A description of the savanna ecosystem project, Nylsvley, South Africa

A Report of the Savanna Ecosystem Project
National Programme for Environmental Sciences

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PREFACE

The Savanna Ecosystem Project of the National Programme for Environmental Sciences is one of several national scientific programmes administered by the CSIR. The National Programme is a cooperative undertaking of scientists and scientific institutions in South Africa concerned with research related to environmental problems. It includes research designed to meet local needs as well as projects being undertaken in South Africa as contributions to the international programme of SCOPE (Scientific Committee on Problems of the Environment), the body set up in 1970 by ICSU (International Council of Scientific Unions) to act as a focus of non-governmental international scientific effort in the environmental field.

The Savanna Ecosystem Project being carried out at Nylsvley is a joint undertaking of more than thirty scientists from the Department of Agricultural Technical Services, the Transvaal Provincial Administration, the National Parks Board, the CSIR, the Transvaal Museum, and eight universities. As far as this is possible, participating laboratories finance their own research within the project. The shared facilities at the study area and the research of participating universities and museums is also financed from a central fund administered by the National Committee for Environmental Sciences and contributed largely by the Department of Planning and the Environment.

This document describes the aims of the project and the planned research programme. The further development of the programme, summaries of findings and lists of scientific publications arising from the project will be given in subsequent reports in this series. This document has been compiled by Dr R G Noble, Dr S M Hirst and Professor B H Walker in consultation with the project leaders concerned.

CURRENT TITLES IN THIS SERIES

1. A description of the Savanna Ecosystem Project, Nylsvley, South Africa. December 1975. 24 pp.

2. Sensitivity analysis of a simple linear model of a savanna ecosystem at Nylsvley. W M Getz and A M Starfield. December 1975. 18 pp.

3. Savanna Ecosystem Project - Progress Report 1974/1975. S M Hirst. December 1975. 27 pp.

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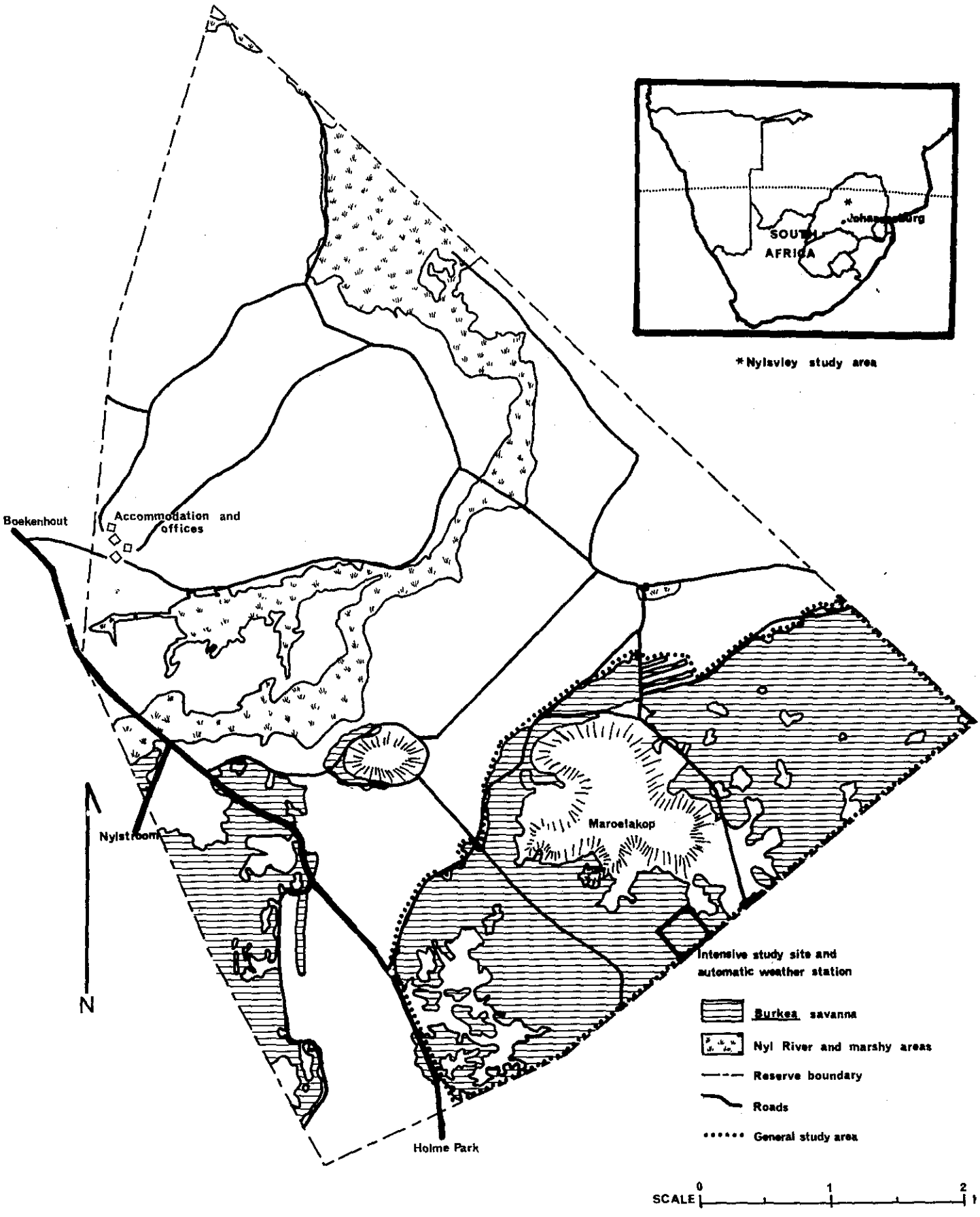
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INTRODUCTION

The savanna ecosystem project being undertaken at Nylsvley in the northern Transvaal is an attempt to improve our ability to predict events within the savanna grazing lands of southern Africa, in particular to predict the consequences of management practices. These savannas stretch in a broad belt across southern Africa and have been greatly affected by increasing exploitation during the past hundred years. Increases in useful productivity have been accompanied by such problems as bush encroachment, loss of species diversity, soil erosion and the spread of desert vegetation. Considerable advances in knowledge will be required if these problems are to be overcome and if rational management strategies are to be developed.

One of the features of the ecosystems of the semi-arid regions of southern Africa is their sensitivity. Over long periods of time, under conditions of low and erratic rainfall and high temperature which occur in these regions, extremely complex ecosystems have evolved which are characterized by a great diversity of plant and animal species. When subjected to stress through overgrazing, abnormal fire regimes or radical changes in the animal component, these systems are easily and rapidly degraded and take a much longer time to recover than do higher rainfall ecosystems elsewhere.

Research into the savanna regions of southern Africa has so far largely been directed towards a single end product - an increase in beef production. The studies that have been undertaken have been largely isolated and limited to larger herbivores and some insect groups. There has been no integrated attempt to understand how the ecosystem operates as a whole. The Nylsvley project has been developed to meet the need for a fundamental examination of the whole ecosystem, to determine its structure, the major energy pathways and the key components and processes which regulate its dynamics.

There are several savanna types in southern Africa, all of which are poorly understood. The Nylsvley project is being carried out in an area of savanna dominated by the woody species *Burkea africana* and *Ochna pulchra* and the grass species *Eragrostis pallens*. This is a widespread savanna type on poor sandy soils and has been selected as a convenient type for initial intensive study.

The Nylsvley project differs from most past and present governmental research in its fundamental nature. It differs from many ecosystem projects elsewhere in its emphasis on a small number of components and processes within the ecosystem selected, first, for their apparent importance in controlling the system's dynamics and, second, because they can be manipulated in management programmes. It is aimed more at gaining new insights into these components and processes than at producing broadly applicable models of energy flow. It is not directly aimed at proving any one management practice superior to any other, or for example at proving whether cattle or game ranching is the better system of land use. Rather the project will aim at, for example, determining how different herbivores, including phytophagous insects, interact with one another and with other trophic levels of the system and at predicting the effects on the ecosystem of different combinations of these herbivores under different conditions.

OBJECTIVES AND PHASES OF THE STUDY

The objectives of the project may be summarized as follows -

(1) To determine the structure and dynamics of the ecosystem as a whole.

(2) To identify the key components and processes which govern the structure and dynamics of the ecosystem.

(3) To undertake research in detail into the more important of these key components and processes, with a view to understanding the controlling and limiting factors.

(4) To undertake research into the effects of human use and manipulation of the ecosystem through fire, grazing and so forth, and to extend this research to experimental and observational studies in areas other than the main study site.

(5) To provide an educational facility for training scientists in inter-disciplinary research (since such a combined team approach is the only way in which problems of this magnitude can be solved) and for teaching students, at all levels, the principles and methods of ecosystem ecology.

The study itself has been divided into phases as follows -

Phase I (mid-1974 to mid-1976) - a pilot study of the Nylsvley study area,

Phase II (1976-1979) - studies of key components and processes, and

Phase III (1979-1984) - extension to other sites and the impact of range management practices.

THE STUDY AREA

The study is located on a part of the Nylsvley Provincial Nature Reserve which is situated in the mixed bushveld of the Transvaal (latitude 24°29'S and longitude 28°42'E), 10 km south of the town Naboomspruit. The altitude varies between 1080m and 1140m ASL, and there is a small but permanent river (the Nyl River) flowing across the reserve from SW to NE, along a vlei or strip of marshy lowland.

In general, the climate is semi-arid, with three rather distinct seasons - a hot, wet season from November to April, a cool, dry season from April to August, and a hot, dry season from August to October. The mean annual temperature is 18,6°C and the mean annual rainfall 587mm.

Table 1 - Temperature and rainfall data from Nylsvley

Month	Rainfall (mm)	Temperature (°C)					
		Mean of daily max.	Extreme daily max.	Mean of daily min.	Extreme daily min.	Mean	Mean daily range
Jan.	112,3	30,3	37,4	16,2	10,0	23,3	14,1
Feb.	80,0	29,8	36,1	15,9	8,0	22,8	13,9
Mar.	68,8	28,5	34,1	14,3	8,6	21,4	14,2
Apr.	32,3	27,1	33,0	9,4	2,1	18,3	17,7
May	12,9	23,9	31,0	5,5	-1,7	14,7	18,4
Jun.	6,1	21,8	27,4	1,3	-5,7	11,6	20,5
Jul.	6,9	21,2	27,2	1,0	-4,9	11,1	20,2
Aug.	4,6	24,8	32,1	4,0	-4,2	14,4	20,8
Sep.	16,0	27,6	36,7	8,6	-3,3	18,1	19,0
Oct.	43,9	30,4	38,8	13,1	4,4	21,7	17,3
Nov.	97,8	29,6	38,7	14,9	6,7	22,3	14,7
Dec.	105,4	29,7	37,7	16,1	11,4	22,9	13,6

Several soil and vegetation types occur, associated with differences in geology and topography. The uplands on which the study area is situated have non-calcareous, sandy soils and support a broad-leaved deciduous savanna. The lowlands have calcareous clay soils with marsh vegetation fringed by microphyllous deciduous thorn savannas.

The striking characteristic of savanna vegetation is its horizontal organization into a mosaic of intergrading open, grassy areas and denser clumps of woody vegetation. Vertically, there are three intergrading strata - trees, shrubs and a herbaceous layer dominated by grasses. The trees, which are up to 12m high with an aerial cover of 20 - 60%, are dominated by *Burkea africana, Terminalia sericea* and such others as *Combretum* species. The dominant species in the shrub layer are *Ochna pulchra* and *Grewia flavescens*, with an aerial cover of 5 - 25%. The herbaceous layer, with a total aerial cover of 15 - 60%, is dominated by the grasses *Eragrostis pallens* and *Digitaria eriantha* in the open areas, with others such as *Panicum maximum* under the trees. The study area occupies about 750 ha within a fairly homogeneous area of this overall mosaic. Owing to the presence of a poisonous plant *Dichapetalum cymosum*, this type of vegetation is traditionally grazed by cattle for only about four months a year, from mid-January to mid-May. Throughout the year it is occupied by varying numbers of wild herbivores which avoid the poisonous plant. Significant among these are impala *(Aepyceros melampus)*, greater kudu *(Tragelaphus strepsiceros)*, common duiker *(Sylvicapra grimmia)*, steenbok *(Raphicerus campestris)* and warthog *(Phacochoerus aethiopicus)*.

PHASE I: PILOT STUDY OF THE NYLSVLEY STUDY AREA

Aims

(1) Survey and map the soils and vegetation of the Nature Reserve and describe its abiotic features and biotic components.

(2) Undertake a structural analysis of the vegetation of the study area, plan the study site and install its weather recording and other facilities.

(3) Identify major components and pathways within the ecosystem.

(4) Determine standing crops of the components and their fluxes over a full year.

(5) Develop crude mathematical simulation models of the ecosystem based on the information gained above and from the literature.

(6) Identify components and processes in the ecosystem relative to the defined objectives, which have to be investigated further during phase II.

For convenience, the pilot study has been divided into six component areas of research.

Abiotic component

A survey of soil types both within the study area and within Nylsvley as a whole has been carried out as a background to the project. Automatic and conventional weather observation equipment is being installed to describe the climate of Nylsvley and microclimates within the savanna. Meso-climatological differences will be identified where these are significant. Microclimatological studies will be used to determine CO_2 and water vapour fluxes into the atmosphere. Mathematical models will be developed to determine the relationships between these fluxes and climatic factors (the driving forces of the ecosystem).

Projects -

(1) "Soils survey of Nylsvley" Professor H.J. v.M. Harmse (Department of Soil Science, Potchefstroom University for C.H.E.), 1974. This survey has been completed and 1:2 500 maps of the distribution of soil series and phases drawn up. Fifty-seven soil types were identified in the Nature Reserve, but the study area consists of fairly uniform sandy soils low in N, P and Ca/Mg.

(2) "An analysis and summary of the climate of Nylsvley" Professor J.M. de Jager (Department of Soil Science and Agrometeorology, University of Natal) 1975-1978. This project will continue through phase II of the ecosystem project. A multi-channel automatic weather station is being installed in the study area capable of recording radiation, temperature, atmospheric humidity and other parameters at 30-second intervals at different atmospheric strata and in representative situations within the ecosystem. The data logging equipment for this station will serve the dual purpose of recording routine observations as well as the measurements required by the microclimatological investigations. The initial study will be aimed at describing the climate of Nylsvley and identifying the main microclimatic features.

(3) "Design and construction of lysimeters for the Nylsvley project" Professor J.M. de Jager (Department of Soil Science and Agrometeorology, University of Natal) and Professor J.J.P. van Wyk (Department of Botany, Potchefstroom University for C.H.E.), 1975-1976.

(4) "The measurement of the vertical fluxes of CO_2 and water vapour from the grassland savanna and modelling of the same in terms of environmental factors" Professor J.M. de Jager (Department of Soil Science and Agrometeorology, University of Natal), 1975-1978. This project will continue through phase II of the ecosystem project. Using micrometeorological techniques and lysimeters it is intended to measure accurately CO_2 and water vapour exchange. The first stage of the work will involve construction and testing of the equipment and establishing the validity of the proposed technique. This will be followed by observations in the field and by the modelling.

(5) "Estimation of soil moisture" Professor J.J.P. van Wyk (Department of Botany, Potchefstroom University for C.H.E.), 1975. Soil cores will be taken from soil survey pits and from intensive sampling sites and moisture content measured by oven-drying and weighing. Soil moisture patterns will be related to distribution of vegetation and soil groups.

Producer component

Surveys have been carried out of the floristic composition of the vegetation of Nylsvley and of the detailed structure, horizontal pattern and plant associations of the vegetation of the study area. Aerial photographs have been taken and the area mapped. These surveys will be repeated at intervals during the study. Phenological observations will be made and a study of seed production by important species will be undertaken.

Direct destructive measurements of changes in above-ground standing crop of grasses, forbs, shrubs and trees will be made during the growing season. Estimates of root biomass will be made. Rates of litter production from different producer components and rates of litter disappearance will be estimated. Growth, photosynthesis and respiration rates of different

species will be determined at different temperatures and light intensities for plants at different stages in their life history and for plants of different nutrient status. The distribution of assimiliation products within plants will be studied at different times of year. The photosynthetic pathways involved in different plant species will be investigated. A study of the toxicity and phenology of *Dichapetalum cymosum* (gifblaar), will be undertaken as this affects utilization patterns by herbivores at Nylsvley.

Projects -

(6) "A phytosociological classification of the Nylsvley Nature Reserve" Mr B.J. Coetzee, Mr F. van der Meulen, Miss S. Zwanziger, Mr P. Gonsalves and Dr P. Weisser (Botanical Research Institute, Department of Agricultural Technical Services), 1974. The vegetation of Nylsvley, excluding the marshy areas, has been classified hierarchically, the study site being surveyed in more detail than the rest of the Reserve. Four major community types, including seven main sub-divisions and several smaller variations, were recognized. The study area was selected within a relatively homogeneous area of *Eragrostis pallens - Burkea africana* savanna. A plant check list and herbarium for Nylsvley is being compiled.

(7) "Quantitative ecological surveys of the woody vegetation of the Nylsvley study area" Dr R.A. Lubke (Department of Botany, Rhodes University), 1974-1975. Five plots were selected within the study area according to the Braun Blanquet classification of the vegetation. These covered 8,2 ha or more than 8% of the study area. Within each of these the density of all woody species was recorded, as well as 15 structural characteristics of the larger trees. The pattern of individual species, their association with other woody species, structural characteristics and importance in each plot has been determined.

(8) "Quantitative ecological surveys of the grasses and forbs of the Nylsvley study area" Dr G.K. Theron (Department of Botany, University of Pretoria), 1974-1975. Within the same plots as in (6), basal cover of all grasses and forbs, as well as the frequency of all woody plants up to 0,5m height has been recorded. The density of the legumes will also be calculated.

(9) "Seed production studies of the more common species in the Nylsvley study area" Dr H.J.T. Venter (Department of Botany, University of the Orange Free State), 1975-1976. Rates of seed production of the dominant grasses, forbs and woody plant species will be measured. Germination experiments will be used to determine the viable seed populations from different situations within the study site. A seed identification key will be drawn up.

(10) "Change in above-ground standing crop of the grass layer in *Eragrostis pallens - Burkea* savanna in protected plots in the Nylsvley study area" Professor J.O. Grunow (Department of Plant Production, University of Pretoria), 1974-1975. Quadrats under and between trees will be clipped at intervals through the year. Dry matter yield (g/m^2) of living and standing dead grass and herbs will be determined. At the same time, two or more of the major grass species will be sampled to determine their yields.

(11) "Measurement of the standing biomass of trees and shrubs in the Nylsvley study area" Mr M.C. Rutherford (Botanical Research Institute, Department of Agricultural Technical Services), 1974-1975. A destructive method is being employed to determine the biomass of *Burkea africana, Terminalia sericea, Strychnos pungens, Ochna pulchra* and *Grewia flavescens*. Relationships are being derived between dry weight and a series of physical dimensions. Amounts of dead wood in trees at different growth stages are being measured.

(12) "The photosynthetic characteristics of the trees and grasses of the Nylsvley study area" Professor C.F. Cresswell and Mr J. Tew (Department of Botany and Microbiology, University of the Witwatersrand), 1974-1976. Photosynthetic rates and CO_2 compensation points have been determined using CO_2 gas analysis techniques for three trees, *Terminalia sericea, Burkea africana* and *Ochna pulchra*. A detailed study of light intensity and temperature on photosynthetic rates and CO_2 compensation points of the above trees has been carried out. $^{14}CO_2$ labelling of *Ochna* has been carried out in order to elucidate the primary intermediates. The leaf anatomy of *Ochna* is also being studied. CO_2 flux is being measured for the grasses *Setaria perennis, Eragrostis pallens, Rhynchelytrum repens, Panicum maximum* and *Digitaria eriantha*, both during the day and night together with concurrent measurements of ambient temperature, leaf temperature, light exposure, water potential and stomatal resistance. From the findings, net productivity rates will be measured.

(13) "A preliminary survey of the root biomass in the top 1m of the soil" Professor J.J.P. van Wyk (Department of Botany, Potchefstroom University for C.H.E.), 1975. Soil cores will be taken at randomly located sites within the study area, washed and the oven-dried roots weighed.

(14) "Determination of the monofluoracetate activity of gifblaar, *Dichapetalum cymosum*" Professor N. Grobbelaar (Department of Botany, University of Pretoria), 1975-1976. The fluctuations in toxicity of this plant will be determined during the year.

Consumer component

Surveys are being undertaken of population density and biomass fluctuations of principal functional groups of animal consumers in the study area. These include all mammals, birds, reptiles and amphibians as well as functional groupings of insects and soil invertebrates. Principal patterns of movements within the study area, within Nylsvley as a whole and in and out of Nylsvley are being observed. The feeding habits of all common species are being investigated, and less common species grouped according to available information on their feeding habits.

Projects -

(15) "Survey of the vertebrate fauna of Nylsvley with special reference to the study area" Mr N.G.H. Jacobsen (Transvaal Provincial Administration), 1974. This survey has been completed and included mammals, reptiles and amphibians.

(16) "Population dynamics, feeding and energy turnover of antelope and cattle on Nylsvley" Professor J.D. Skinner (Mammal Research Institute, University of Pretoria), 1975-1977. Population densities and biomass of antelope will be determined and food preferences, food intake rates, defaecation rates and growth rates of both antelope and cattle estimated. This project will be continued through phase II. During phase II the energy and protein content of food, faeces and urine will be determined. Energy turnover will be investigated in metabolic cages and water and mineral balances will be studied in the laboratory.

(17) "The seasonal incidence of parasitic infections of impala and cattle at Nylsvley" Dr I.G. Horak (Department of Parasitology, University of Pretoria), 1975. Impala will be culled at monthly intervals and examined for ecto- and endoparasites. During the period that the cattle graze the area, weaned calves are to be introduced into the ecosystem for four week intervals, slaughtered and examined for parasites.

(18) "Population dynamics, feeding and energy turnover of small mammals at Nylsvley" Dr J.A.J. Nel (Mammal Research Institute, University of Pretoria), 1975-1976. Population and biomass fluctuations will be determined on a grid network using trap lines. Reproduction and mortality rates of each species will be determined and food preferences and feeding and defaecation rates estimated.

(19) "A study of the bird population at Nylsvley" Mr W.A. Tarboton (Transvaal Provincial Administration), 1974-1976. Population and biomass fluctuations of bird species at Nylsvley will be determined. By ringing and recapture, migrations and movements in and out of Nylsvley as well as reproduction, growth and mortality rates will be estimated. The feeding habits of each species will be investigated.

(20) "A study of the reptile and amphibian populations of the Nylsvley study area" Mr N.H.G. Jacobsen (Transvaal Provincial Administration), 1975. Population density and biomass fluctuations will be determined. Food habits of each species will be investigated, as will reproduction, growth and mortality rates and movements in and out of the study area.

(21) "Dynamics of phytophagous, predatory and social insects of the Nylsvley study area" Dr E. Holm (Department of Entomology, University of Pretoria) and Dr D.J. Brothers (Department of Entomology, University of Natal), 1975-1976. A set of six continuously operating Malaise traps combined with pit traps will be set up to collect phytophagous insects. Censuses, beating and sweeping of all the vegetation on a monthly basis will be used to interpret the trapping data. Tables for approximate biomass for size will be drawn up for different groups to make possible the estimation of biomass. Food consumption rates will be determined both in the field and in the laboratory. The relative importance of various phytophagous insects will be interpreted from these data.

Decomposer component

A study of leaf fall, litter accumulation and removal rates is being planned. Surveys are being undertaken of the fluctuations in density of principal groups of invertebrates involved in the reduction of dead plant and animal material.

Projects -

(22) "Dynamics of the ground living and dung insects of the Nylsvley study area" Dr S. Endrödy-Younga (Transvaal Museum), 1975-1976. Intensive sampling will be undertaken at frequent intervals using different techniques to collect insects from different biotopes. The food of the insects collected will be determined. Fluctuations in biomass of coprophagous, saprophagous and other functional groups will be followed. Rates of dung clearing will be estimated at different times and related to climatic factors and insect activity.

(23) "Dynamics of soil Acari, Oligochaeta and Collembola in the Nylsvley study area" Dr G.C. Loots (Department of Zoology, Potchefstroom University for C.H.E.) and Dr J.F. Prinsloo (Department of Zoology, University of Fort Hare), 1975-1976. Intensive regular sampling to follow fluctuations in population densities and biomass of soil invertebrates will be undertaken.

Mineral cycling component

During phase I a simple model of N cycling in the Nylsvley study area is to be developed. N analyses in the soil series within the study site have been undertaken. Apparatus is being designed to sample rain water for analysis of dissolved N. Estimates will be made of rates of biological nitrogen fixation and nitrification and chemical analyses of plants in the ecosystem will be undertaken.

Projects -

(24) "Uptake and global rates of biological nitrogen fixation and denitrification in the Nylsvley study area" Professor N. Grobbelaar (Department of Botany, University of Pretoria), 1975-1976. Nitrogen fixation will be determined periodically by the acetylene reduction method and occasionally checked using N^{15}. Losses in bound nitrogen which cannot be ascribed to plant uptake, leaching or runoff will be ascribed to denitrification. Preliminary work has revealed unexpected evidence of nitrogen fixation in soil associated with roots of such plants as *Burkea africana* which do not form nodules and which are not usually associated with nitrogen fixation.

(25) "Nitrogen content of plant material and soil samples from Nylsvley" Professor P.L. Steyn (Department of Microbiology and Plant Pathology, University of Pretoria), 1974-1975. Kjeldahl determinations will be undertaken as a service function to the project as a whole.

Modelling component

During phase I a series of simple dynamic models will be developed to describe the behaviour of different parts of the ecosystem, the effects of the driving forces (radiation, temperature and rainfall) on the biotic components and the inter-relations of the biotic components.

Projects -

(26) "Data handling for the savanna ecosystem project" Dr J.W. Morris (Botanical Research Institute, Department of Agricultural Technical Services) and Mr J.N. de Bruyn (Biometry Section, Department of Agricultural Technical Services), 1975-1984. Curation of all raw field data collected by researchers, computer storage of the data and the development of a summarisation and retrieval system suitable for the modellers and other researchers.

(27) "A first mathematical model for the Nylsvley ecosystem" Professor A.M. Starfield (Department of Applied Mathematics, University of the Witwatersrand) and Mr W. Getz (National Research Institute for Mathematical Sciences), 1974-1975. The ecosystem has been crudely simulated by a set of linear differential equations describing the behaviour of each of 15 variables in terms of the flows between them. Estimates of the annual standing crop of each of these components were used to establish a near-equilibrium solution of these equations, and this solution was used to refine estimates of the flow rates between the compartments. The sensitivity of the system to flow rates and flow paths was then investigated.

(28) "A second mathematical model for the Nylsvley ecosystem" Professor A.M. Starfield and Dr P.R. Furniss (Department of Applied Mathematics, University of the Witwatersrand), 1975-1976. The model described above is to be refined from an annual to a seasonal model incorporating the main features of the ecosystem.

PHASE II: STUDIES OF KEY COMPONENTS AND PROCESSES

Aims

(1) To undertake a selected number of studies of components and processes within the Nylsvley study area, selected during phase I to fit in with the long-term objectives of the ecosystem project.

(2) To develop mathematical models to simulate the dynamics of structure and function within the ecosystem and to reflect advances in understanding achieved during phase II.

(3) To design validation experiments to be carried out during phase III, so that the models developed during phase II can be tested at other comparable sites elsewhere.

(4) To design experiments to be carried out during phase III, in which the effects on the ecosystem of such human management factors as fire, different grazing strategies and fertiliser application can be investigated.

The component groups will collaborate closely during phase II to produce information on the following topics, which are considered important either in terms of ecosystem function or in potential ecosystem manipulation. It is emphasized that these topics do not constitute the complete or final research programme for phase II. They are simply those which are already known to be necessary. Further projects will arise from the results of phase I and changes in emphasis may well develop in those listed below.

Abiotic component

(1) An analysis and summary of the climate of Nylsvley. This is a continuation of the phase I project. It is intended to supply information needed in other projects and, in itself, will be an investigation into the characteristics of the savanna ecosystem climate - both macro- and microclimate.

(2) Measurement of vertical fluxes of CO_2 and water vapour and modelling in terms of environmental factors. Water vapour and CO_2 exchange monitored by micrometerological instrumentation attached to automatic weather station, and by small lysimeters.

(3) Surface and subsurface hydrology of the *Burkea*-veld. A quantitative study of the water input into the system via precipitation, the redistribution of water via canopies and stems of trees and shrubs and foliage of the herbaceous layer, and the losses to the system via evaporation from vegetation and the soil and surface and sub-surface drainage.

Producer component

(4) Determination of above-ground standing crops, productivity and biomass losses of grasses and forbs. Measurement of periodic standing crops, production per unit time, loss per unit time to herbivores and litter and functional relationships of temperature, moisture, radiation and other environmental variables to the above-ground layer of grasses and forbs under trees and shrubs and in the open.

(4) Determination of below-ground biomasses, productivity and biomass losses of grasses and forbs. Measurement of periodic biomasses, production per unit time and losses per unit time of grass and forb roots in various sites within the ecosystem. Relationships of these parameters to soil moisture, temperature and other driving forces.

(6) Determination of growth, death, translocation and net primary productivity of important grasses and forbs at various stages throughout the growth season. Field measurements of CO_2 fluxes of all important grasses and forbs. Net carbon flux related to stage of growth, season, environmental factors, total leaf area and total cover of plant. Derivation of net primary productivity. Measurement of changes in growth and mortality rates and in translocation of photosynthesates.

(7) Determination of net primary productivity and translocation within important woody plants at various stages throughout the growth season. Field and laboratory measurements of CO_2 fluxes of leaves from important woody plants. Net carbon flux and net primary productivity related to stage of growth, age of plant, season and environmental factors. Measurement of rates and timing of translocation within the plants.

(8) Quantitative ecological surveys of woody vegetation. Belt transects within study area to sample for density, frequency, distribution, canopy structure, dead wood, browsing incidence and animal and parasite damage.

(9) Quantitative ecological surveys of grasses and forbs. Measurement of total cover, canopy cover, frequency and density of all herbaceous vegetation.

(10) Quantitative study of woody plant : herbaceous plant interactions. Pattern analysis of important woody and herbaceous species, measurement of competitive or mutualistic interactions with special reference to water, nutrients and light, and effects of grazing and fire on the interactions.

(11) Quantitative phenology of vegetation. Determination of phenological characteristics of woody plants, grasses and forbs over an annual cycle. Quantitative measurement of germination, sprouting, budding, flowering, seeding, seed drop, leaf drop, leaf area, total cover, canopy cover, dying and other important stages, and relation of these to temperature, radiation, moisture and day length.

(12) A study of plant transpiration and water uptake within the *Burkea*-veld. Quantitative assessments of periodic moisture uptake by woody and herbaceous vegetation, water fluxes between plants and the soil/atmosphere, and losses by transpiration. Special reference to environmental factors which affect water balance of plants.

(13) Impact of plant parasites and diseases on plant growth and productivity. Identification of fungal, bacterial and nematode infestations on dominant woody and herbaceous plants and measurement of their quantitative effect on the plants' growth and productivity.

(14) Autecology of *Dichapetalum cymosum*. Life cycle of *Dichapetalum cymosum* with particular reference to phenology, periodic toxicity and factors contributing to intake by cattle.

Consumer component

(15) Interrelationships between cattle and vegetation. Study of forage intake by cattle and secondary productivity as affected by grazing site selection, grazing behaviour, grass palatability, plant phenology and various environmental variables.

(16) Population dynamics, feeding and energy turnover of antelope. Measurements of population densities, seasonal biomasses, food preference, food intake rates, growth and excretion in impala and kudu.

(17) Population dynamics, feeding and energy turnover of small mammals. Measurements of population and biomass fluctuations, home ranges, food preferences, food intake rates, growth and excretion in small mammals (springhares and smaller).

(18) Detailed quantitative ecology of dominant leaf-eating Lepidoptera and Coleoptera. Feeding site selection, feeding patterns, rates of food intake, productivity and mortality, as influenced by system driving variables.

(19) Detailed quantitative ecology of dominant grass-eating Orthoptera, Lepidoptera and Coleoptera. Feeding behaviour, feeding intake rates, population dynamics, productivity and interrelations with other grazing animals. Functional relationships to driving variables.

(20) Quantitative ecology of termites, ants and other important social insects. Population dynamics, feeding behaviour and intake, productivity and relationship to vegetation condition.

(21) Quantitative ecology of important wood-boring insects. Host plant selection, population dynamics, behaviour, productivity and mortality rates.

(22) Quantitative ecology of endoparasites in cattle. Host-parasites relationships between cattle and nematode parasites, with special reference to effects on cattle productivity, build-up of nematode parasitic infestations in host and on veld and environmental factors affecting these rates.

(23) Quantitative ecology of ectoparasites of large wild ungulates. Host-parasite relationships between impala and their tick and other endoparasites, as influenced by season, condition and other factors.

Decomposer component

(24) Rates and sources of litter accumulation and rates and pathways of litter breakdown. Measurement of the sources, rates and sites of litter accumulation, with special reference to woody tissue, leaf and canopy material, grasses and forbs and other important organic material such as dung. Measurement of the rates of breakdown and CO_2, mineral and nitrogenous release, and the environmental factors affecting such rates.

(25) Quantitative study of decomposition. Measurement of the biomass change and activities of the organisms concerned with decomposition of organic plant material, and the principal biochemical and metabolic processes taking place. Functional effects of environmental variables on decomposition rates and pathways.

Mineral cycling component

(26) Quantitative study of the nitrogen cycle. Measurements of nitrogen input to the total system via rainwater and nitrogen fixation by symbionts and free-living micro-organisms; nitrogen loss via run-off, leaching, denitrification and animal removal; and changes in nitrogen balance via plant uptake, decomposition and animal excretion.

(27) Quantitative study of the phosphorus cycle. Measurements of amounts, forms and rates of change in phosphates held within various components of the system, including soil, herbaceous plants, woody plants, litter, run-off, consumers, etc.

(28) Cycling of calcium and other mineral elements in the Nylsvley study area.

Modelling component

(29) Data handling for the savanna ecosystem project.

(30) Modelling of specific systems and subsystems within the ecosystem, including (i) a seasonal model with special reference to the growth of grasses and woody species and their utilization by herbivores (including cattle, insects etc.), (ii) a stochastic model of the rainfall and water relations of the study area, (iii) a model of the population dynamics of the major herbivores, (iv) a litter and decomposer cycle model and (v) a model of herbaceous - woody plant interaction. These models will be interlinked to study, for example, the influence of climate on land usage by the herbivores and the long term interaction between the grasslands and woody parts of the study area.

PHASE III: EXTENSION TO OTHER SITES AND THE IMPACT OF MANAGEMENT PRACTICES

In this phase, the work will expand to increase the applicability and value of the project. Some of these activities will include -

(1) The use of controlled experiments to investigate the effects of such stresses to the system as fire, modification of browser : grazer ratios and changes in herbivore biomass and grazing regimes.

(2) The development of management models to explore further the implications of (i) above, in conjunction with what is discovered during phase II.

(3) Measurements and experiments conducted at sites other than Nylsvley, for example at the Mara Research Station and in cattle ranching areas and nature reserves, to allow for extrapolation of the findings to a wider area.

(4) Education. Regular courses for scientists and students are proposed.

ADMINISTRATION OF THE ECOSYSTEM PROJECT

The National Programme for Environmental Sciences comprises the South African programme for SCOPE (Scientific Committee on Problems of the Environment of ICSU, the International Council of Scientific Unions) and is a cooperative research undertaking of South African scientists concerned with environmental problems. It is administered by a National Committee (Chairman Dr C. v.d.M. Brink, CSIR) and the savanna ecosystem project is the largest single project of the Terrestrial Biology Section (Convener Dr J.C. Strydom, Department of Agricultural Technical Services).

The ecosystem project itself is administered by a Working Group for Ecosystems Research, specific responsibilities within the project being as follows -

Chairman : Working Group for Ecosystems Research	Dr A.J. Pienaar, Department of Agricultural Technical Services
Component group leaders -	
Abiotic group	Professor J.M. de Jager, University of Natal
Producer group	Professor C.F. Cresswell, University of the Witwatersrand
Consumer group (up to August 1975)	Dr S.M. Hirst, CSIR
Decomposer group	vacant
Mineral cycling group	Professor N. Grobbelaar, University of Pretoria
Modeller group	Professor A.M. Starfield, University of the Witwatersrand
Adviser (1974-1975) and Convener: Planning Panel (from September 1975)	Professor B.H. Walker, University of the Witwatersrand
Visiting advisers	
August 1974	Professor D.A. Jameson, Colorado State University
January - May 1975	Professor C.D. Pigott, University of Lancaster
July 1975	Dr J Phillipson, Oxford University.
Coordinators	
Data	Dr O.J.H. Bosch, Botanical Research Institute
Scientific (up to August 1975)	Dr S.M. Hirst, CSIR

Scientific (from September 1975)	Mr B.J. Huntley, CSIR
Organizational (up to June 1975)	Professor J.J.P. van Wyk, Potchefstroom University for C.H.E
National Programme for Environmental Sciences	Dr R.G. Noble, CSIR
Convener : Data Panel	Dr J.W. Morris, Botanical Research Institute
Modeller	Dr P.R. Furniss, University of the Witwatersrand
Other members of the Working Group	Dr B. de Winter and Dr D. Edwards Botanical Research Institute; Professor H.J.v.M. Harmse, Potchefstroom University for C.H.E Dr P.F.S. Mulder, Transvaal Provincial Administration

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