a large weight loss of the beetle. Despite a strong host specificity, the chemistry of *S. impressithorax* resembled that of other bruchid beetles. During larval development zinc and copper were extracted strongly from food, and accumulated, whereas all other divalent metals (Ca, Mg, Fe, Mn) were mostly excreted. The development time from egg to emergence is reduced with increasing ambient temperature in the range from 20 to 30 degrees C. At

4 degrees C no development occurs, so that seed storage at this temperature is very favourable. Ovipositing beetles have an olfactory preference for seeds of *E. abyssinica* as host, but after a long delay accept seeds of other species in the absence of the host seed. Larval development terminated after the first instar in seeds of non-host species of the co-occurring miombo woodland trees *Acacia erioloba* and *Brachystegia spiciformis* and the pulses *Cajanus cajan*, *Phaseolus vulgaris* and *Vigna unguiculata*, thus *S. impressithorax* will not affect other stored seeds of forest trees

21. Fuller, D.O. and S.D. Prince. 1996. Rainfall and foliar dynamics in tropical Southern Africa: Potential impacts of global climatic change on savanna vegetation. *Clim.Change* 33:69-96.
Keywords: rainfall/climatic changes/vegetation/remote sensing/arid lands/regional analysis/leaves/Africa/ savannahs/climate
Abstract: Foliar dynamics in tropical southern Africa are examined using meteorological satellite observations (NOAA-AVHRR) collected from 1981-1990, processed as monthly Normalized Difference Vegetation Index (NDVI) images, and resampled to 7.6 km resolution. Time series of NDVI and raingauge data are presented and analyzed using a variety of statistics. The analysis of time series from individual locations revealed positive correlations between NDVI and rainfall at semiarid locations where rainfall tended to be highly variable; whereas the relationships between these variables was insignificant in more mesic sites where the climate tended to be more predictable. In addition, there appeared to be an annual rainfall threshold of approximately 600 mm beyond which relationships between rainfall and NDVI were insignificant at the monthly time scale. Relationships between rainfall and NDVI were stronger at annual time scale, which suggests that factors other than contemporaneous rainfall account for photosynthetic activity in any given growing season. Using a rainfall surface and NDVI imagery, a large area of 'early' greening behavior is identified, which corresponded approximately to the distribution of mesic, plateau woodlands. These so-called, 'miombo' woodlands may be especially vulnerable if the arrival of spring rainfall were to undergo a positive shift in phase
22. Grundy, I.M., B.M. Campbell, S. Balebereho, R. Cunliffe, C. Tafangenyasha, R. Fergusson, and D. Parry. 1993. Availability and use of trees in Mutanda Resettlement Area, Zimbabwe. *For.Ecol.Manage.* 56:243-266.
Keywords: resource management/trees/resource availability/resource utilization/wood/Zimbabwe,Mutanda Resettlement Area/Zimbabwe/biomass/cultivation/deforestation/cover
Abstract: This study quantifies current wood supply and consumption, and investigates the effect of wood use on wood supply and the current uses of wood. More than one-third of the study area was miombo woodland, supporting about 20 t ha super(-1) of woody biomass, and 10% of the area was mopane, supporting over 60 t ha super(-1). The remaining area, cultivated lands and wooded grasslands, supported little woody biomass. Cultivation has been the chief source of deforestation, with dramatic reductions in overall woody cover since 1981 when the area was first resettled. Wood harvesting has a much more local effect on woodland structure, its impact being limited to within 300 m of a village. The dominant species of the woodland are used for fuel wood, but householders are more selective of species for wood for construction and other household requirements
23. Grundy, I.M., B.M. Campbell, and P.H. Frost. 1994. Spatial pattern, regeneration and growth rates of *Brachystegia spiciformis* and *Julbernardia globiflora*. *Vegetatio* 115:101-107.
Keywords: *Brachystegia spiciformis*/*Julbernardia globiflora*/spatial distribution/recruitment/savannahs/Zimbabwe/growth/*Brachystegia*/*Julbernardia*/cover/plants/trees
Abstract: Past work on tree-to-tree interactions in semi-arid savannas, through the use of nearest neighbour analysis, has shown both a regular dispersion pattern and a positive correlation between the size of a tree and the distance to its nearest neighbour. From these results, the importance of competition has been inferred. In the present study, tree-to-tree interactions in a mesic savanna woodland at Marondera, Zimbabwe, dominated by relatively small-sized individuals of *Brachystegia spiciformis* and *Julbernardia globiflora*, were examined. Results show that the regular dispersion pattern is uncommon; that there are few significant positive correlations between size of individual

and distance to nearest neighbour; and that growth rate is not consistently correlated with size and distance of nearest neighbour. Results of a study of regeneration relative to canopy cover suggest a possible mechanism for these findings: unlike semi-arid savannas, young plants often grow in under-canopy environments so that early spacing of young trees does not occur. Significant positive correlations between the size of a tree and the distance to its nearest neighbour were found in a stand of larger, presumably older, trees, suggesting that such a relationship only develops in mesic miombo woodland through a thinning process as the trees mature. Familial clumping, which is common in the study area, may mask spatial patterns

24. Guy, P.R. 1981. Changes in the Biomass and Productivity of Woodlands in the Sengwa Wildlife Research Area, Zimbabwe. *J.Appl.Ecol.* 18:507-519.
Keywords: forests/biomass/primary production/annual variations/Zimbabwe,Sengwa Wildlife Area/environmental effects/productivity/Zimbabwe/miombo/trees/recruitment/fires
Abstract: Changes in biomass and annual production measured over the period 1972 to 1976 in four woodlands, the miombo, the Sengwa/Lutope riverine, the Manyoni riverine and the mopane woodland, are described. The greatest changes in biomass were recorded in the miombo woodland where it is estimated that the biomass decreased by 45%. The biomass of the Sengwa/Lutope riverine, a woodland with three strata, increased by 14%, whilst that of the Manyoni riverine changed little. The biomass of the mopane woodland decreased by over 6%. The annual production of the miombo, the Manyoni riverine and the mopane woodlands decreased between 1972 and 1976, whereas that of the Sengwa/Lutope riverine woodland increased. The change in the biomass of the miombo woodland was primarily a result of the removal by elephant of large trees which were not replaced due to the effects of elephant and fire. The increase in biomass of the Sengwa/Lutope riverine woodland was a result of recruitment to both the tree and shrub layers. The decrease in biomass of the mopane woodland which is seldom affected by fierce fires, was almost certainly due to the effects of elephant
25. Guy, P.R. 1989. The influence of elephants and fire on a *Brachystegia-Julbernardia* woodland in Zimbabwe. *J.Trop.Ecol.* 5:215-226.
Keywords: community composition/biomass/disturbance/fires /*Loxodonta africana*/Zimbabwe/forests/miombo/species composition/shrubs
Abstract: *Brachystegia-Julbernardia* (miombo) woodlands inside and outside the Sengwa Wildlife Research Area, Zimbabwe, show major differences in structure, biomass and species composition. The woodlands inside the research area have a lower stem area, tree density and biomass than those outside it. The shrubs inside the research area occur at a higher density than they do outside it, but the biomasses of shrubs in the two woodlands are similar. The woodlands inside the research area are affected by elephants and fire, whereas those outside it are affected mainly by fire
26. Hailey, A., I.M. Coulson, and R.L. Chidavaenzi. 1997. Fungus eating by the African tortoise *Kinixys spekii*. *J.Trop.Ecol.* 13:469-474.
Keywords: *Kinixys spekii*/fungi/food organisms/diets/Zimbabwe/Africa
Abstract: The use of fungi by vertebrates has not been investigated in the tropics, although macrofungi are common in some tropical systems, such as the miombo woodlands of southern Africa. The use of fungi by vertebrates other than small mammals is also little known. This paper describes a quantitative analysis of the diet and food selection of a tropical tortoise reported to feed on fungi
27. Happold, D.D. and M. Happold. 1997. Conservation of mammals on a tobacco farm on the Highlands of Malawi. *Biodivers.Conserv.* 6:837-852.
Keywords: Malawi /Mammalia/conservation/farms/Africa
Abstract: The natural vegetation of the Shire Highlands of Malawi has become fragmented because of human activities. As a consequence, some species of mammals have become locally extinct and the population numbers and geographical ranges of other species have declined. This study investigated the species richness of mammals on a commercial tobacco farm, and the

importance of remnants of natural vegetation on farms for the conservation of mammals. The farm covered 180 ha and supported 44 species of mammals (equivalent to 66% of the species known to occur in the Shire Highlands at a similar altitude, and 24% of the total mammalian fauna of Malawi). Most of the species were bats (22 species) and rodents (13 species). The largest remnants of natural 'miombo' woodland supported more species and more individuals than smaller remnants. The high species richness was due, in part, to the variety of different habitats on the farm ('miombo' woodland, riverine forest, grassland, swamp, streams and dams), as well as to good conservation practices. The farm is especially important for the conservation of 13 species which are rare and/or have limited geographical ranges in Malawi. It is suggested that well-managed farms which contain remnants of natural vegetation can play a significant role in the conservation of mammals, and other vertebrates, in Central Africa

28. Hepburn, H.R. and S.E. Radloff. 1996. Beeswax exports and rainfall in the savanna woodlands of east central Africa. *Apidologie* 27:473-478.
Keywords: beeswax/rainfall/Africa/savannahs/honey/Apis mellifera/Apidae/Hymenoptera/climate
Abstract: Time series and regression analyses of rainfall and beeswax exports from the woodland savanna of east central Africa establish that these two variables are most significantly and highly correlated when phase-lagged by one bee year, running from July to June of the following year. Rainfall and honey production are also highly significantly correlated when lagged by one bee year. However, honey and wax production are highly correlated on a same been year basis. Thus beeswax harvest of any one year depends on the rainfall of the previous bee year. This is consistent with general effects of climate on vegetation and, specially with the fact that the bee-trees of the miombo flower in the dry season
29. Hoegberg, P. and J.E. Nylund. 1981. Ectomycorrhizae in Coastal Miombo Woodland of Tanzania. *Plant And Soil.* 63:283-289.
Keywords: Afzelia quazensis/Brachystegia spiciformis/Tanzania/tropical environment/mycorrhizas/roots/miombo/trees/Brachystegia/plants/climate
Abstract: Ectomycorrhizae were found in root samples of the trees Afzelia quanzensis Welw. and Brachystegia spiciformis Benth. (Caesalpiniaceae), collected in the coastal miombo type woodland 50 km west of Dar-es-Salaam, Tanzania. Root nodules with a structure resembling that of nitrogen-fixing root nodules of other leguminous plants were observed in the A. quanzensis material. The climate of the locality is rather dry, and strongly seasonal. In the tropics, ectomycorrhizae have previously been found only in humid or rain forest climate zones
30. Hoegberg, P. 1982. Mycorrhizal associations in some woodland and forest trees and shrubs in Tanzania. *New Phytol.* 92:407-415.
Keywords: Tanzania/forests/trees/shrubs/mycorrhizas/symbiosis/association/Uapaca kirkiana/Brachystegia/miombo/Africa
Abstract: The mycorrhizal associations in 47 indigenous Tanzanian trees and shrubs, mainly from less humid areas, were studied. Forty species were found to be endomycorrhizal. One, Uapaca kirkiana Muell. Arg. (Euphorbiaceae) was ectendomycorrhizal while six, four Brachystegia spp., Fulbernardia globiflora (Benth.) Troup. (Caesalpiniaceae) and Monotes elegans Gilg. (Dipterocarpaceae), were ectomycorrhizal. The results demonstrated a dominance of endomycorrhizal species, which is typical for the tropics and is further reinforced by taxonomic considerations. However, in the Miombo (Brachystegia-Fulbernardia) woodlands, a major ecosystem in East and South Central Africa, ectomycorrhizal trees predominate in volume. In three other ecosystems studied - a Combretum woodland, a groundwater forest and a semi-evergreen forest-ectomycorrhizal species were absent or almost absent. Nodulated leguminous species appeared to be more common in the fire-induced woodlands than in the closed forests
31. Hoegberg, P. and G.D. Pearce. 1986. Mycorrhizas in Zambian trees in relation to host taxonomy, vegetation type and successional patterns. *J.Ecol.* 74:775-785.
Keywords: trees/mycorrhizas/vegetation type/succession/Zambia/host

plants/taxonomy/vegetation/plants/fungi/ectomycorrhizas/Brachystegia/Julbernardia/miombo

Abstract: Thirteen species of common Zambian trees were found to be ectomycorrhizal and ten endomycorrhizal. Observations of ectomycorrhizas in *Brachystegia*, *Julbernardia* (both *Caesalpiniaceae*), *Monotes* (*Dipterocarpaceae*) and *Uapaca* (*Euphorbiaceae*) confirmed earlier reports, while ectomycorrhizas in *Faurea* (*Proteaceae*), *Isobertia* (*Caesalpiniaceae*), *Marquesia* (*Dipterocarpaceae*) and *Pericopsis* (*Papilionaceae*) are reported for the first time. These genera constituted about 70% of the basal area in a representative miombo (*Brachystegia-Isobertia-Julbernardia*) woodland stand—a high proportion for a diverse tropical ecosystem. Associated species in the miombo were endomycorrhizal as were principal species of the Zambian Kalahari sand vegetation, namely species of *Baikiaea*, *Erythrophleum*, *Guibourtia* (all *Caesalpiniaceae*) and *Pterocarpus* (*Papilionaceae*). *Colophospermum mopane* (*Caesalpiniaceae*), a species often forming pure stands, was also endomycorrhizal

32. Hoegberg, P. and I.J. Alexander. 1995. Roles of root symbioses in African woodland and forest: Evidence from super(15)N abundance and foliar analysis. *J.Ecol.* 83:217-224.

Keywords: Africa/forests/mycorrhizas/nitrogen fixation

Abstract: To gain insight into the nutrition of trees with ectomycorrhizas (ECM), VA-mycorrhizas (VAM) or VAM plus N₂-fixing legume root nodule symbioses (NOD) in tropical woodland and forest ecosystems, we measured foliar nutrient concentrations and super(15)N abundances in miombo woodland in Zambia (22 spp.) and in lowland rain forest in Cameroon (20 spp.). In miombo woodland, confirmed NOD species had low super(15)N abundances (mean super(15)N = 0.2ppt), high % N and high N:P ratios. *Baphia bequaertii*, a species thought likely to be NOD, shared these characteristics, but so did *Cassia abbreviata* which is less likely to be NOD. Among VAM and ECM species in miombo there were, in general, positive correlations between super(15)N abundance and % N, and between % N and % P. Dominant ECM species (*Caesalpinoideae-Dipterocarpaceae*) had slightly higher % N, but not higher super(15)N abundance than VAM species. The super(15)N data do not agree with data on ECM and VAM species previously obtained from Tanzanian miombo. In the rain forest, there were no large differences between the three symbiotic groups. For NOD species delta super(15)N was almost 4ppt above that of atmospheric N₂ and only slightly lower than that of non-NOD species. NOD species also had relatively high foliar % N. Data on species composition, foliar super(15)N abundance and N:P ratios support the idea that N₂-fixation carried out by N₂-fixing trees is more important in the woodland than in the rain forest

33. Hogberg, P. and I.J. Alexander. 1995. Roles of root symbioses in African woodland and forest: evidence from 15N abundance and foliar analysis. *The Journal of ecology*.1995.v.83 (2) p.217-224 217-2244.

Keywords: forest trees/woody plants/woodlands/tropical rain

forests/leguminosae/ectomycorrhizas/vesicular arbuscular mycorrhizas/nitrogen fixation/root nodules/nitrogen fixing trees/nitrogen content/nitrogen/stable isotopes/phosphorus/nutrient content/leaves/nutrient uptake/n:p ratio/miombo woodlands/abundance/trees/miombo/miombo woodland/Zambia /species composition

Abstract: To gain insight into the nutrition of trees with ectomycorrhizas (ECM), VA-mycorrhizas (VAM) or VAM plus N₂-fixing legume root nodule symbioses (NOD) in tropical woodland and forest ecosystems, we measured foliar nutrient concentrations and 15N abundances in miombo woodland in Zambia (22 spp.) and in lowland rain forest in Cameroon (20 spp.). In miombo woodland, confirmed NOD species had low 15N abundances (mean 15N = 0.2 per thousand), high % N and high N:P ratios. *Baphia bequaertii*, a species thought likely to be NOD, shared these characteristics, but so did *Cassia abbreviata* which is less likely to be NOD. Among VAM and ECM species in miombo there were, in general, positive correlations between 15N abundance and % N, and between % N and % P. Dominant ECM species (*Caesalpinoideae-Dipterocarpaceae*) had slightly higher % N, but not higher 15N abundance than VAM species. The 15N data do not agree with data on ECM and VAM species previously obtained from Tanzanian miombo. In the rain forest, there were no large differences between the three symbiotic groups. For NOD species delta 15N was almost 4 per thousand above that of atmospheric N₂ and only slightly lower than that of

non-NOD species. NOD species also had relatively high foliar % N. Data on species composition, foliar 15N abundance and N:P ratios support the idea that N₂-fixation carried out by N₂-fixing trees is more important in the woodland than in the rain forest

34. Jackson, H.D. 1986. Avifaunal survey of the Mutare Municipal area III. The Gimboki collection: A comparison of samples from riparian thicket, miombo woodland on sandflats and miombo woodland on rocky slopes. *Arnoldia (Zimbabwe)*. 9:325-332.
Keywords: Aves/community composition/Zimbabwe,Mutare/miombo/habitat
Abstract: The Mutare Museum is conducting an avifaunal survey of the Mutare Municipal area; this paper is the third in the series reporting the results and it deals with a collection of 495 specimens in 68 species taken on Gimboki Farm. Samples were drawn simultaneously, by mistnetting only, from riparian thicket, miombo woodland on sandflats and miombo woodland on rocky slopes. The habitats are described briefly and their avifaunas are compared. The Coefficients of Community between the avifaunas are 35.8% for riparian thicket and sandy woodland, 28.0% for riparian thicket and rocky woodland, and 37.7% for sandy woodland and rocky woodland. The differences between avifaunas are accounted for by certain species that show a significant preference for one or other of the habitats
35. Jones, J.A. 1989. Environmental influences on soil chemistry in central semiarid Tanzania. *Soil Science Society of America journal.Nov/Dec 1989.v.53 (6) p.1748-1758.maps 1748-1758.*
Keywords: soil formation/soil chemistry/physico-chemical properties of soil/soil parent materials/landforms/landscape/vegetation types/termitaria/Isoptera/soil/Tanzania/vegetation/vegetation type/cover/species composition/miombo/woodlands
Abstract: This study assessed the effectiveness of landscape features for predicting the variation in a set of chemical properties from 81 soil profiles sampled in a 236-km² site in central Tanzania. Soil samples were treated as points and coded by horizon and by groups, including landform, parent material, vegetation type, vegetation percent cover, and presence or absence of hypogeal termites. The variation captured by these groups in eight soil chemical properties (organic C, total N, acid-extractable P, exchangeable cations, and extractable Al) was assessed using analysis of variance, Duncan's multiple range test, and discriminant analysis. Soil development fits the catena model along hillslope transects, but lateral subsurface transport of dissolved Fe and cations has produced plinthite and highly base-saturated horizons just above the lithic or paralithic contact down-slope of transitions between ferruginous sediments and granitic sediments. Nevertheless, biotic factors (vegetation type and density of termites) captured more variation than other groups at the regional level. Vegetation species composition and the density and type of termites in central Tanzania reflect soil depth, texture, clay mineralogy, and drainage characteristics influenced by landform and parent material. Root symbioses of native miombo and *Acacia* spp. woodlands may also modify local soil chemistry via selective uptake of C and exchangeable cations. Termites contribute to the depletion of organic C, total N, and associated nutrients throughout the soils they occupy in this region
36. Kikula, I.S. 1986. The influence of fire on the composition of Miombo woodland of SW Tanzania. *Oikos*. 46:317-324.
Keywords: Tanzania,Miombo/forests/fires/community structure/ecosystem dynamics/miombo/Tanzania/Zambia
Abstract: Ecological experiences on Miombo woodland in Zambia are applicable to neighbouring areas in Tanzania. Studies undertaken in both countries show that fire is important in the ecology of Miombo woodland, resulting in ecological groups of species. However, although a continuum dynamic relationship exists among species in the different ecological groups, distinct association entities are not clearly defined
37. King, J.A. and B.M. Campbell. 1994. Soil organic matter relations in five land cover types in the miombo region (Zimbabwe). *For.Ecol.Manage.* 67:225-239.
Keywords: Zimbabwe/soil characteristics/organic matter/cover/agricultural land/carbon
Abstract: The objective of the present work was to contrast soil characteristics, with a focus on soil

organic matter, in five adjacent land cover types on granite-derived soils in Zimbabwe. Soil tillage and stumping on clearing and planting had altered soil profiles at the managed land cover types (pine plantation, eucalyptus plantation, grassland and arable maize), with resulting higher bulk density and higher clay content in the A horizon at these sites in comparison with those at the indigenous miombo woodland site. The sites differed in carbon concentration largely in the top 0.1 m, with the miombo and grassland site having high levels. Conversion of miombo woodland to pine plantation and arable maize results in a 10% loss of carbon from the top 0.5 m of soil. There were lower soil nitrogen levels at both the sites where there was major offtake of material, wood at the eucalyptus site and grain at the arable site. An inherent soil variability of clay content and consolidation after planting accounted for differences in the size distribution of soil aggregates, but their water stability was directly correlated to their organic matter content. Miombo leaf litter had the lowest C:N ratios (34) and, in comparison with pine and eucalyptus litter, persisted least on the soil surface. High total input and slower breakdown due to high C:N ratios (59 and 52 respectively), accounted for deep litter layers under pine and eucalyptus. Although of similarly poor quality (C:N ratios of 52 and 67 respectively), maize stover and *Hyparrhenia* grass litter did not persist. Higher soil temperatures in more open cover types and smaller litter quantities resulted in more complete litter decomposition, and also progressive mineralisation of soil organic matter. Only at the eucalyptus site was there evidence that poor quality litter led to higher C:N ratios in soil organic matter (20-40). Because of high C:N ratios in leaves and litter, none of the species studied are particularly suitable for green manures

38. Lawton, R.M. 1982. Natural resources of miombo woodland and recent changes in agricultural and land-use practices. *For.Ecol.Manage.* 4:287-297.
Keywords: Africa/forests/ecosystem dynamics/human impact/miombo/land use/cover/wood/beeswax/honey/human
Abstract: Miombo woodland covers a large area of central Africa, south of the equator. The renewable natural resources of miombo, i.e., timber, poles, wood fuel, beeswax and honey, mushrooms, edible caterpillars, wild fruits and livestock browse are discussed and roughly evaluated. A brief account is given of the salient ecological features of miombo, including the role of fire and its timing in determining the tree population dynamics, and the parts played by tsetse fly and wildlife populations in the history of human occupation in the region
39. Leirs, H., Verhagen, R., Verheyen, W., and Perrin, M. R. The biology of *Elephantulus brachyrhynchus* in natural miombo woodland in Tanzania. 1995. Sydney (Australia). Symposium on the Biology of Elephant Shrews at 6. International Theriological Congress. 1993. (GENERIC)
 Ref Type: Conference Proceeding
Keywords: *Elephantulus brachyrhynchus*/Tanzania/forests/rare species/habitat
Abstract: Field expeditions between 1986 and 1989 yielded information about the distribution of macroscelids in Tanzania. The rare *Elephantulus brachyrhynchus* was captured in a natural habitat complex of miombo woodland, Combretum savanna and grassland in Dakawa, Tanzania. Basic ecological data for this species were obtained from 46 animals in a removal-trapping study and 58 in a live-trapping study. Sex ratio was near to parity. There was no evidence of a restricted reproductive period, although pregnancy incidence was higher around January-February. Litters in utero comprised one or two embryos. *E. brachyrhynchus* had a preference for the transitional Combretum savanna. Stomach contents analysis showed a remarkably high proportion of green plant material in the diet
40. Matthee, C.A. and T.J. Robinson. 1997. Mitochondrial DNA phylogeography and comparative cytogenetics of the springhare, *Pedetes capensis* (Mammalia: Rodentia). *J.Mammal.Evol.* :53-73.
Keywords: *Pedetes capensis*/mitochondrial DNA/DNA/cytogenetics/phylogeny/population genetics/chromosome number/genetic variance/geographical distribution/taxonomy/genetic diversity/Mammalia/Africa/Brachystegia/habitat
Abstract: Variation in mitochondrial DNA (mtDNA) was used together with comparative cytogenetics to examine the evolutionary history and taxonomic status of an African

hystricomorphous rodent, the springhare *Pedetes capensis*. The mtDNA phylogeographic structure showed that the majority of the southern African populations (*P. c. capensis*) are characterized by unique but closely related maternal lineages. Based on restriction endonuclease fragment analysis, the east African populations (*P. c. surdaster*) appear more structured and are distinguished from those in southern Africa by an average sequence divergence of 5.52% (plus or minus 1.4%). This marked divergence is concordant with results of the cytogenetic study. Specimens from southern Africa have $2n = 38$, and those from east Africa $2n = 40$. The change in diploid number is due to a single centric fusion. It is suggested that the closure of the *Brachystegia* or "miombo" woodland (20,000-10,000 B.P.), which delimits contemporary springhare ranges, may have been too recent to account for the accumulated genetic differences that distinguish these taxa. While rifting and associated habitat changes in east Africa can be invoked to explain genetic structure in this region, the southern African springhare populations, which have a high incidence of locality-specific haplotypes, show a shallow phylogeographic structure, in keeping with a relatively recent range expansion from smaller source populations. Given the magnitude of genetic, morphological, and ethological differences between the two geographic isolates, we believe that there is strong support for the elevation of the east African and southern African springhare populations to full species status, thus supporting earlier taxonomic treatments of this rodent

41. McGregor, J. 1994. Woodland pattern and structure in a peasant farming area of Zimbabwe: Ecological determinants and present and past use. *For.Ecol.Manage.* 63:97-133.

Keywords: trees/species composition/population structure/forests/land use/agricultural land/Zimbabwe

Abstract: This article relates the species pattern and structure of miombo woodland in a deforested peasant farming area of central Zimbabwe to its ecological determinants and its present and past use. Data on species composition, basal area, height and physiognomy of the woody vegetation are presented for different parts of the landscape. The nature and degree of disturbance from harvesting for fuel and timber is quantified. Woodland in the arable areas and close to village lines is shown to be dominated by fruit trees, other trees with cultural controls on their cutting and species which quickly invade disturbed ground. The latter may be highly productive of woody biomass. In the grazing area, deeper soils which were cultivated in the past have retained an open structure and tend to be dominated by heavily coppiced *Brachystegia spiciformis* and *Combretum molle* (also dominants of less disturbed miombo woodland). Lithic soils which have not been cleared support denser, coppiced woodlands also dominated by climax species. Woody vegetation on kopjes and along riverine fringes is less disturbed in terms of its distribution, species composition, density and height than woodland in other parts of the landscape. The spatial pattern and nature of cutting is shown to vary between land use categories, between different species and according to the dimensions of individual stems. Miombo woodland shows a relatively high degree of stability in species composition under disturbance by cutting: of the 94 species included in the analysis, relatively few were shown to be significantly associated with a particular soil type, catenal position or land use category

42. Meiswinkel, R. 1991. Afrotropical *Culicoides* : *C. (Avaritia) miombo* sp. nov., a widespread species closely allied to *C. (A.) imicola* Kieffer, 1913 (Diptera: Ceratopogonidae). *Onderstepoort J.Vet.Res.* 58:155-170.

Keywords: new species/Malawi/Afrotropical Region/Ceratopogonidae/Diptera/Culicoides miombo/Africa/Zimbabwe

Abstract: *Culicoides (Avaritia) miombo* sp. nov. is described and illustrated from both sexes collected in northern Malawi. Two references in the literature have previously referred to this new species as either *C. brosseti* Vattier & Adam or *C. imicola* Kieffer. A further 4 references are discussed that most likely deal with *C. miombo* sp. nov. and not *C. brosseti*, *C. miombo* sp. nov. is apparently widespread in subtropical and tropical Africa and is now recorded from Zimbabwe, Botswana, South Africa, Nigeria and the Ivory Coast. There are also probable records from Angola, Burkina Faso, Zambia and eastern Madagascar

43. Meiswinkel, R. 1992. Afrotropical Culicoides: *C. (Avaritia) loxodontis* sp. nov., a new member of the *Imicola* group (Diptera: Ceratopogonidae) associated with the African elephant in the Kruger National Park, South Africa. *Onderstepoort J.Vet.Res.* 59:145-160.
Keywords: Culicoides loxodontis/new species/South Africa/Ceratopogonidae/Diptera/Africa/Afrotropical Region
Abstract: Culicoides (*Avaritia*) *loxodontis* sp. nov. is described and illustrated from both sexes collected in South Africa. It is the 5th species of the *Imicola* group of the subgenus *Avaritia* to be described from the Afrotropical Region, and is presently known only from the Kruger National Park where it has been collected in light-traps and reared from the dung of the African elephant (*Loxodonta africana*) on various occasions. A number of character states, and statistical analyses of antennal and palpal measurements, are used to separate the new species from its taxonomic congeners *C. imicola* Kieffer, 1913, *C. pseudopallidipennis* Clastrier, 1958, *C. bolitinos* Meiswinkel, 1989 and *C. miombo* Meiswinkel, 1991. It is suggested that the occurrence of the African elephant is the primary factor that determines the distribution of *Culicoides loxodontis* sp. nov., and that this close association, coupled with the fact that *C. loxodontis* sp. nov. can be locally abundant, may result in the cycling of certain arboviruses between this biting midge and the elephant
44. Menaut, J.C. 1983. The vegetation of African savannas.
Keywords: vegetation patterns/plant communities/savannahs/Africa/tropical environment/vegetation/vegetation type/miombo
Abstract: In this chapter an attempt has been made to describe the various vegetation types generally considered as "savannas". The designations chosen are either very general (e.g., savanna), or descriptive (e.g., woodland) or vernacular (e.g., miombo); they must be considered as convenient labels, and no more. They are discussed and described as precisely as possible, to help the reader to make useful comparisons, particularly between different continents
45. Monela, G.C., A. O'Kting'ati, and P.M. Kiwele. 1993. Socio-economic aspects of charcoal consumption and environmental consequences along the Dar es Salaam-Morogoro highway, Tanzania. *For.Ecol.Manage.* 58:249-258.
Keywords: charcoal/resource utilization/socio-economic aspects/environmental degradation/Tanzania/cover
Abstract: A study was done to assess socio-economic aspects of charcoal consumption and its impact on the environment along the Dar es Salaam-Morogoro highway in Eastern Tanzania. This is typically a miombo woodland area. Data collection was done during a 1-year period designed to cover both rainy and dry seasons. The methodology used to collect data included: field observation, monitoring at a selected forest-products checkpoint and interviewing charcoal makers, traders and consumers. Some parameters used in the calculation of the area cleared to meet the charcoal consumption were taken from related past studies. Household income from charcoal was Tanzanian Shillings (T.Shs.) 34 200 year⁻¹ (where US\$1 is equivalent to T.Shs. 193) and income redistribution flowing from Dar es Salaam, the capital city, to the rural areas along the highway was T.Shs. 40 253 400 year⁻¹. The total area of miombo forest cleared annually for producing charcoal was 4354 ha year⁻¹, or 1524 km² in 35 years. Such a huge area is cleared as a consequence of the fact that energy from charcoal is the most affordable and efficient fuel for most poor urban dwellers in the area of study. Therefore, charcoal consumption near a growing city such as Dar es Salaam promotes lucrative business with a positive economic impact on households. However, this is realized at the expense of environmental protection
46. Mtambanengwe, F. and H. Kirchmann. 1995. Litter from a tropical savanna woodland (miombo): Chemical composition and C and N mineralization. *Soil Biol.Biochem.* 27:1639-1651.
Keywords: plants/litter fall/nutrient content/mineralization/savannahs/Zimbabwe/*Brachystegia/Brachystegia spiciformis/Julbernardia*
Abstract: The decomposability of 15 litter types from four miombo woodland species, two tree species, *Brachystegia spiciformis* and *Julbernardia globiflora*, a grass species, *Dactyloctenium aegyptium*, and a sedge, *Bulbostylis megastachys*, was determined on the assumption that different

plant components could be used as predictors for C and N mineralization. The chemical composition of the litter, in terms of lignin, polyphenol, cellulose and total C and N contents was determined. The C and N mineralization patterns of the litter were also investigated during 75 days of aerobic laboratory incubation with soil and correlated with the initial composition. The litter materials contained between 40-51% organic C and total N contents of 13 of the 15 litter types were low, ranging from 0.47% for *D. aegyptium* leaf to 1.29% for lichens + bark fragments found associated with *B. spiciformis* stem. The lignin contents ranged from 0.03% in lichens + bark fragments to 16.5% in twig litter from *B. spiciformis*. Polyphenol contents ranged from 0 to 6%, with the highest values being found in twigs and pods. Cumulative C mineralization data were fitted to first-order kinetics estimating the decomposition parameters. Seed litter from *B. spiciformis* evolved more CO₂, 68.8% of initial C, than all the other litter materials tested. It was found that identical plant parts from the two tree species showed a similar rate of C mineralization, which was as follows: seed > lichens + bark fragments > tree leaflet litter > rachis litter > twig litter. Cellulose, which has received less attention in the literature, was found to influence both C and N mineralization patterns among other natural biopolymers ($P < 0.001$) but the content of ash-free available C, which was calculated as the difference between total C and lignin C + polyphenol C + cellulose C on an ash-free basis, had the highest R² value (0.910) for C mineralization and total N had the highest R² value (0.881) for N mineralization. Net N mineralization during 75 days was only apparent in 6 of the 15 litter samples, with results ranging from 0.2% of initial N in lichens + bark fragments from *J. globiflora* to 46% of initial N in *B. spiciformis* seed. The remaining samples immobilized N during the 75 days. Net N mineralization-immobilization was better correlated with the lignin C-to-N ratio (R² = 0.695; $P < 0.001$) and the (lignin + polyphenol) C-to-N ratio (R² = 0.688; $P < 0.001$) than the lignin-to-N ratio (R² = 0.656; $P < 0.001$) or lignin + polyphenol-to-N ratio (R² = 0.613; $P < 0.001$). Total N concentrations, C-to-N ratios and cellulose-to-N ratios appeared to be good predictors of N mineralization rates of the N-poor woodland ($P < 0.001$). The major part of miombo litter may not be a source for mineral N during the first 2-3 months after addition but the fractionation of litter into different C fractions gave a good indicator of potential C mineralization

47. Ngulube, M.R., J.B. Hall, and J.A. Maghembe. 1995. Ecology of a miombo fruit tree: *Uapaca kirkiana* (Euphorbiaceae). *For.Ecol.Manage.* 77:107-117.

Keywords: *Uapaca kirkiana*/population ecology/ecological distribution/conservation/management/Malawi/soil/vegetation/Africa/Tanzania/Zambia/Zimbabwe/rainfall/*Brachystegia*/*Julbernardia*

Abstract: Records in herbaria and published information on the distribution of *Uapaca kirkiana* Muell. Arg. were assembled and summarized 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. *Uapaca kirkiana* is reported from most countries within the Zambezi centre of endemism and adjacent transitional phytochoria. This species has been recorded growing in Angola, Burundi, Malawi, Mozambique, Tanzania, Zaire, Zambia and Zimbabwe. Within the natural range, occurrence is related to a unimodal rainfall regime with an annual range of 500-1400 mm occurring over a 4-5 month period followed by a long dry season lasting 5-7 months. The mean day time temperature range is 18-29 degree C in the hot season and 12-24 degree C in winter. Typically *Uapaca kirkiana* grows in well-drained escarpments at altitudes of 500-2000 m, with infertile sand or gravelly soils of acidic reaction. As a miombo species, it occurs in mixed communities of *Brachystegia-Julbernardia* woodland as dominant or co-dominant species, often gregarious, forming dense groves, commonly referred to as *Uapaca* woodlands. Throughout the range, listings of associated woody species frequently include *Albizia*, *Anisophyllea*, *Brachystegia*, *Burkea*, *Isobertinia*, *Julbernardia*, *Monotes*, *Parinari*, *Protea*, *Pericopsis*, *Pterocarpus*, *Ochna* and other *Uapaca* spp. Attention is drawn to various relationships with mycorrhizae and animals (including man) and their significance in conservation and management options. Definitive studies aimed at generating relevant data to aid husbandry action are outlined. Suggestions for positive management prescriptions and domestication initiatives are made

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49. PERRY, D., M. AMARANTHUS, J. BORCHERS, S. BORCHERS, and R. BRAINERD. 1989. Bootstrapping in Ecosystems. *BioScience* 39:230-237.

Keywords: ecosystem dynamics/MYCORRHIZAL FUNGI/MICROBIAL ECOLOGY /PLANT-SOIL RELATIONS/BOOTSTRAPPING/POSITIVE FEEDBACK/BIOLOGICAL SYSTEMS/productivity/plants/soil/roots/fungi/miombo/miombo woodlands/miombo woodland/woodlands/Africa/forests/plant communities/disturbance/management

Abstract: Positive feedback, or bootstrapping, is being increasingly recognized as an important component of ecosystem dynamics. Within the constraints of resource supply or other environmental factors, the biological system characterized by strong positive feedback among its components is in many respects self-generating--its productivity and stability determined largely through its internal interactions. Such systems can be complex, productive, and quite stable under conditions to which they are adapted, but when key linkages are disrupted, they are fragile and subject to threshold changes. One example is the reciprocal interactions between plants and soils. Through close mutual interactions between plant and soil organisms, these ecosystems create the conditions that allow the systems to persist. Severing the close links between the ecosystems has contributed to their degradation, and restoring the links is an important step toward rehabilitation. Plants allocate a high proportion of photosynthate to roots, and much is either directed to mycorrhizal symbionts or exuded into the surrounding rhizosphere or mycorrhizosphere. Photosynthate flowing from roots and mycorrhizal hyphae supports a diverse community of soil organisms including mycorrhizal fungi. Bacterial grazing by protozoa, amoebae, nematodes, and microarthropods accelerates release of nutrients in plant-available form. However, these self-helping links in the system also may present a problem: stress in one portion of the system can be rapidly amplified and spread to the whole system. But it seems likely that diversity in both the plant and microbial communities stabilize the plant-soil system during environmental fluctuations. Altered environments frequently result in replacement of one mycorrhizal fungal species by another, but the plant retains a below ground partner throughout its life. Disruption of the natural links between plants and soils may have resulted in ecosystem degradation in the Miombo woodlands of southern Africa as well as in western North America and in moist tropical forests. In western North America, for example, some annual grasslands which have been converted from perennial grasslands by overgrazing, no longer support perennial grasses even when planted. Perennial grasses require mycorrhizae, at least when certain

nutrients are in short supply, but invading annual grasses probably do not. It is thus reasonable to hypothesize that overgrazing eventually reduces energy flow to mycorrhizal fungi and associated organisms, weakening the link until annuals successfully invade. Much still needs to be learned about bootstrapping and ecosystem stability, but one conclusion already seems warranted. Diversity--in the plant community, the microbial community, and the ecosystem as a whole--plays a seminal role in buffering against disturbance and maintaining healthy links between plants and soils. Management systems aimed at protecting diversity are thus an important step toward sustainable resource utilization

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Keywords: deforestation/regrowth/remote sensing/Tanzania
Abstract: Monitoring of large scale deforestation in miombo woodland is possible with Landsat Multispectral Scanner System (MSS) data. It is possible to assess conversion of miombo woodland into cleared and regrowth areas after the first year of fallow. By change detection, this result adds to the understanding of the deforestation versus regrowth rate, as well as degradation of virgin miombo woodland when exposed to intensive agricultural use
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Keywords: toxicity tests/biological vectors/disease control/*Swartzia madagascariensis*/*Bulinus nasutus*/*Schistosoma*/molluscicides/miombo/miombo woodland/Tanzania/Africa
Abstract: *Swartzia madagascariensis* is a wild leguminous tree that is widespread throughout the miombo woodland areas of Tanzania. Various parts of this plant are used by traditional healers in Africa. The fruit pods of this plant have been briefly mentioned to have molluscicidal properties. To our knowledge there are no other studies on the molluscicidal properties of the fruit of *S. madagascariensis* . The present paper reports on our observations on the molluscicidal properties of the fruit pods on *Bulinus* (*Physopsis*) *nasutus*
52. Stroemgaard, P. 1992. Immediate and long-term effects of fire and ash-fertilization on a Zambian miombo woodland soil. *Agric.* 41:19-37.
Keywords: fires/short-term/long-term effects/ash/fertilization/soil/Zambia/phosphorus/carbon/nitrogen/regrowth
Abstract: The effects of burning and ash-fertilization were studied by regular time-serial sampling for 9 years after burning of piled vegetation in miombo woodland. Substantial immediate increases of available phosphorus were observed down to 40 cm soil depth; as the increase was not paralleled by an increase in pH, this may have been caused by heat rather than increase solubility of phosphorus complexes with iron and aluminium as ash is leached down into the soil. Increased levels of phosphorus were also found in plots burned 16 years previously. Topsoil showed an increase in organic carbon as well as total nitrogen. The increase in total nitrogen was short-lived and the soil content of nitrogen declined rapidly to that seen prior to burning. The carbon:nitrogen ratio increased accordingly throughout the period. The immediate increase and later depletion of exchangeable, non-acid cations, during fallow and regrowth, were paralleled by a slight increase in cation-exchange capacity with soil depth over the period
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Keywords: biomass/growth/burning/forests/Zambia/cultivation/Africa/trees/vegetation/ash
Abstract: In four 20 x 20 m plots in the miombo woodland of Northern Zambia all trees were located, identified, and felled after measuring height and diameter at breast height. One of the plots was in chipya, a fire-adapted type of vegetation, often considered to have developed as a result of the repeated burning of the miombo. The overwhelming dominance in chipya of one species, *Syzygium guineense* ssp. *macrocarpum* (64%) was shown. Biomass of chipya was approximately 41 t ha super(-1) fresh weight (17 t ha super(-1) dry matter) and basal area was about 10 m super(2) ha

super(-1), approximately as in regrown miombo which had been cleared, burned and cultivated 16 years previously. Clear-felling of three plots in miombo showed a growth rate of 2.5 t ha super(-1) y super(-1) fresh weight, equivalent to 1 t ha super(-1) y super(-1) dry matter, and an annual basal area increment of 0.5 m super(2) ha super(-1) y super(-1). Above-ground fresh biomass of a miombo stand, undisturbed for 16 years, was 108 t ha super(-1), equivalent to 48 t ha super(-1) dry matter. Organised burning of the vegetation from two of the clear-felled plots in miombo consumed 50-77% (wet weight) of the above-ground biomass, leaving between 1.6 and 3.2 kg m super(-2) ash in one tenth of the chopped area

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Keywords: Zambia/succession/agricultural land/community structure/species diversity/forests/abandoned/miombo woodland/miombo/Africa/cultivation/regrowth/burning/vegetation/cover
Abstract: In the burned miombo of northern Zambia, succession was followed on plots cleared and burned during the practice of shifting cultivation. Twelve formerly cultivated gardens were surveyed in various stages of regrowth (1, 2, 4, 6, 13, and 25 yr after burning). The early vegetation was woody, mainly caused by stumps and root stocks remaining at the site from the preexisting cover. Species diversity was lowest after four years, primarily because the distribution of individuals among species was highly uneven in the middle of the succession. Early and late stages of succession were found to be more similar than intermediate stages. Three phases could be distinguished: 0-1 yr, 2-6 yr, and 6-25 yr. The canopy of woody species developed in the late stage did not include the dominant miombo species
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Keywords: Tanzania/cultivation/forests/habitat fragmentation/vegetation surveys
Abstract: A survey of woody species persisting in cultivated farmland was carried out in Iringa Region in south-west Tanzania. Following a maize (*Zea mays*) harvest in July, a series of farm plots (5 M '5 M) were laid down in cultivated areas close to village centres, where no following had taken place during the past 15 years. Miombo vegetation was dominant in the areas prior to 1974. Nineteen plant families and forty woody species were recorded, the most common species being *Randia taylorii* S. Moore, *Piliostigma thonningii* (Schumach) Milne-Redhead, and *Aganza garckeana* (Hoffm.) Exell and Hille. Few stems were listed with heights above 2 metres, or with diameter values greater than 5 cm dbh. The mean number of woody individuals per plot was 33 (S.E.=5.7) and the mean number of species per plot was nine. Vegetative propagation was most common, in particular root suckering, coppicing, and epicormic sprouting. Suffruticose vegetation was also found. Sixty percent of all species were found to regenerate through more than one mechanism. The diversity and resilience shown by these tree and shrub species highlighted a potential for miombo species in farm-forestry initiatives
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Keywords: ectomycorrhizas/fungi/Malaysia/forests
Abstract: Field observations of suspected ectomycorrhizal fungi in Malaysian dipterocarp forests are discussed in the light of (1) the same taxa occurring in Philippine communities and (2) parallel taxa present in Central African Miombo woodland
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Ref Type: Conference Proceeding
Keywords: cultivation/carbon/flux/forests/savannahs/Africa,Southern/Africa
Abstract: The rapid transition from miombo woodland and savanna to maize-based agriculture in Southern Africa results in a near universal loss of total system and biomass carbon. Forests and

savannas occupy approximately 3.1 million km² in southern Africa. Two natural ecosystems, a miombo woodland (Zimbabwe) and a broadleaved dry savanna (South Africa), contained 48 and 94 Mg C ha⁻¹, respectively. Clearing of the miombo and establishment of maize-based agriculture on a sandy Alfisol resulted in a decline in soil organic carbon from 28 to as little as 9 Mg ha⁻¹. This decline is not related to annual aboveground productivities which, in many cases is greater in the cropping system than in the savanna or forest. Severe declines in total soil organic matter resulting from shifting cultivation were also observed in coastal Mozambique. The CENTURY plant/soil simulation model was used to simulate long-term carbon dynamics a miombo woodland and maize-based cropping system in Marondera, Zimbabwe. The miombo woodland continues to accumulate total system C but shifting cultivation and commercial cultivation of maize result in annual carbon losses of 0.15 and 0.14 Mg ha⁻¹ yr⁻¹. Increases in temperature (2 degree C) accompanied by 25% increases in photosynthetic efficiency did not effect the decline in total system carbon, however, improved organic matter management within the agroecosystem reduced the losses in total system carbon within the agroecosystem by 57% under the climate change scenario