

**Contributions to the ecology of Maputaland, southern Africa, with
emphasis on Sand Forest**

by

Wayne Sidney Matthews

Submitted in partial fulfilment of the requirements for the degree

Philosophiae Doctor

In the Faculty of Natural and Agricultural Sciences

Department of Botany

University of Pretoria

Pretoria

Promoter: Prof. Dr. A.E. van Wyk
Co-promoter: Dr. N. van Rooyen

2005



“No man crosses the same river twice. It is impossible for two reasons. The second time it is not the same river, and the second time it is not the same man. In the interval of time between the first and second crossing, no matter how short, both the river and man have changed.”

Heraclitus of Ephesus, 540–486BC

*Dedicated to my family and friends. . .
Specifically to those friends who stopped me from throwing this thesis into the dustbin*

ABSTRACT

Contributions to the ecology of Maputaland, southern Africa, with emphasis on Sand Forest

by

Wayne Sidney Matthews

Promoter: Prof. Dr. A.E. van Wyk
Co-promoter: Dr. N. van Rooyen

Submitted in partial fulfilment of the requirements for the degree

Philosophiae Doctor

Keywords

Braun-Blanquet classification, endemism, Maputaland, Sand Forest, Woody Grassland, allelopathy, elephant, forage preference indices, evolution, vegetation dynamics

The principal hypothesis of this thesis was that the Maputaland Centre of Plant Endemism [MC] is characterised by plant communities that match a particular set of environmental variables, and their rich biodiversity with endemic and rare taxa reflecting the geomorphological history of the region. Data assembled supports the hypothesis. Vegetation studies highlighted two plant communities, endemic to the MC as being an important component of the region's biodiversity, namely Sand Forest and Woody Grassland.

A broad approach to the floristic classification of vegetation was adopted for information on the floristics patterns and diversity of the endemic/rare plants and plant communities of the MC. A hierarchical classification, description and ecological interpretation of the plant communities of the Tembe Elephant Park, Sileza Nature Reserve and surrounding areas are presented. Much of the vegetation distribution can be ascribed to the level of the water table, vegetation dynamics and historic evolution of the geomorphology of the region.

The hypothesis is presented that Sand Forest may have allelopathic effects on its environment. Data of exploratory germination trials are presented to test this hypothesis. Sand Forest soil inhibits the emergence of seedlings, the inhibiting effect decreasing progressively from Sand Forest through grassland to woodland.

University of Pretoria etd – Matthews, W S (2007)

Sand Forest was defined as a community, and its possible dynamics are described. Ideas were formulated (albeit largely hypothetical) on the likely origin of this vegetation type. It is proposed that ancient Dune Forest is the precursor of Sand Forest, but that Sand Forest has subsequently become a separate functioning plant community on its own. Sand Forest appears to be a relictual vegetation type of which the historical factors responsible for its original establishment and expansion are currently no longer present in the region.

The use of woody species by elephant in different vegetation types in Tembe Elephant Park was investigated. A classification of species into utilization categories was produced which enabled assessment of the importance of different species to elephants, and also of the potential impact of elephants on different tree species. Management implications are highlighted.

CONTENTS

CHAPTER 1. INTRODUCTION	1
1.1 Background	1
1.2 Maputaland Centre of Endemism.....	2
1.3 Sand Forest.....	4
1.4 Rational and motivation	4
1.5 Objectives.....	6
1.6 Layout.....	7
CHAPTER 2. STUDY AREA	9
2.1 Locality.....	8
2.2 People of Maputaland.....	11
2.3 Physical environment	12
2.3.1 Topography	12
2.3.2 Climate	13
2.3.2.1 Moisture and rainfall	13
2.3.2.2 Temperature	14
2.3.2.3 Fire	14
2.3.3 Hydrology.....	14
2.3.4 Geology	15
2.3.4.1 Condensed geological history	18
<i>Gondwana records</i>	18
<i>Dune cordons</i>	19
2.3.4.2 Main formations	22
2.3.5 Sea levels.....	24
2.3.6 Soils.....	26
2.4 Vegetation and flora	27
2.4.1 Unique plant communities	28
2.4.1.1 Sand Forest or Licuáti Forest	29
2.4.1.2 Woody Grassland	30

CHAPTER 3. GENERAL METHODS.....	31
3.1 Methodological approach.....	31
3.1.1 Phytosociology	31
3.1.2 Phytosociological sampling strategy	31
3.1.3 Germination trials	32
3.1.4 Soil analyses.....	32
3.1.5 Elephant vegetation utilisation	33
3.1.6 Literature review	34
CHAPTER 4. VEGETATION OF SILEZA NATURE RESERVE AND NEIGHBORING AREAS.....	35
CHAPTER 5. VEGETATION OF TEMBE ELEPHANT PARK.....	54
CHAPTER 6. POSSIBLE ALLELOPATHIC INTERFERENCE IN SAND FOREST.....	77
CHAPTER 7. VEGETATION-ELEPHANT INTERACTION IN TEMBE ELEPHANT PARK.....	98
CHAPTER 8. SAND FOREST: CHARACTERISTICS, ECOLOGY AND HYPOTHESES ON ORIGIN.....	124
8.1 Introduction.....	124
8.2 Sand Forest characteristics	126
8.2.1 What is Sand Forest?.....	126
8.2.1.1 Distribution.....	128
8.2.1.2 Species richness and endemicy	129
8.2.1.3 Forest structure and deciduousness.....	131
8.2.1.4 Dispersal and fruit types.....	132
8.2.1.5 Rooting	133
8.2.1.6 Fauna	134
8.2.1.7 Environment.....	134
<i>Rainfall and moisture</i>	134

	<i>Temperature</i>	135
	<i>Historic</i>	136
8.2.1.8	Substrate: soil and soil moisture.....	137
	<i>Origin and age of the Sand Forest sands and sand dunes</i>	137
	<i>Soil chemistry</i>	139
8.2.1.9	Fire	141
8.2.2	Sand Forest dynamics.....	142
8.2.2.1	Succession and resilience	142
	<i>Preamble</i>	142
	<i>Colonization/secondary sites</i>	144
	<i>Vegetation acting as units or per chance groupings of species</i>	144
	<i>Lags</i>	145
	<i>Episodic</i>	146
	<i>Time aspect</i>	146
	<i>Stability and persistence</i>	147
8.2.2.2	Allelopathy	148
	<i>Density-dependence</i>	149
8.2.2.3	Gap replacements	150
	<i>How is gap fall-succession influenced by allelopathy?</i>	153
8.3	Sand Forest evolution: speculations and hypotheses	154
8.3.1	Evolution/speciation preamble.....	154
	<i>Stress (adverse environmental conditions–evolution)</i>	154
8.3.2	Hypotheses on origin of Sand Forest	156
	Guiding principles and assumptions	156
	Primary hypothesis: Sand Forest is transformed Dune Forest	157
	<i>Pointers in support of hypothesis</i>	158
	<i>Origin of the woodland and other communities</i>	159
	Arguments for/against the hypothesis	160
	Conclusion.....	164
CHAPTER 9. GENERAL DISCUSSION		172
9.1	General discussion.....	172

9.2	Reflecting on outcome of study	174
9.3	Future research	176
CHAPTER 10. MANAGEMENT IMPLICATIONS.....		179
<i>Preamble</i>		179
10.1	Maputaland.....	181
	<i>Recommendations</i>	182
10.2	Sileza Nature Reserve	182
	<i>Recommendations</i>	182
10.3	Tembe Elephant Park	183
CHAPTER 11. CONCLUSIONS.....		187
11.1	Maputaland environment and general ecology	187
11.2	Plant-soil characteristics.....	187
11.3	Phytosociology	188
11.4	Tembe Elephant Park	188
	11.4.1 Plant communities	188
	11.4.2 Floristics	189
	11.4.3 Large herbivore (elephant) impacts.....	190
11.5	Sileza Nature Reserve and surrounding areas	191
	11.5.1 Plant communities	191
	11.5.2 Floristics	191
11.6	Woody Grassland	192
11.7	Sand Forest (Licuáti Forest).....	192
11.8	Sand Forest structure	193
11.9	Environment.....	193
11.10	Dynamics.....	194
11.11	Endemicity and floristics.....	195
11.12	Fire	196
11.13	Sand Forest evolutionary history.....	196
11.14	Management.....	196
SUMMARY		197

ACKNOWLEDGEMENTS	199
CURRICULUM VITAE	200
REFERENCES	203
ANNEXURES.....	230
Annexure 1	231
Annexure 2	238
Annexure 3	254

SUMMARY

Contributions to the ecology of Maputaland, southern Africa, with emphasis on Sand Forest

by

Wayne Sidney Matthews

Promoter: Prof. Dr. A.E. van Wyk

Co-promoter: Dr. N. van Rooyen

Submitted in partial fulfilment of the requirements of the degree

Philosophiae Doctor

This study focused on aspects of the vegetation of Maputaland, an area with a rich biodiversity located in the extreme northeast of KwaZulu-Natal, South Africa, and adjacent parts of southern Mozambique. The principal hypothesis of this thesis was that the Maputaland Centre of Plant Endemism [MC] is characterised by plant communities that match a particular set of environmental variables, with a rich biodiversity including endemic and rare taxa reflecting the geomorphological history of the region. Data assembled supports the hypothesis. Vegetation studies highlighted two plant communities, both endemic to the MC, as being important components of the region's biodiversity, namely Sand Forest and Woody Grassland. Knowledge of the vegetation and flora of the MC and the role that large herbivores (specifically elephant) and fire may play in the dynamics of the different vegetation communities can help facilitate the formulation of management strategies. Notable for their richness in MC endemic/near-endemic taxa, the conservation of Sand Forest and Woody Grassland, should be a high priority.

A broad approach to the floristic classification of vegetation was adopted to address the need for information on the distribution patterns and diversity of the endemic/rare plants and plant communities of the MC. A hierarchical classification, description and ecological interpretation of the plant communities of the Tembe Elephant Park, Sileza Nature Reserve and surrounding areas are presented. The classifications resulted in mainly Sand Forest, woodland and grassland communities. Much of the vegetation distribution can be ascribed to the level of the water table, vegetation dynamics and historic evolution of the geomorphology of the region, either directly or indirectly, through its role in soil formation on the geologically young sandy substrate. Fire is an essential factor, particularly in maintaining the Woody Grassland. Geoxyllic suffrutices abound in

the Woody Grassland, raising questions about whether this vegetation type is best considered as grassland or extremely stunted savanna.

The hypothesis is presented that Sand Forest may have allelopathic effects on its environment, hence the characteristic zonation of the surrounding vegetation. Data of exploratory germination trials, as well as inorganic and organic soil analyses, are presented to test this hypothesis. Sand Forest soil inhibits the emergence of seedlings, the inhibiting effect decreasing progressively from Sand Forest through grassland to woodland.

Sand Forest was defined as a community, and its possible dynamics are described. Many biophysical factors were considered to formulate ideas (albeit largely hypothetical) on the likely origin of this vegetation type. It is proposed that ancient Dune Forest is the precursor of Sand Forest, but that Sand Forest has subsequently become a separate functioning plant community on its own. Sand forest appears to be a relictual vegetation type of which the historical factors responsible for its original establishment and expansion are currently no longer present in the region.

The use of woody species by elephant in different vegetation types in Tembe Elephant Park was investigated using a modified Point-centred Quarter sampling design. A classification of species into utilization categories was produced which enabled assessment of the importance of different species to elephants, and also of the potential impact of elephants on different tree species. Ninety of the 137 plant species encountered in the study were utilized. Thirteen species were selected for, 32 were used at random, 35 were avoided and at least nine were rejected. Management implications are highlighted.

ACKNOWLEDGEMENTS

Thanks are due to the many people who assisted in one way or another towards the completion of this work. In particular:

Prof. Braam van Wyk, my promoter, for his invaluable guidance, mentorship and helping me cope with my “writing disability”.

Dr. Noel van Rooyen, my co-promoter, for his invaluable guidance, scientific input and encouragement.

Dr Greg Botha whom was always ready to help me understand the geological and geomorphological aspects of Maputaland.

Mr Bruce Page for the nightlong coffees while debating data and issues around elephant.

Mr Rob Hattingh who’s input into ground water biochemistry was invaluable.

Dr Peter Goodman for the many challenging debates around Maputaland ecology and conservation management as a whole.

Ms Elsa van Wyk, Department of Botany, University of Pretoria, for handling the administration of this project.

The Van Rooyen Family for their hospitality and for putting up with me in the final stages of the compilation of the thesis.

Dr Berndt van Rensburg for his continued support and encouragement.

The help of Malcolm Burningham, Miranda Deutchländer, Ian Felton, Catharine Hanekom, Graham Mann, James Mitchell, Peter Neal, Ed Ostrosky, Stefan Siebert, Yolande Steenkamp, Brad Tilley and Lawrence Wahlberg is acknowledged with gratitude.

This research was supported by Ezemvelo KwaZulu-Natal Wildlife, University of Pretoria and in part by the University of KwaZulu-Natal. Richards Bay Minerals kindly assisted with some of the soil analyses.

CURRICULUM VITAE

Wayne Sidney Matthews was born in 1961 and grew up in Springs, South Africa. He received his school education there, and completed his tertiary education at the University of Pretoria. In 1988 he did his National Service, followed by an MSc, which he received with distinction. His thesis dealt with the phytosociology of the North-eastern Mountain Sourveld. In 1992 he joined the then KwaZulu Bureau of Natural Resources as a Regional Ecologist for Maputaland. This post he still holds today in the Ezemvelo KwaZulu-Natal Wildlife where he is based in Tembe Elephant Park, Maputaland. Wayne has worked as a natural history tour guide for Trialblazers and Lapalala Wilderness Trails. He has travelled widely on advisory trips (compiling plant species lists, wildlife carrying capacities, biodiversity, ecological methodologies) and is familiar with the flora and fauna of many areas, such as Transkei/Pondoland, Southern Namibia/Richtersveld, Botswana/Okavango and Kalahari, Zimbabwe highlands, Western Zambia (Kafue area) and Maputaland (northern KwaZulu-Natal/southern Mozambique). He is an avid photographer and has had many of his photographs published. A list of his publications follows:

SCIENTIFIC PUBLICATIONS

Matthews, W.S., Bredenkamp, G.J. & Van Rooyen, N. 1991. The grassland associated vegetation of the Black Reef Quartzite and associated large rocky outcrops in the North-eastern mountain sourveld of the Transvaal Escarpment. *South African Journal of Botany* 57(3): 143–150.

Matthews, W.S., Bredenkamp, G.J. & Van Rooyen, N. 1992. The vegetation of the dry dolomitic regions of the North-eastern mountain sourveld of the Transvaal escarpment, South Africa. *Phytocoenologia* 20(4): 467–488.

Matthews, W.S., Bredenkamp, G.J. & Van Rooyen, N. 1992. The phytosociology of the high altitude hygrophilous vegetation regions of the North-eastern Mountain Sourveld of the Transvaal, South Africa. *Phytocoenologia* 20(4): 489–504.

Matthews, W.S., Van Wyk, A.E. & Bredenkamp, G.J. 1993. Endemic flora of the North-eastern Transvaal Escarpment, South Africa. *Biological Conservation* 63: 83–94.

Matthews, W.S., Bredenkamp, G.J. & Van Rooyen, N. 1994. The phytosociology and syntaxonomy of the relatively low-altitude areas in the north-eastern mountain sourveld, in the eastern Transvaal escarpment region. *Koedoe* 37(2): 73–87.

Felton, I. & Matthews, W. 1997. A regional database for the mapping and analysis of plant distribution in Maputaland, KwaZulu-Natal. *Plantlife* 17: 23–25.

Matthews, W.S., Van Wyk, A.E. & Van Rooyen, N. 1999. Vegetation of the Sileza Nature reserve and neighbouring areas, South Africa, and its importance in conserving the woody grasslands of the Maputaland Centre of Endemism. *Bothalia* 29: 151–167.

Matthews, W.S., Van Wyk, A.E., Van Rooyen, N. & Botha, G.A. 2001. Vegetation of the Tembe Elephant Park, Maputaland, Northern KwaZulu-Natal, South Africa. *South African Journal of Botany* 67:573–594.

Van Rensburg, B.J., McGeoch, M.A., Matthews, W., Chown, S.L. & Van Jaarsveld, A.S. 2000. Testing generalities in the shape of patch occupancy frequency distributions. *Ecology* 81(11): 3163–3177.

Fourie, A.B., Matthews, W.S. & Hattingh, R.P. 2002. Vegetation induced variability of hydraulic characteristics of an Aeolian sand. Proceedings of the 3rd International Conference on unsaturated soils 1: 411–415, Recife, Brazil.

Van Rooyen, M.W., Theron, G.K., Van Rooyen, N., Jankowitz, W.J. and Matthews, W.S. 2003. Mysterious circles in the Namib Desert: review of hypotheses on their origin. *Journal of Arid Environments* 57: 467–485.

Van Rooyen, M.W., Tosh, C.A., Van Rooyen, N., Matthews, W.S. and Kellerman, M.J.S. 2004. Impact of harvesting and fire on *Phragmites australis* reed quality in Tembe Elephant Park, Maputaland. *Koedoe* 47(1): 1–16.

Gaugris, J.Y., Matthews, W.S., Van Rooyen, M.W. & Bothma, J. du P. 2004. The vegetation of Tshanini Game Reserve and a comparison with equivalent units in the Tembe Elephant Park in Maputaland, South Africa. *Koedoe* 47(1):9-29.

Mucina, L. & Geldenhuys, C.J. 2004. Contributions by G. Maltitz, M.C. Lötter, W. Matthews, M.C. Rutherford, L. Dobson & L.W. Powrie. Afrotropical, Subtropical and Azonal Forests. *Strelitzia* 16: 1–28.

UNPUBLISHED REPORTS

Matthews, W.S. 1995. The vegetation of the Sileza Nature Reserve and surrounding community areas, in Maputaland, northern KwaZulu-Natal. Internal report for KwaZulu Bureau of Natural Resources.

Matthews, W.S., Page, B., & Janse van Rensburg, B. 1995. The vegetation, potential for reintroduction and carrying capacities for wildlife in the Malongane concession area in southern Mozambique. Prepared for concessionaires, Mozambique.

Ostrosky, E & Matthews, W.S. 1995. The Transfrontier conservation initiatives in southern Maputo Province, Mozambique, comments on feasibility of the Futi Corridor. Prepared for Direcção Nacional de Florestas e Fauna Bravia (DNFFB), Mozambique.

Matthews, W.S. 1998. Biophysical studies and inventories chapter In: Consultancy for the preparation of a demonstration game ranch management and development plan. David Grossman & Associates. For Botswana Game Department.

Van Aarde, R., Matthews, W.S., De Boer, F., Page, B., Ntumi, C & Els, H. 1999. The restoration of the Tembe-Futi-Maputo coastal plain elephant population. Project co-ordinators For Peace Parks Foundation-Maputaland Transfrontier project.

Matthews, W.S. 2000. Assessment of the ecological integrity of selected areas in the Tshoba and Manzana systems, Vryheid. For Pulles Howard & De Lange Incorporated.

Matthews, W.S. 1992, 1993, 1994, 1995, 2000, 2002, 2003, 2004. Large herbivore population estimates for Tembe Elephant Park. Internal reports for KwaZulu-Natal Wildlife.

Matthews, W.S. 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000. Large herbivore population estimates for Ndumo Game Reserve. Internal reports for KwaZulu-Natal Wildlife.

Matthews, W.S. 2003, 2004. Large herbivore population estimates for Phongola Game Reserve. Internal reports for KwaZulu-Natal Wildlife.

Matthews, W.S. & Moffett, M. 2001. Assessment of the ecological status and sensitivity of the vegetation at the proposed new Impala Platinum mine, Burgersfort. For Pulles Howard & De Lange Incorporated.

Matthews, W.S. & Moffett, M. 2002. Second survey of the natural vegetation at the proposed new Impala Platinum mine, Burgersfort. For Pulles Howard & De Lange Incorporated.

POPULAR PUBLICATIONS AND ARTICLES

Matthews, W.S. & Bredekamp, G. 1999. Great Escarpment. In: *The Magnificent Natural Heritage of South Africa*. Johann Knobel. Sunbird publications, Cape Town.

Els, H & Matthews, W.S. 2001. Tshanini. *Wildside* 1(8). Guest Magazine of KwaZulu-Natal Wildlife.

Matthews, W.S. 2002. Tembe Lion Relocation. *Wildside* 2(4). Guest Magazine of KwaZulu-Natal Wildlife.

Hattingh, R. & Matthews, W.S. 2002. Nyamithi Pan. *Wildside* 2(5). Guest Magazine of KwaZulu-Natal Wildlife.

Matthews, W.S. & Slotow, R. 2002. Return of Lion to Tembe – Maputaland. Strategies and motives for lion re-introduction to small reserves. *Timbila*. 3(6). Penta Publication.

Matthews, W.S. & Mathenjwa, D. 2003. Monitoring Tembe's Lions. *Wildside* Vol 2. No7. Guest Magazine of KwaZulu-Natal Wildlife.