OPSOMMING

DIE EKOLOGIE EN PLANTEGROEIBESTUUR VAN DIE OLIFANTSRIVIERSISTEEM

deur

Willem Johannes Myburgh

Promotor : Prof. Dr. N. van Rooyen
Mede-promotor : Prof. Dr. G.J. Bredenkamp

Departement Plantkunde
Universiteit van Pretoria
vir die graad

PHILOSOPHIAE DOCTOR (PLANTKUNDE)

Die Olifantsrivier is die tweede grootste rivier in die voormalige Transvaal, nou bekend as die Noordelike Provinsie en Mpumalanga en is een van die mees besoedelde riviere in die streek. Die motivering van hierdie projek was onder andere om 'n breë oorsig te verkry van die huidige toestand van die makrokanaal en om impakte te identifiseer wat kan lei tot die verdere degradering van die makrokanaal en die riviersisteem as sulks.

Die primêre doelstellings van hierdie studie was die identifisering, beskrywing en kartering van die homogene plantegroei-eenhede, die identifisering van uitheemse- en indringerplante en die saamstel van bestuursaanbevelings en riglyne wat 'n bydrae sal lewer tot die effektiewe bestuur en instandhouding van die makrokanaal.

Hierdie projek het oor 'n periode van vier jaar gestrek. Floristiese- en habitatsdata is oor 'n tydperk van drie jaar by 'n totaal van 155 varieerbare strookpersele ingesamel. Dataverwerking is met behulp van die PHYTOTAB-PC rekenaarprogrampakket gedoen.

Die makrokanaal van die Olifantsrivier kan in twee breë groepe verdeel word na aanleiding van die plantegroeistruktuur met die makrokanaalbanke geassosieer naamlik die banke waar 'n houtagtige komponent afwesig of beperk is tot enkele dwergstruike (Grasveldbioom) en die banke wat gekenmerk word aan 'n ruie houtagtige komponent (Savannebioom).

'n Totaal van agt plantgemeenskappe is geïdentifiseer in die makrokanaal van die Olifantsrivier geassosieer met die Grasveldbioom. Die makrokanaal van hierdie gedeelte van die Olifantsrivier varieer van 6 meter breed met geen duidelike oewersone nie, behalwe vir enkele gras-, biesie- en pionierkruidspesies geassosieer met die waterrand, tot so breed as 32 meter met 'n duidelik gedefinieerde oewersone.

Daar is nege plantgemeenskappe in die makrokanaal van die Olifantsrivier geassosieer met die Savannebioom geïdentifiseer. Die makrokanaal varieer van 17 meter tot 210 meter breed. Die Olifantsrivier in die Laeveld is 'n goed ontwikkelde riviersisteem wat aan die teenwoordigheid van verskeie kanale, eilande en voormalige eilande, gedomineer deur houtagtige plantegroei, gekenmerk word.

Die negatiewe impak van plantspesies met die makrokanaal in die Nasionale Krugerwildtuin geassosieer is 'n ernstige bedreiging vir die biodiversiteit van hierdie areas. Die lyste van verklaarde onkruide en indringers soos gestipuleer in die wet is onvolledig en behoort hersien te word na konsultering met die relevante rolspelers en organisasies.

Na die vloede in die Olifantsriviersisteem gedurende 1996 is daar besluit om heropnames by geselekteerde persele gedurende die 1996 en 1998 groeiseisoene te doen. Die onderskeie datastelle is ge-analiseer en vergelyk om die impak van vloede op die floristiese samestelling van die makrokanaal te kwantifiseer.

Daar is aangedui dat aktiwiteite wat die stabiliserende rol van die oewerplantegroei nadelig beïnvloed bydra tot 'n verhoogde impak deur vloedwater. Hierdie studie bevestig die opportunistiese aard van sommige uitheemse plantspesies wat 'n merkbare toename in gemiddelde kroonbedekkings en konstanthede na afloop van die vloede getoon het.

Die belangrikste impakte in die makrokanaal en omliggende areas word deur die mynbou-, industriële- en landbousektore veroorsaak. Hierdie impakte is aan die hand van huidige

omgewingswetgewing ge-evalueer om vas te stel of enige van hierdie impakte 'n oortreding van die wet is. Die bevindinge en bestuursaanbevelings wat voortspruit uit hierdie projek verskaf 'n wetenskaplik gefundeerde basis vir die bestuur van die makrokanaal van die Olifantsriviersisteem.

SUMMARY

THE ECOLOGY AND VEGETATION MANAGEMENT OF THE OLIFANTS RIVER SYSTEM

by

Willem Johannes Myburgh

Promoter : Prof. Dr. N. van Rooyen
Co-promoter : Prof. Dr. G.J. Bredenkamp

Department of Botany
University of Pretoria
for the degree

PHILOSOPHIAE DOCTOR (BOTANY)

The Olifants River is the second largest river in the former Transvaal (now the Northern Province and Mpumalanga) and is regarded as one of the most polluted rivers in the region. The initiation of this project was *inter alia* an attempt to obtain a holistic perspective of the current state of the macro channel and to identify the impacts that could lead to the further degradation of the macro channel and the river system itself.

The primary objectives of this study were to identify and describe the homogeneous vegetation units, to map these vegetation units, to identify exotic and invader plants and provide management recommendations and guidelines that will contribute to the effective management and maintenance of the macro channel.

This project was conducted over a period of four years. A total of 155 variable length transect sample plots were used to record floristic and habitat data over a period of three years. The data were processed using the PHYTOTAB-PC computer program package. The macro channel of the Olifants River can broadly be divided into two types according to the structure of the vegetation associated with the macro channel banks namely the banks where woody

cover is absent or restricted to a few dwarf shrubs (Grassland Biome) and the banks characterized by a dense woody component (Savanna Biome).

A total of eight plant communities were identified in the macro channel of the Olifant River associated with the Grassland Biome. The macro channel of this portion of the Olifants River varied from a mere 6 metres with no distinct riparian zone, with the exception of a few grass- sedge- and pioneer forb species directly bordering the water edge to 32 metres with a well defined riparian zone.

Nine plant communities were identified in the macro channel of the Olifants River associated with the Savanna Biome. The macro channel of the Olifants River varied from 17 metres up to 210 metres wide. The Olifants River in the Lowveld is a mature well developed river system characterized by various channels, islands and former islands dominated by woody species.

The negative impact of exotic plant species associated with the macro channel within the Kruger National Park poses a serious threat to the biodiversity of this area. The lists of declared weeds and invaders as stipulated in the law are incomplete and should be revised after consultation with the relevant role players and organizations.

Floods that occurred in the Olifants River during 1996 lead to the decision to resample sites that had been sampled during the 1995 season as well as during the 1998 season and to compare these sites to quantify the impact of the floods on the floristic composition of the macro channel.

This study indicates that activities that cause the destabilization of the riparian vegetation lead to an increase in the impact of floods. An increase in the average crown cover and constancy of certain exotic plant species after flooding had occurred, confirms the opportunistic nature of these species.

The most significant impacts recorded within the macro channel and the adjacent land are due to activities of the mining, industrial and agricultural sectors. These impacts were evaluated against current relevant environmental legislation to determine whether any of these

activities transgressed the law. The findings and management recommendations provide a sound scientific basis for the management of the macro channel of the Olifants River System.

BEDANKINGS

Graag wil ek die volgende persone en instansies bedank vir hulp en bystand wat hulle gelewer het gedurende hierdie studie :

- Prof. N. van Rooyen en prof. G.J. Bredenkamp vir hulle bekwame leiding, aanmoediging en positiewe kritiek.

- Die Waternavorsingskommissie (WNK) vir finansiering van hierdie navorsingsprojek asook vir toestemming om die resultate aan te wend vir verdere studie.

- Dr. G.R. Backeberg vir die professionele wyse waarop navrae en probleme onder sy aandag gebring, hanteer is.

- Lede van die loodskommitee aangewys deur die WNK vir insette gelewer – in die besonder vir Prof. C. Breen vir belangstelling, kommentaar en aanbevelings.

- Mnr'e H.J. Vermeulen, M.D. Panagos en P. Michau vir opoffering tydens hulpverlening gedurende die veldwerkfase van hierdie projek. Hierdie persone was soms vir lang tydperke aaneen in die veld weg van hul huise, vriende en familie.

- Mev. J. Schaap vir die natrek, voorbereiding en finalisering van die grafieka vir die projek.

- Mnr. J.M. van Staden van LNR-Enviro vir insette gelewer ten opsigte van omgewingsbestuursaspekte en die beskikbaarstelling van nuwe en gewysigde relevante Omgewingswetgewing en Wetsontwerpe.

- IGS-biblioteek vir die doeltreffende wyse waarop literatuur navrae en soektogte uitgevoer is.

- Dr. R.H. Westfall vir die nodige wysigings aangebring aan die programpakket gebruik vir die ontleding van die data asook die opgradering van rekenaarfasiliteite ten einde die verslag te kan saamstel.

- Mev. D. Argo van die Insituut vir Grond, Klimaat en Water vir die vriendelike wyse waarop sy klimaatsdata vanaf die Agromet-databasis verskaf het.

- Me J. Minisi van die Roodeplaat Herbarium vir die hantering en montering van die planteksemplare versamel as verwysingseksemplare gedurende hierdie studie.

- Departement van Waterwese en Bosbou vir die beskikbaarstelling van data ten opsigte van damkapasiteite in die Olifantsriviersisteem en vloedpieke gedurende en direk na afloop van die vloede gedurende 1996. Die beskikbaarstelling van die onderskeie volumes van die verslag "Water Resources Planning of the Olifants River Basin"

- Mnr. Dries Visser van Bohlweki Environmental Pty(Ltd.) vir die insette en aanbevelings ten opsigte van Omgewingswetgewings- en bestuursaspekte na verwys in die projek.

- Mnr. E. Dollar vir insette gelewer ten opsigte van die geomorfologie van die Olifantsriviersisteem.

- Die Landbounavorsingsraad vir finansiële steun en in die besonder Dr. A. Aucamp vir die nodige motivering en reëlings ten opsigte van 'n studiebeurs.

- Ek wil ook my ouers en skoonouers bedank vir aanmoediging en belangstelling.

- Marietha, ek is baie dank verskuldig aan jou vir opoffering, geduld en enkel ouer wees, veral tydens die veldwerkfase van hierdie studie.

- Laastens wil ek my dank betuig teenoor my Hemelse Vader, sonder wie se beskermende hand en hulp hierdie studie nie 'n sukses kon wees nie.

CURRICULUM VITAE

Willem Johannes Myburgh is op 28 Desember te Bloemfontein, Oranje Vrystaat gebore. Hy voltooi sy hoërskool opleiding in 1982 aan die Hoërskool Driehoek in Vanderbijlpark waarna hy sy Nasionale Diensplig in 1984 voltooi.

In 1985 registreer hy as student aan die Universiteit van Pretoria. Die B.Sc-graad met Plantkunde en Dierkunde as hoofvakke word aan die einde van 1987 aan hom toegeken. In 1988 aanvaar hy 'n betrekking as Landbounavorsingstegnikus by die Navorsingsinstituut vir Plantkunde en vanaf 1989 by die Navorsingsentrum vir Weiding. Hy is tans werksaam by die Landbounavorsingsraad-Veld en Weidingsinstituut. In 1989 registreer hy vir die B.Sc Hons-graad (deeltyds) wat aan die einde van 1990 met lof behaal word.

Hy registreer in 1991 vir die graad M.Sc.-Plantkunde met spesialisering in plantekologie wat in 1993 met lof toegeken word. Verskeie kursusse in omgewingsbestuur word suksesvol voltooi gedurende 1997 en 1998 aan die Potchefstroomse Universiteit vir Christelike Hoër Onderwys. In 1997 registreer hy vir die graad P.hd.-Plantkunde (plantekologie) aan die Universiteit van Pretoria. Na 10 jaar diens is hy outeur en/of mede-outeur van 9 wetenskaplike en verskeie populêre artikels

LITERATUURVERWYSINGS

ACOCKS, J.P.H. 1976. Riverine vegetation of the semi-arid and arid regions of South Africa. *Journal of the South African Biological Society* 17:21-35.

ACOCKS, J.P.H. 1988. Veld types of Southern Africa. (3rd. ed.) *Memoirs of the Botanical Survey of South Africa* 57:1-146.

AGROMET DATABASIS 1995. LNR - Instituut vir Grond, Klimaat en Water, P/S X79, Pretoria, 0001.

ALLANSON, B.R. 1995. An introduction to the management of inland water ecosystems in South Africa. WNK verslag TT 72/95:60-74. Waternavorsingskommissie, Posbus 824, Pretoria, 0001.

ANONIEM 1988. Hulpbronidentifikasie en Benuttingskursus. Departement van Landbou en Watervoorsiening, Hoëveldstreek, Potchefstroom.

ARTHINGTON, A.H. 1991. An evaluation of the Kruger National Park Rivers Research Programme. Report to Coordinating Committee for the Kruger National Park Rivers Research Programme. Nasionale Parkeraad, Skukuza.

BARKMAN, J.J., MORAVEC, J. & RAUSCHERT, S. 1986. Code of phytosociological nomenclature. *Vegetatio* 67 (3): 145-197.

BARNARD, D. 1997. Notes on Environmental Law. Ongepubliseerde notas, Potchefstroomse Universiteit vir C.H.O., Potchefstroom.

BEHR, C.M. & BREDENKAMP, G.J. 1988. A phytosociological classification of the Witwatersrand Botanical Garden. *South African Journal of Botany* 54:525-533.

BELL, D.T. 1974. Tree stratum composition and distribution in a streamside forest. *Am. Midl. Nat.* 92:35-46.

BELL, D.T. & DEL MORAL, R. 1977. Vegetation gradients in the stream-side forest of Hickory Creek, Will County, Illinois. Bulletin of the Torrey Botanical club. 104:127-135.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivieropvang-gebied, Transvaal. M.Sc.-verhandeling, Potchefstroomse Universiteit vir C.H.O., Potchefstroom.

BLOEM, K.J. 1988. 'n Plantsosiologiese studie van die Verlorenvaleinatuurreservaat, Transvaal. M.Sc.-verhandeling, Universiteit van Pretoria, Pretoria.

BOWMAN, D.M.J.S. & MCDONOUGH, L. 1991. Tree species distribution across a seasonally flooded elevation gradient in a Australian monsoon tropics. *Journal of Biogeography* 18:203-212.

BRADLEY, C.E. & SMITH D.G. 1986. Plains cottonwood recruitment and survival on a prairie meandering river floodplain, Milk river, southern Alberta and northern Montana. *Canadian Journal of Botany* 64:1433-1442.

BREDENKAMP, G.J. 1975. 'n Plantsosiologiese studie van die Suikerbosrand-natuurreservaat. M.Sc.-verhandeling, Universiteit van Pretoria, Pretoria.

BREDENKAMP, G.J. 1982. 'n Plantekologiese studie van die Manyeleti-wildtuin. D.Sc.-proefskrif, Universiteit van Pretoria, Pretoria.

BREDENKAMP, G.J. & THERON G.K. 1980a. A synecological account of the Suiker-bosrand Nature Reserve. 1. The phytosociology of the Witwatersrand geological system. *Bothalia* 12:513-529.

BREDENKAMP, G.J. & THERON G.K. 1980b. A synecological account of the Suiker-bosrand Nature Reserve. 2. The phytosociology of the Ventersdorp geological system. *Bothalia* 13:199-216.

BREDENKAMP, G.J. & VAN ROOYEN, N. 1991. A survey of the riparian vegetation of the Sabie River in the Kruger National Park. Unpublished report to FRD. Ekotrust.

BREDENKAMP, G.J. & VAN ROOYEN, N. 1993. A survey of the vegetation of the Olifants River in the Kruger National Park. Unpublished report to FRD. Ekotrust.

BREYTENBACH, P.J.J. 1991. Die fitososiologie van die Villiers- Grootvlei-omgewing. M.Sc.-verhandeling, Universiteit van Pretoria, Pretoria.

CAIN, S.A. & CASTRO, G.M. DE O. 1959. Manual of vegetation analysis. Harper, New York.

CARBIENER, R. & SCHNITZIER, A. 1990. Evolution of major pattern models and processes of alluvial forest of the Rhine in the rift valley (France/Germany). *Vegetatio* 88:115-129.

CHUTTER, F.M. 1973. An ecological account of the past and the future of South African rivers. *Newsletter of the Limnological Society of South Africa*. 21:22-34.

CLARKE, J. 1991. Back to Earth – South Africa's environmental challenges. Nasionale Drukker, Kaapstad.

COETZEE, B.R. 1972. 'n Plantsosiologiese studie van die Jack Scott-Natuurreservaat. M.Sc.-verhandeling, Universiteit van Pretoria, Pretoria.

COETZEE, B.J. & WERGER, M.J.A. 1973. On hierarchical syndrome analysis and the Zurich-Montpellier table method. *Bothalia* 11:159-164.

COETZEE, P.J. 1993. Phytosociology of the Ba and Ib land types in the Pretoria-Witbank-Heidelberg area. M.Sc.-verhandeling, Universiteit van Pretoria, Pretoria.

DAUBENMIRE, R. 1968. Plant Communities. A textbook of plant synecology. New York : Harper & Row.

DAVIES, B.R., O'KEEFFE, J.H. & SNADDON, C.D. 1993. A synthesis of the ecological functioning, conservation and management of South African river ecosystems. WNK Verslag No TT62/93. Waternavorsingskommissie, Posbus 824, Pretoria, 0001.

DEALL, G.B. 985. A plant-ecological study of the Eastern Transvaal escarpment in the Sabie area. M.Sc. - verhandeling, Universiteit van Pretoria, Pretoria.

DEPARTEMENT VAN MINERAAL EN ENERGIESAKE 1978a. 1:250 000 2528 Pretoria Geologiese kaart. Staatsdrukker, Pretoria.

DEPARTEMENT VAN MINERAAL EN ENERGIESAKE 1978b. 1:250 000 2428 Nylstroom Geologiese kaart. Staatsdrukker, Pretoria.

DEPARTEMENT VAN MINERAAL EN ENERGIESAKE 1986a. 1:250 000 2628 Oos Rand Geologiese kaart. Staatsdrukker, Pretoria.

DEPARTEMENT VAN MINERAAL EN ENERGIESAKE 1986b. 1:250 000 2428 Pilgrim's Rest Geologiese kaart. Staatsdrukker, Pretoria.

DEPARTEMENT VAN WATERWESE EN BOSBOU 1992. Water for managing the natural environment. Voorlopige verslag. Departement van Waterwese en Bosbou, P/S X313, Pretoria, 0001.

DEPARTEMENT VAN WATERWESE 1986. Bestuur van die Waterhulpbronne van die Republiek van Suid-Afrika. CTP Boekdrukkers, Kaapstad - namens die Staatsdrukker, Pretoria.

DEPARTEMENT VAN WATERWESE 1991a. Water resources planning of the Olifantsriver River Basin - study of development potential and management of the water resources. Vol 2. Departement van Waterwese en Bosbou, P/S X 313, Pretoria, 0001.

DEPARTEMENT VAN WATERWESE 1991b. Water resources planning of the Olifantsriver River Basin - study of development potential and management of the water resources. Vol 1. Departement van Waterwese en Bosbou, P/S X 313, Pretoria, 0001.

DEPARTEMENT VAN WATERWESE 1991c. Water resources planning of the Olifantsriver River Basin - study of development potential and management of the water

resources. Annexure 4 Part 2:2. Departement van Waterwese en Bosbou, P/S X 313, Pretoria, 0001.

DEPARTEMENT VAN WATERWESE 1991d. Water resources planning of the Olifantsriver River Basin - study of development potential and management of the water resources. Annexure 12:10. Departement van Waterwese en Bosbou, P/S X 313, Pretoria, 0001.

DEPARTEMENT VAN WATERWESE 1991e. Water resources planning of the Olifantsriver River Basin - study of development potential and management of the water resources. Annexure 20:30-34. Departement van Waterwese en Bosbou, P/S X 313, Pretoria, 0001.

DEPARTEMENT VAN WATERWESE 1991f. Water resources planning of the Olifantsriver River Basin - study of development potential and management of the water resources. Annexure 1:3-5. Departement van Waterwese en Bosbou, P/S X 313, Pretoria, 0001.

DEPARTEMENT VAN WATERWESE 1991g. Water resources planning of the Olifantsriver River Basin - study of development potential and management of the water resources. Annexure 2:51-52. Departement van Waterwese en Bosbou, P/S X 313, Pretoria, 0001.

EDWARDS, D. 1983. A broad-scale structural classification of vegetation for practical purposes. *Bothalia* 14:705-712.

ELLENBERG, H. 1963. Vegetation Mitteleuropas mit den Alpen. Eugen Ulmer, Stutgart, Germany.

ENPAT 1997. Environmental Potential Atlas, Departement van Omgewingsake en Toerisme, P/S X447, Pretoria, 0001.

ERASMUS, D.J., MEINHARDT, H.R. & CLOETE, M.M. 1995. Investigation into the alleged herbicide damage and environmental impact in the Limpopo Valley east of Messina. Finale Verslag. LNR - Navorsingsinstituut vir Plantbeskerming, P/S X134, Pretoria, 0001.

FRIEDEL, M.H. & SHAW, K. 1987. Evaluation of methods for monitoring sparse patterned vegetation in arid rangelands I. Herbage. *Journal of Environmental Management* 25:297-308.

FRD, 1990. Characteristics and dynamics of the riparian zones of the Kruger National Park rivers : A research approach. NRF, Posbus 2600, Pretoria, 0001.

FURNESS, H.D. & BREEN, C.M. 1980. The vegetation of seasonally flooded areas of the Pongolo River Floodplain. *Bothalia* 13(1&2):217-231.

FRYE, R.J. & QUINN, J.A. 1979. Forest development in relation to topography and soils on a floodplain of the Raritan River, New Jersey. Bulletin of the Torrey Botanical club. 106(4):334-345.

GERTENBACH, W.P.D. 1987. 'n Ekologiese studie van die suidelikste Mopanieveld in die Nasionale Krugerwildtuin. D.Sc.-proefskrif, Universiteit van Pretoria, Pretoria.

GODMAN, A. & PAYNE, E.M.F. 1979. Longman dictionary of scientific usage. : Longman publishers, London.

GOODALL, D.W. 1953. Objective methods for classification of vegetation. 1. The use of positive interspecific correlation. *Australian Journal of Botany* 1:39-63.

GOSZ, J.R. 1991. Fundmental ecological characteristics of landscape boundaries in management and restoration of changeing environments (Ed. by M.J. Holland; P.G. Risser & R.J. Naiman) pp 8-29. Routledge, Chapman and Hall, Inc, U.S.A.

GRUNOW, J. O. 1965. Objective classification of plant communities -a synecological study in the sour-mixed bushveld of Transvaal. D.Sc. (Agric.)-proefskrif, Universiteit van Pretoria, Pretoria.

GRUNOW, J.O. & LANCE, G.N. 1969. Classification of savanna by information analysis. *South African Journal of Science* 65:341-348.

HACK, J.T. & GOODLET, J.C. 1960. Geomorphology and forest ecology of a mountain region in the Central Appalachians. United States Geological Survey Professional Paper 347.

HANSON, H.C. 1962. Dictionary of ecology. New York: Philosophical Library.

HAWKES, H.A. 1975. River Zonation and Classification, in : Whitton, B.A. (Ed), River Ecology, Blackwell, London, 312-374.

HENDERSON, L. & MUSIL, K.J. 1987. Indringerplante van die Transvaal. Bulletin 412. Departement van Landbou en Watervoorsiening, Staatsdrukker, Pretoria.

HENDERSON, M., FOURIE, D.M.C., WELLS, M.J. & HENDERSON, L. 1987. Verklaarde onkruide en uitheemse indringerplante in Suid-Afrika. Bulletin 413. Departement van Landbou en Watervoorsiening, Staatsdrukker, Pretoria.

HERITAGE, G.L., VAN NIEKERK, A.W., MOON, B.P., BROADHURST, L.J., RODGERS, K.H., JAMES, C.S. 1997. The geomorphological response to changing flow regimes of the Sabie and Letaba River Systems. WNK Verslag No 376/1/97, . Waternavorsingskommissie, Posbus 824, Pretoria, 0001.

HILL, M.O. 1979b. TWINSPAN: A FORTRAN programme for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Department of Ecology and Systematics, Cornell University. Ithaca, New York.

HUPP, C.R. 1982. Stream-grade variation and riparian-forest ecology along Passage Creek, Virginia. Bulletin of the Torrey Botanical Club 109(4):488-488.

HUPP, C.R. 1983. Vegetation pattern on channel features in the Passage Creek gorge, Virginia. *Castanea* 48:62-72.

HUPP, C.R. & OSTERKAMP, W.R. 1985. Bottomland vegetation distribution along Passage Creek, Virginia, in relation to fluvial landforms. *Ecology*, 66(3): 670-681.

HUPP, C.R. 1986. Upstream variation in bottomland vegetation patterns, northwestern Virginia. Bulletin of the Torrey Botanical Club 113(4):421-430.

HUPP, C.R. 1988. Plant ecological aspects of flood geomorphology and paleo flood history. Flood Geomorphology (Ed. By V. Baker, R. Kochel & P. Patton) pp 335-356. John Wiley and Sons Ltd., New York, USA.

JOHNSON, W.C., BURGESS, R.L. & KEAMMERER, W.R. 1976. Forest overstory vegetation and environment on the Missouri River Floodplain in North Dacota. *Ecol. Monogr.* 46:59-84.

JONES, R.H., SHARITZ, R.R. & MCLEAD, K.W. 1989. Effects of flooding and root competition on growth of shaded bottomland hardwood seedlings. *American Midland Naturalist* 121:165-175.

KING, J.M., DAY, J.A., DAVIES, B.R. & HENSHALL-HOWARD, M.P. 1987. Particulate organic matter in a mountain stream in the south-western Cape, South Africa. *Hydrobiologia* 154:165-187.

KIRKBY, J., O'KEEFE, P. & TIMERLAKE, L. 1995. Sustainable development. Earthscan Publications, London.

KLEYNHANS, C.J. 1992. There was a river.... *Fauna & Flora* No 48:2-14. Transvaal Hoofdirektoraat van Natuur- en Omgewingsbewaring, Pretoria.

KLEYNHANS, C.J. & HILL, L. 1998. A preliminary ecoregion classification system for South Africa. Ongepubliseerde verslag. Departement van Waterwese en Bosbou, P/S X313, Pretoria, 0001.

KOOIJ, M.S. 1990. A phytososiological survey of the vegetation of the north western Orange Free State. M.Sc.-verhandeling, Universiteit van Pretoria, Pretoria.

KOVALCHIK, B.L. & CHITWOOD, L.A. 1990. Use of geomorphology in the classification of riparian plant associations in mountainous landscapes of central Oregon, U.S.A. *Forest Ecology and Management*, 33/34:405-418.

KRUGER, J.A. 1971. 'n Ekologiese ondersoek van die plantegroei van die plaas Somerville 53 en omgewing (Dist. Ventersdorp), met besondere aandag aan die bodemkundige aspek. M.Sc. - verhandeling, Potchefstroomse Universiteit vir C.H.O., Potchefstroom.

LANDTIPE-OPNAMEPERSONEEL 1988. Landtipes van die kaarte 2426 Thabazimbi en 2428 Nylstroom. *Memoir van die Natuurlike Landbouhulpbronne van Suid-Afrika* No 10. Departement van Landbou en Watervoorsiening, Staatsdrukker, Pretoria.

LANDTIPE-OPNAMEPERSONEEL 1985. Landtipes van die kaarte 2628 Oos Rand en 2630 Mbabane. *Memoir van die Natuurlike Landbouhulpbronne van Suid-Afrika* No 5. Departement van Landbou en Watervoorsiening, Staatsdrukker, Pretoria.

LANDTIPE-OPNAMEPERSONEEL 1987. Landtipes van die kaarte 2526 Rustenburg en 2528 Pretoria. *Memoir van die Natuurlike Landbouhulpbronne van Suid-Afrika*. No 5. Departement van Landbou en Watervoorsiening, Staatsdrukker, Pretoria.

LANDTIPE-OPNAMEPERSONEEL 1989. Landtipes van die kaarte 2330 Tzaneen en 2430 Pilgrim's Rest. *Memoir van die Natuurlike Landbouhulpbronne van Suid-Afrika*. No 5. Departement van Landbou en Watervoorsiening, Staatsdrukker, Pretoria.

LANDTIPEREEKS 1985a. Landtipekaart 2628 Oos Rand (1:250 000). Staatsdrukker, Pretoria.

LANDTIPEREEKS 1985b. Landtipekaart 2528 Pretoria (1:250 000). Staatsdrukker, Pretoria.

LANDTIPEREEKS 1986. Landtipekaart 2430 Pilgrim's Rest (1: 250 000). Staatsdrukker, Pretoria.

LANDTIPEREEKS 1987. Landtipekaart 2428 Nylstroom (1:250 000). Staatsdrukker, Pretoria.

LOUW, W.J. 1951. An ecological account of the vegetation of the Potchefstroom area. *Memoirs of the Botanical Survey of South Africa*. 24:1-150. Staatsdrukker, Pretoria.

LOW, A.B. & REBELO, T.G. 1996. Vegetation of South Africa, Lesotho and Swaziland. Departement van Omgewingsake en Toerisme, P/S X447, Pretoria, 0001.

LOXTON, R.F. 1966. A simplified soil survey procedure for farm planning. *Scientific Bulletin of the Department of Agricultural Technical Services* 383. Staatsdrukker, Pretoria.

MACAN, T.T. 1961. A review of running water studies. *Verh. Int. Verin. Theor. Angew. Limnol.* 14, 587-602.

MACDONOLD, R.J.; SCOTT, W.E., HATTING, W.H.J., KEMPSTER, P.L., SARTORY, D.P., TOERIEN, D.F., VAN VLIET, H.R. & VILJOEN, H.C. 1984. Pollutants. In: Hart, R.C. & Allanson, B.R. (eds). Limnological criteria for management of water quality in the Southern Hemisphere. *South African National Scientific Programmes Report* No 93:64-85. WNNR, Pretoria.

MACVICAR, C.N., LOXTON, R.F., LAMBRECHTS, J.J.N., LE ROUX, J., DE VILLIERS, J.M., VERSTER, E., MERRYWEATHER, F.R., VAN ROOYEN, T.H. & VON M. HARMSE, H.J. 1977. Grondklassifikasie, 'n Binomiese sisteem vir Suid-Afrika. Departement Landboutegniesedienste, Pretoria.

McBRIDE, J.R. & STRAHAN, J. 1984. Fluvial processes and woodland succession along Dry Creek, Sanoma County, California. California Riparian Systems (Ed. by R. Warner & K. Hendrix) pp 110-119. University of California Press, Berkley, USA.

MENTIS, M.T. 1981. Evaluation of the wheel-point and step-point methods of veld condition assessment. *Proceedings of the Grassland Society of Southern Africa* 16:89-94.

MENTIS ,M.T. 1982. A simulation of the grazing of sour grassveld. Phd.-proefskrif, Universiteit van Natal, Pietermaritzburg.

MENTIS, M.T. , COLLINSON, R.F.H. & WRIGHT, M.G. 1980. The precision of assessing components of the condition of Moist Tall Grassveld.. *Proceedings of the Grassland Society of Southern Africa* 15:43-46.

MOON, B.P., VAN NIEKERK, A.W., HERITAGE, G.L., ROGERS, K.H. & JAMES, C.S. 1997. A geomorphological approach to ecological management of rivers in the Kruger National Park : a case study of the Sabie River. *Trans. Inst. Br. Geogr.*, N.S. 22:31-48.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation ecology. New York: John Wiley & sons.

MYBURGH, R.M. 1998. Response of tomatoes (*Lycopersicon esculentum* Mill.) to three photosynthesis – inhibiting herbicides. M.Sc.-verhandeling, Universiteit van Pretoria, Pretoria.

MYBURGH, W.J., BREYTENBACH, P.J.J., THERON, G.K. & BREDENKAMP, G.J. 1992. Die fitososiologie van die Bankenveld in die Grootvlei-omgewing, Suid-Transvaal. *Bothalia* 22(2):245-254.

MYBURGH, W.J. 1993. Die fitososiologie van die suurgrasveld en ander plantegroei in die suid-transvaalse Hoëveld. M.Sc. -verhandeling, Universiteit van Pretoria, Pretoria.

MYBURGH, W.J. & VERMEULEN, H.J. 1995. Oewerplantegroei van die Olifantsrivier in Transvaal se funksie ondersoek. *S.A. Waterbulletin* Vol 21(5):18-20.

NAIMAN, R.J., DECAMPS, H., PASTOR, J. & JOHNSTON, A.C. 1988. The potential importance of boundaries to fluvial ecosystems. *Journal of the North American Benthological Society* 7:289-306.

NAIMAN, R.J. LONZARICH, D.G., BECCHIE, T.J. & RALPH, S.C. 1990. Stream classification and the assessment of conservation potential in : P.J. Boon., P. Calow. And G.E. Petss (Eds). River conservation and Management, Wiley, Chichester, 93-123.

NILLSON, C., EKBLAD, A., DYNESIUS, M., BACKE, S., GARDFJELL, M., CARLBERG, B., HELLQVIST, S., & JANSSON, R. 1994. A comparison of species richness and traits of riparian plants between a main river channel and its tributaries. *Journal of Ecology* 82:281-295.

NOBLE, R.E. & MURPHY, P.K. 1975. Short term effects of prolonged backwater floodinon understory vegetation. *Castanea*. 40:228-238.

NOBLE, R.G. & HEMENS, J. 1978. Inland water ecosystems in South Africa - a review of research needs. *South African National Scientific Programmes Report* No 34. WNNR, Pretoria.

NRCS 1995. Riparian forest buffer. Natural Resources Conservation Service – Conservation Practice Standard, Code 391. USA.

ODUM, E.P. 1971. Fundamentals of ecology. Saunders, Philadelphia.

O'KEEFFE, J.H.O. 1986a. The concervation of South African Rivers. *South African National Scientific Programmes Report* No 131. WNNR, Pretoria.

O'KEEFFE J.H.O. 1986b. Ecological research on South African rivers - a preliminary synthesis. *South African National Scientific Programmes Report* No 121. WNNR, Pretoria.

O'KEEFFE, J.H.O. 1989. Conserving Rivers in Southern Africa. *Biological Conservation* 49:255-274.

OLIFANTS RIVER FORUM 1995. Save water - or face wars. On Track October/November pp 60-61, Penta Publications, Sandton.

OMERNIK, J.M. 1987. Ecoregions of the conterminous United States. *Annals of the Association of American Geographers* 77:118-125.

OWEN, O.S. & CHIRAS, D.D. 1995. Natural resource conservation management for a sustainable future. Prentice-Hall Inc., Englewood Cliffs, New Jersey.

PANAGOS, M.D. 1995. A comparitive classification of the Sourish-Mixed Bushveld on the farm Roodeplaat (293 JR) using Quadrat and Point methods. M.Sc.-verhandeling, Universiteit van Natal, Pietermaritzburg.

ROBERTS, B.R. 1966. The ecology of Thaba Nchu. A statistical study of the vegetation/habitat relationships. D.Sc.(Agric)-proefskrif. Universiteit van Natal, Pietermaritzburg.

RODGERS, K.H. & VAN DER ZEL, D.W. 1989. Water quality requirements of riparian vegetation and floodplains. Ecological flow requirements for South African rivers (Ed. by A.A. Ferrar) pp 94-108. Pretoria, South Africa.

ROGERS, K.H. & BESTBIER, R. 1997. Development of a protocol for the definition of the desired state of riverine systems in South Africa. Departement van Omgewingsake en Toerisme, P/S X447, Pretoria, 0001.

ROOSEBOOM, A., WHYTE, I., GERTENBACH, W., WHITFIELD, T., ENGELBRECHT, J., THERON, C., ASHTON, P., DU TOIT, P., STRAUS, V., THERON, T. & PULLEN, R. 1987. Olifants River water requirements. Workshop on water requirements for ecological systems. Nasionale Parkeraad, Skukuza,.

ROWNTREE, K. 1991. An assessment of the of the potential impact of alien invasive vegetation on the geomorphology of river channels in South Africa. *South African Journal of Aquatic Sciences* 17:28-43.

ROWNTREE, K.M. & WADESON, R.A. 1998. A hierarchical geomorphological model for the classification of selected South African Rivers. Finale Verslag, Waternavorsings-kommissie, Posbus 824, Pretoria, 0001.

RUTHERFORD, M.C. & WESTFALL, R.H. 1986. Biomes of Southern Africa - an objective catagorization. *Memoirs of the Botanical Survey of South Africa* 54:45-65. Staatsdrukker, Pretoria.

RUSSEL, I.A. 1987. River classification - Kruger National Park. Ongepubliseerde verslag. Nasionale Parkeraad, Skukuza.

SCHEEPERS, J.C. 1969. A preliminary assessment of assosiation- analysis in the Kroonstad area. *Proceedings of the Grassland Society of Southern Africa* 4:78-83.

SCHEEPERS, J.C. 1978. Vegetation of Westfalia on the North Eastern Transvaal Escarpment. *Memoirs of the Botanical Survey of South Africa* 42:1-230. Staatsdrukker, Pretoria.

SCHULZE, B.R. 1965. Klimaat van Suid-Afrika : Algemene oorsig, WB 28. Staatsdrukker, Pretoria.

SCHULZE, B.R. 1984. Klimaat van Suid-Afrika : Deel 8. Algemene oorsig, WB 28. Staatsdrukker, Pretoria.

SCHULZE, R.E. & McGEE, O.S. 1978. Climatic indices and classification in relation to the biogeography of Southern Africa. In: Biogeography and ecology of Southern Africa, Werger, M.J.A. (red) pp 19-52. Dr. W. Junk Publishers, Den Haag.

SIGAFOOS, R.S. 1961. Vegetation in relation to flood frequency near Washington, D.C. United States Geological Survey Professional Paper. 424(c): 248-249.

SMIT, R.L. 1974. Ecology and field biology. New York : Harper & Row.

SNYMAN, H.A. & OPPERMAN, D.P.J. 1984. Afloopstudies vanaf natuurlike veld in verskillende suksessiestadia van die sentrale Oranje-Vrystaat. *Tydskrif van die Weidingsvereniging van Suid-Afrika* 1(4):11-15.

SNYMAN, H.A. & VAN RENSBURG, W.L.J. 1986. Effect of slope and plant cover on runn-off, soil loss and water use efficiency of natural veld. *Journal of the Grassland Society of Southern Africa* 3(4):153-158.

STRAHLER, A.N. 1975. Physical geography. John Willey and Sons, Inc., New York

TAYLOR, H.C. 1969. A vegetation survey of the Cape of Good Hope Nature Reserve. M.Sc.-verhandeling, Universiteit van Kaapstad, Kaapstad.

THOMSON, M. 1996. A standard land-cover classification scheme for remote-sensing applications in South Africa. *South African Journal of Science* 92:34-42.

TIDMARSH, C.E.M. & HAVENGA, C.M. 1955. The wheel-point method of survey and measurement of semi-open grasslands and Karoo vegetation in South Africa. *Memoirs of the Botanical Survey of South Africa* 29.

TOWNSEND, C.R. 1989. The patch dynamics concept of stream community ecology. *Journal of the North American Benthological Society*. 8: 36-50.

TURNER, B.J. 1989. A phytosociological study of the south-eastern Transvaal Highveld grasslands. M.Sc.-verhandeling, Universiteit van Pretoria, Pretoria.

VAN COLLER, A.L. 1992. Riparian vegetation of the Sabie River: relating spatial distribution patterns to the physical environment. M.Sc. -verhandeling, Universiteit van die Witwatersrand, Johannesburg.

VAN VUUREN, D.R.J. 1961. 'n Ekologiese studie van die plantegroei van 'n noordelike en suidelike kloof van die Magaliesberge. M.Sc. -verhandeling, Universiteit van Pretoria, Pretoria.

VANNOTE, R.L., MINSHALL, G.W., CUMMINS, K.W., SEDELL, J.R. & CUSHING, C.E. 1980. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences* 37:130-137.

VAN ROOYEN, N. 1978. 'n Ekologiese studie van die plantgemeenskappe van die Punda-Milia-Pafuri-Wambiyagebied in die Nasionale Krugerwildtuin. M.Sc.-verhandeling, Universiteit van Pretoria, Pretoria.

VAN STADEN, J.M. 1991. Die fitososiologie van die Steenbokpan omgewing in die noordwes-Transvaal. M.Sc. -verhandeling, Universiteit van Pretoria, Pretoria.

VAN WYK, B. & MALAN, S. 1988. Veldgids tot die veldblomme van die Witwatersrand- & Pretoria-gebied. p 344. Struik Uitgewers, Kaapstad.

VAN WYK, P. 1988a. Veldgids tot die bome van die Nasionale Kruger Wildtuin. Struik Uitgewers, Kaapstad.

VAN WYK, S. 1983. 'n Plantekologiese studie van die Abe Bailey- natuurreservaat. M.Sc.-verhandeling, Potchefstroomse Universiteit vir C.H.O., Potchefstroom.

VENTER, F.J. 1991. Fisiese kenmerke van bereike van die standhoudende riviere in die Nasionale Krugerwildtuin. Departement van Navorsing en Kommunikasie, Nasionale Parkeraad, Skukuza,.

WADESON, R. & ROWNTREE, K. 1995. A hierarchical geomorphological model for classification of South African river systems, in : M.C. Uys (Ed) Classification of rivers and environmental health indicators, Water Research Commission Report No:TT63/94.

WALTER, H. 1963. Climatic diagrams as a means to comprehend the various climatic types for ecological and agricultural purposes. In: The water relations of plants, (red) Rutler, A.J. & Whitehead, F.H. Blackwells, Oxford.

WARD, J.V. & STANFORD, J.A. 1987. The ecology of regulated streams: past accomplishments and directions for future research. Regulated Streams. Advances in Ecology (eds. J.F. Craig & J.B. Kemper), pp 391-409, Plenum Press, New York.

WARE, G.H. & PENFOUND, W.T. 1949. The vegetation of the lower levels of the floodplain of the South Canadian River in Central Oklahoma. *Ecology.* 30:478-484.

WASSON, J.G.1989. Elements pour une typoligie fonctionelle des eaux courantes :1. Reve Critique de guoles approches existantes, *Bulletin d' Ecologie*, 20:109-127.

WATTS, D. 1971. Principles of Biogeography. McGraw-Hill, London.

WEERBURO 1990. Klimaat van Suid Afrika. Klimaatstatistieke 1961-1990. WB 42. Staatsdrukker, Pretoria.

WERGER, M.J.A. 1974. On concepts and techniques applied in the Zurich-Montpellier method of vegetation survey. *Bothalia* 11:309-323.

WESTFALL, R.H. 1981. The plant ecology of the farm Groothoek, Thabazimbi district. M.Sc.-verhandeling, Universiteit van Pretoria, Pretoria.

WESTFALL, R.H. 1990. Phytotab-PC:A program package for vegetation classification and mapping. LNR – Veld en Weidingsinstituut, P/S X05, Lynn East, 0039.

WESTFALL, R.H. 1992. Objectivity in stratification, sampling and classification of vegetation. Phd.-proefskrif, Universiteit van Pretoria, Pretoria.

WESTFALL, R.H., THERON, G.K. & VAN ROOYEN, N. 1997. Objective classification and analysis of vegetation data. *Plant Ecology* 132:137-154.

WESTFALL, R.H. & PANAGOS, M.D. 1988. The Plant Number Scale- an improved method of cover estimation using variable belt transects. *Bothalia* 18,2: 289-291.

WESTFALL, R.H. & DE WET, B.C. 1988. New programs for preliminary sequencing of releves and species in phytosociological data sets. *Bothalia* 18: 122-123.

WHARTON, C.H., KITCHENS, W.M., PENDELTON, E.C. & SIPE, T.W. 1982. The ecology of bottomland wood swamps of the Southeast : a community profile. FWS/OBS-81-37 United States Fish and Wildlife Services, Washington, D.C., USA.

WHITE, P.S. 1979. Pattern, process and natural disturbance in vegetation. The Botanical Review. 45(3):230-299.

WISSMAR, R.C. & SWANSON, F.J. 1990. Landscape disturbances and lotic ecotones. Ecology and Management of aquatic-terrestrial ecotones. (Ed. By R. Naiman & H. DéCamps), pp 65-89. The Partherson Publishing Group Inc., New York, USA.