

SOURCES AND NOTES

Introduction: context and early beginnings

1. Curtis, B.A. & Mannheimer, C.A. 2005. *Tree Atlas of Namibia*. National Botanical Research Institute, Windhoek.
 2. The FAO defines Other Wooded Land as “Land not classified as forest, spanning more than 0.5 hectares; with trees higher than 5 metres and a canopy cover of 5-10%, or trees able to reach these thresholds, or with a combined cover of shrubs, bushes and trees above 10%.”
 3. Derived from a comparison between an analysis of average annual green vegetation production produced by the Ministry of Agriculture, Water and Forestry from NDVI data provided by NOAA satellite images and an analysis of tree cover for selected regions, as reported in Verlinden, A. & Laamanen, R. 2002. *The role of remote sensing in monitoring woody vegetation resources in Northern Namibia*. Namibia Finland Forestry Programme, Directorate of Forestry, Windhoek. Data for Africa were obtained from www.glc.umiacs.umd.edu/treecover.
 4. From Mendelsohn, J.M., Jarvis, A.M., Roberts, C.S. & Robertson, T. 2002. *Atlas of Namibia*. David Philip, Cape Town.
 5. Same as Note 4.
 6. Erkkilä, A. & Siiskonen, H. 1992. *Forestry in Namibia, 1850-1990*. Silva Carelica 20. University of Joensuu, Finland.
 7. Breitenbach, Von, F. 1968. *Long-term plan of forestry development in the Eastern Caprivi Zipfel*. Department of Forestry, George; Geldenhuys, C.J. 1975. *Stock enumeration and management planning of the woodlands of Kavango*. Saasveld Forestry Research Centre, George; Geldenhuys, C.J. 1977. *Woodland management plan for Nakabunze Reserve, Eastern Caprivi*. Report. Division of Forest Science & Technology, CSIR, Pretoria.
- ### Ecology: the life of trees
1. From Mendelsohn, J.M., Jarvis, A.M., Roberts, C.S. & Robertson, T. 2002. *Atlas of Namibia*. David Philip, Cape Town. The co-efficient of variation is the standard deviation of annual rainfall divided by average rainfall and then multiplied by 100.
 2. Timberlake, J. 1996. A review of the ecology and management of Mopane *Colophospermum mopane*. In Flower, C, Wardell-Thompson, G. & Jamieson, A. (editors). *Management of Mopane in Southern Africa*. Directorate of Forestry, Windhoek.
 3. From data supplied by the Namibian Meteorological Services.
 4. From Mendelsohn, J.M., Jarvis, A.M., Roberts, C.S. & Robertson, T. 2002. *Atlas of Namibia*. David Philip, Cape Town.
 5. Tropical and sub-tropical soils are relatively rich in iron and aluminium oxides with which phosphorus readily forms complexes. Phosphorous is not available to plants once it is bound into such a complex. Other limitations on the availability of phosphorous result from the formation of calcium phosphate in alkaline soils and the binding of phosphorous onto the surface of clay particles. The main problem for plant growth is the limited availability of phosphorous to nitrogen-fixing bacteria. The bacteria use an enzyme which requires phosphorous for nitrogen fixation. With limited phosphorous, the bacteria are unable to fix large amounts of nitrogen, resulting in low rates of nitrogen production. The bacteria are hosted in nodules in roots, where they feed off sugars supplied by the host plants. Up to 50% of the energy produced by some plants is spent on feeding sugars to the bacteria. Nitrogen fixation is the most important way in which savanna soils are enriched by nitrogen, but soils in most areas are too low in phosphorous for nitrogen to be produced faster than it is lost to the atmosphere. Nitrogen is also deposited as fall-out from the atmosphere, but at low levels. Unlike some nutrients, phosphorous is not cycled through the atmosphere, but remains ‘locked’ in the ground: in the parent rock, in plants and animals, or chemically bound with other elements, usually iron or calcium.
 6. Adapted from information supplied by the Ministry of Agriculture, Water and Forestry.
 7. Bond, W.J., Midgley, G.F. & Woodward, F.I. 2003. What controls South African vegetation – climate or fire? *South African Journal of Botany*. 69: 79-91.
 8. Based on data supplied by Spatial Data Services & Mapping, Namibia and National Air & Space Administration (NASA) Shuttle Radar Topography Mission (SRTM).
 9. Bond, W.J., Midgley, G.F. & Woodward, F.I. 2003. The importance of low atmospheric CO₂ and fire in promoting the spread of grasslands and savannas. *Global Change Biology* 9: 973-982.
 10. Hoffman, M.T., Cowling, R.M., Douie, S. & Pierce, S.M. 1989. Seed predation and germination of *Acacia erioloba* in the Kuiseb River Valley, Namib Desert. *South African Journal of Botany* 55: 103-106.
 11. Jacobson, P. J., Jacobson, K.M. & Seely, M.K. 1995. *Ephemeral rivers and their catchments: sustaining people and development in western Namibia*. Desert Research Foundation of Namibia,

- Windhoek; and Petra Moser (personal communication).
12. Petra Moser, Desert Research Foundation of Namibia (personal communication).
 13. Based on data collected and reported by the forest inventories conducted by the Directorate of Forestry.
 14. Analysis of data collected and reported by Worbes. M. 1999. *Growth of trees from Namibia - A dendrochronological study*. Report for Namibia-Finland Forestry Project, Windhoek.
 15. Steenkamp. C.J., Vogel, J.C., van Rooyen, M.W. & van Rooyen, N. Submitted. Age determination of *Acacia erioloba* trees. *Forest Ecology and Management*; Walter, H. 1940. Die Jahresringe der Bäume als Mittel zur Feststellung der Niederschlagsverhältnisse in der Vergangenheit, insbesondere in Deutsch-Südwestafrika. *Die Naturwissenschaften* 38: 607-612; and Henschel JR. & Seely M.K. 2000. Long-term growth patterns of *Welwitschia mirabilis*, a long-lived plant of the Namib Desert (including a bibliography). *Plant Ecology* 150: 7-26.
 16. Vogel, J.C. 2003. The age of dead trees at Sossusvlei and Tsondabvlei, Namib Desert, Namibia. *Cimbebasia* 18: 247-251.
 17. Adapted from Mendelsohn, J.M., Jarvis, A.M., Roberts, C.S. & Robertson, T. 2002. *Atlas of Namibia*. David Philip, Cape Town.
 18. Based on an interpolation of data collected per quarter degree by the Namibian Tree Atlas project.
 19. Endemic trees: same as Note 18; endemic birds: same as Note 17.
 20. Curtis, B.A. & Mannheimer, C.A. 2005. *Trees Atlas of Namibia*. National Botanical Research Institute, Windhoek.
 21. The list was kindly compiled by Pat Craven.
 22. Based on an interpolation of data collected per quarter degree by the Namibian Tree Atlas project.
 23. From data collected and reported by the forest inventories conducted by the Directorate of Forestry.
 24. Derived from a comparison between forest inventory data (published in reports by the Directorate of Forestry), an analysis of average annual green vegetation production produced by the Ministry of Agriculture, Water and Forestry from NDVI data provided by NOAA satellite images, and an analysis of tree cover for selected regions, as reported in Verlinden, A. & Laamanen, R. 2002. *The role of remote sensing in monitoring woody vegetation resources in Northern Namibia*. Namibia Finland Forestry Programme, Directorate of Forestry, Windhoek.
 25. Based on data collected and reported by the forest inventories conducted by the Directorate of Forestry.
 26. From data supplied by Alex Verlinden, collected under the auspices of the Namibia-Finland Forestry Project and reported in Verlinden, A. & Laamanen, R. Submitted. Modeling woody vegetation resources using Landsat TM imagery in Northern Namibia.
 27. From the Namibia Forestry Strategic Plan of the Directorate of Forestry. See also Hines, C.J., Viitanen, J. & Tuomasjukka, T. 2003. *Environmental Forestry in Namibia: preliminary site descriptions of strategic forests*. Report for Directorate of Forestry, Namibia-Finland Forestry Programme.
 28. From Department of Water Affairs; Ward, J.D & Breen, C.M. 1983. Drought stress, and the demise of *Acacia albida* along the lower Kuiseb River, central Namib Desert: preliminary findings. *South African Journal of Science* 79: 444-447; and Carole Roberts (personal communication).
 29. Pieters, I. & Laamanen, R. 2002. *Inventory Report for Rehoboth Acacia Park*. Namibia-Finland Forestry Programme, Directorate of Forestry, Windhoek.
 30. Plantations have been established at Ngoma (Caprivi), Musese, Ndiyona, Kaisosi, Mile 37 and Kehemu (Kavango), Onuno (Ohangwena), Onankali (Oshikoto), Osire (Otjozondjupa), Drimiopsis (Omaheke), and Aranos, Mariental and Kalkrand (Hardap). In addition, almost 9,000 trees were planted between 2002 and 2005 in an area of 30 hectares in the *ombuga* grasslands south of Oshakati. Most of these trees are indigenous to Namibia.
 31. From Forest Inventory Reports of the Directorate of Forestry, Windhoek.
 32. Kobus Theron, personal communication.
 33. Geldenhuys, C. J. 1996. Past, present and future forest management in the southern African region with special emphasis on the northern regions of Namibia. *Forestry Publication No. 5*, Directorate of Forestry, Windhoek; and Erkkilä, A. 2002. *Development of forest research networking system: A report prepared for the Namibia-Finland Forestry Programme*. Namibia-Finland Forestry Programme, Directorate of Forestry, Windhoek.
 34. Bethune, S., Griffin, M. & Joubert, D. 2004. *National Review of Invasive Alien Species – Namibia*. Final Report to SABSP. Directorate of Environmental Affairs Discussion Document. Windhoek.

Benefits: more than wood

1. Leffers, A. 2003. *Gemsbok bean and Kalahari truffle: traditional plant use by Ju'hoansi in north-eastern Namibia*. Gamsberg Macmillan, Windhoek.

2. Klaus Endresen (personal communication) and www.fao.org.
3. Wood fuel consumption measures are variable and so an average was taken from the results of 16 studies in and around southern Africa. Four of the studies were in Namibia: Wamukonya, L. 1997. *Study on energy consumption patterns of rural and peri-urban households in Namibia*. University of California, Berkeley; Klaeboe, J. & Omwami, R. 1997. *Forest Policy for Sustainable Utilization of the Woodlands and Savannas of Namibia. A study on consumption patterns of major wood and wood products in Namibia*. Directorate of Forestry, Windhoek; Negumbo, H.M.T. 2004. *Fuelwood consumption in Namibia: a case study on fuelwood consumption in Oshana Region*. University of Wales, Bangor; Ollikainen, T. 1991. *Study on wood consumption in Namibia*. Directorate of Forestry, Windhoek. Each cubic metre was taken as equivalent to 0.8 metric tons.
4. Fuel wood estimates are based on approximately 213,000 households that mainly cooked with wood in 2001, with each household consuming 4.6 cubic metres per year (see Note 3). Estimates on construction and fencing wood use are based on about 72,000 households using 4.37 cubic metres of poles per year (see Note 19 below). Estimates for craft, commercial firewood and Mopane are extrapolated increases from Klaeboe, J. and Omwami, R. 1997. *Forest Policy for Sustainable Utilisation of the Woodlands and Savannas of Namibia. A study on consumption patterns of major wood and wood products in Namibia*. Directorate of Forestry, Windhoek. Figures on wood imports are for 2003 and were supplied by the National Planning Commission to the Directorate of Forestry. Ian Galloway provided estimates on charcoal production.
5. From analyses of data collected in the Population and Housing Census held in 2001 by the Central Bureau of Statistics, National Planning Commission.
6. Same as Note 5.
7. Same as Note 5.
8. Same as Note 5.
9. Negumbo, H.M.T. 2004. *Fuel wood consumption in Namibia: a case study on fuel wood consumption in Oshana Region*. University of Wales, Bangor.
10. Based on information supplied by Ian Galloway and Aigams Professional Services. 1997. *Charcoal production in Namibia*. Report for the Development Fund of Namibia, Windhoek.
11. From analyses of data collected in the Population and Housing Census held in 1991 and 2001 by the Central Bureau of Statistics, National Planning Commission.
12. Mendelsohn, J.M., el Obeid, S. & Roberts, C.S. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek.; Erkkilä, A. 2001. *Living on the land: change in forest cover in north-central Namibia 1943-1996*. Silva Carelica 37. University of Joensuu, Finland.
13. Information supplied by the Directorate of Forestry, Windhoek.
14. Erkkilä, A. & Siiskonen, H. 1992. *Forestry in Namibia, 1850-1990*. Silva Carelica 20. University of Joensuu, Finland.
15. Klaeboe, J. & Omwami, R. 1997. *Forest Policy for Sustainable Utilization of the Woodlands and Savannas of Namibia. A study on consumption patterns of major wood and wood products in Namibia*. Directorate of Forestry, Windhoek.
16. From data collected by the Tree Atlas Project and kindly supplied by Barbara Curtis.
17. Based largely on du Plessis, P. 2002. *Promoting indigenous fruit in Namibia (PIF)*. Indigenous Plant Task Team Report, Ministry of Agriculture, Water & Rural Development.
18. Bond, W.J., Midgley, G.F. & Woodward, F.I. 2003. The importance of low atmospheric CO² and fire in promoting the spread of grasslands and savannas. *Global Change Biology* 9: 973-982.
19. See Barnes, J.I., Nhuleipo, O., Macgregor, J. & Muteyauli, P.I. 2005. *Preliminary development of wildlife and woodland asset accounts in Namibia*. Research Discussion Paper, Directorate of Environmental Affairs, Windhoek.
20. CBS. 2004. *Republic of Namibia national accounts: 1995-2003*. Central Bureau of Statistics, National Planning Commission, Windhoek, Namibia; and Note 19.
21. Lange, G., Schade, K., Ashipala, J. & Haimbodi, N. 2004. A social accounting matrix for Namibia 2002: a tool for analyzing economic growth, income distribution and poverty. *NEPRU Working Paper 97*. Namibia Economic Policy Research Unit, Windhoek, 47pp

Changing management: conservation for use

1. Directorate of Forestry Annual Report for 2003.
2. Worbes, M. 1999. *Growth of trees from Namibia - A dendro-chronological study*. Unpublished report for Namibia-Finland Forestry Project, Windhoek.
3. Erkkilä, A. 2002. *Development of forest research networking system: A report prepared for the Namibia-Finland Forestry Programme*. Namibia-Finland Forestry Programme, Directorate of Forestry, Windhoek.
4. Figures supplied by the Directorate of Forestry.

5. Görden, M. & Gsänger, J. 2002. *Gemeindewaldbewirtschaftung im Nordosten Namibias: Studie zur Wirtschaftlichkeit der Projektmaßnahmen*. Report for Community Forestry Project in North-eastern Namibia, Directorate of Forestry, Windhoek.
6. Based on data in Mendelsohn, J.M., Jarvis, A.M., Roberts, C.S. & Robertson, T. 2002. *Atlas of Namibia*. David Philip, Cape Town.
7. Görden, M. & Gsänger, J. 2002. *Gemeindewaldbewirtschaftung im Nordosten Namibias: Studie zur Wirtschaftlichkeit der Projektmaßnahmen*. Report for Community Forestry Project in North-eastern Namibia, Directorate of Forestry, Windhoek.
8. NACSO. 2004. *Namibia's communal conservancies: a review of progress and challenges*. NACSO, Windhoek.
9. Same as Note 8.
10. This provision does not apply to surveyed plots in local authority areas.

Prospects: seeing the wood and the trees

1. Robbins, L.H. & Murphy, M.L. 1998. The Early and Middle Stone Age. In Lane, P., Reid, A. & Segobye, A. (eds). *Ditswa Mmung: The archaeology of Botswana*. Pula Press & The Botswana Society, Gaborone. The earliest evidence of crop farming in Namibia comes in the form of pottery made in about 850 AD at Kapako west of Rundu. The pots were used to store grain.
2. From Le Roux, J. 2000. *Expansion of subsistence agriculture in north-central Namibia*; Mendelsohn, J.M., el Obeid, S & Roberts, C.S. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek; and Mendelsohn, J.M. & el Obeid, S. 2003. *Sand and Water, A profile of the Kavango region of Namibia*. Struik, Cape Town.
3. Bond, W.J., Midgley, G.F. & Woodward, F.I. 2003. What controls South African vegetation – climate or fire? *South African Journal of Botany*. 69: 79-91.
4. These are maps of areas that have been burnt, as detected from NOAA and MODIS satellite images. The interpretation of these satellite images and the mapping of burnt areas were done by Simon Trigg (1997), Johan le Roux (2000 and 2001), the National Remote Sensing Centre (2002, and David Roy (2003 - see <http://edcdaac.usgs.gov/order.asp>). The global map shows areas burnt in 2000, as provided by the Global Burned Area 2000 initiative (see Grégoire, J.-M., Tansey, K. & Silva, J.M.N. 2003. Developing a global burned area database from SPOT-VEGETATION imagery. *International Journal of Remote Sensing*. 24: 1369-1376.
5. An excellent overall reference on fires in Africa is provided by Goldammer, J.G. & de Ronde, C. (editors). 2004. *Wildland fire management handbook for southern Africa*. Global Fire Monitoring Centre.
6. Analyses of data reported in Verlinden, A. 2002. *A local operational tool for fire monitoring and management for the Kavango and Caprivi Regions*. Report for Lux-Development S.A. (Agence Luxembourgeoise pour la Coopération au Développement), and National Remote Sensing Centre, Directorate of Forestry.
7. Based on data for 2003 provided by David Roy (see <http://edcdaac.usgs.gov/order.asp>).
8. Chakanga, M., Selännemi, T. & Korhonen, K. 1999. *Forest inventory report of Caprivi State Forest*. Namibia Finland Forestry Programme, Directorate of Forestry, Windhoek.
9. Scholes, R.J., van der Merwe, M.R., Landmann, T., Venter, G., Basson, J., de Klerk, N. du Plessis, P. & Burke, A. 2005. *Review of Greenhouse Gas Emission Factors for Namibia*. Ministry of Environment & Tourism, Windhoek. The following figures come from this report. Methane and nitrous oxide have global warming potentials of 21 and 310 times that of CO₂. Multiplying those potentials by the 54,000 tons of methane and 2,000 metric tons means that bush fires produce total emissions equivalent to 1,754,000 tons of CO₂. A total of 12,400,000 tons of carbon, equivalent to 45,400,000 tons of CO₂ as a green house gas is estimated to be taken up each year in bush encroached areas.
10. De Klerk, N. 2004. *Bush encroachment in Namibia*. Ministry of Environment & Tourism.
11. Adapted from Bester, F.V 1999. Major problem: bush species and bush densities in Namibia. *Agricola* 10: 1-3.
12. Same as Note 10.
13. Adapted from data analysed for De Klerk, N. 2004. *Bush encroachment in Namibia*. Ministry of Environment & Tourism.
14. Braune, E. 1991. *Hydrology of the Lower Kuiseb River*. Department of Water Affairs, Windhoek.
15. Dams were mapped and kindly supplied by Carole Roberts.
16. Martin, R.K. 2005. *Elephants: Background study for the Transboundary Species Project*. Ministry of Environment & Tourism, Windhoek.
17. Midgley, G. Hughes, G. Thuiller, W., Drew, G. & Foden, W. 2005. *Assessment of potential climate change impacts on Namibia's floristic diversity, ecosystem structure and function*. Report for Namibian National Biodiversity Programme. Directorate of Environmental Affairs, Ministry of Environment & Tourism.

18. Scholes, R.J., van der Merwe, M.R., Landmann, T., Venter, G., Basson, J., de Klerk, N., du Plessis, P. & Burke, A. 2005. *Review of Greenhouse Gas Emission Factors for Namibia*. Ministry of Environment & Tourism, Windhoek.
19. For cleared land, these are 5x5 kilometre blocks in which more than 5% of the block was cleared for crops, as derived from Mendelsohn, J.M., Jarvis, A.M., Roberts, C.S. & Robertson, T. 2002. *Atlas of Namibia*. David Philip, Cape Town; burnt areas are those that burnt in three or more of the five years shown in Figure 28; bush encroached areas those with more than 3,000 bushes per hectare as provided by Bester, F.V 1999. Major problem: bush species and bush densities in Namibia. *Agricola* 10: 1-3.
20. The arguments are based on analyses of farming systems in north-central Namibia, north-eastern Otjozondjupa and Kavango, as reported in Mendelsohn, J.M., el Obeid, S. & Roberts, C.S. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek; Mendelsohn, J.M. & el Obeid, S. 2002. *The communal lands of eastern Namibia*. RAISON, Windhoek; Mendelsohn, J.M. & el Obeid, S. 2003. *Sand and Water, A profile of the Kavango region of Namibia*. Struik, Cape Town.

Sources of photographs

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