TREE/GRASS PROGRAMME

University of Cape Town in collaboration with the Kruger National Park

Text draft design for KNP and UCT website

Introduction

Approximately 50% of the land surface of Africa is covered by savannas, a tropical vegetation type in which both trees and grasses are an important component. How these two very different life forms coexist, and what mechanisms determine the proportions of each, has been a central question in savanna ecology for many years (Scholes and Archer 1997). Walter (1971) first proposed the idea that trees and grasses exploit different rooting niches with grasses using superficial soil layers and trees using deeper layers. Walter's idea was developed as an analytical model, based on Lotka-Volterra equilibrium theory of coexistence between competitors, by Walker and Noy-Meir (1982). The root-niche separation hypothesis (NSH) has since become widely accepted as the central paradigm for tree-grass interactions in savannas (Polley 1997).

Higgins, Bond and Trollope (2000) suggested an entirely different mechanism for the coexistence of trees and grasses. They argued that the critical problem for savanna trees is demographic in nature. Seedlings seldom establish because of frequent droughts and competition with grasses. If they do establish successfully, juvenile plants are burnt by frequent grass fires. Fires kill stems, preventing juvenile plants from escaping to mature size classes. Trees can persist if 1) both rainfall and the severity of fires are sufficiently variable to allow occasional opportunity for successful growth to maturity and 2) mature trees live long enough to straddle these rare recruitment events. We refer to this second coexistence hypothesis as the demographic bottleneck hypothesis (DBH) of tree/grass coexistence since trees are prevented from forming closed woodlands by the rarity of recruitment events. Persistence of tree populations depends on storing successful recruitment events between generations, thereby allowing the population to recruit strongly when conditions are favourable.

The two hypotheses for tree/grass coexistence have entirely different philosophical backgrounds. The NSH, as developed by Walker and Noy-Meir (1982), takes a systems perspective and assumes that trees and grasses reach a fixed equilibrium for a given set of conditions. The DBH, on the other hand, takes a demographic perspective and assumes that variance in demographic rates are central in determining grass and tree abundance.

Objectives

The broad objective of the Tree/grass Programme is to develop a predictive understanding of tree/grass interactions. This will be done by using site-specific versions of the Rooting-niche and Demographic bottleneck models of savanna dynamics to predict the outcome of various burning treatments. These will be tested by using the Experimental Burn Plots (EBP's) within the Kruger National Park. A predictive model of how fire influences tree/grass ratios across soil and rainfall gradients could be a powerful management tool. Such a model, coupled to Kruger Park GIS databases, will be used to explore the consequences of different fire policies on tree/grass ratios throughout the Park.

Experimental design

The study is focusing on two fenced sites in the vicinity of Satara and Pretoriuskop rest camps. These two sites represent different ecological conditions in terms of soil type and rainfall amount. The experimental work is concentrated on the dominant tree species at each site (*Acacia nigrescens* at Satara and *Terminalia sericea* at Pretoriuskop). Within the exclosure, vegetation biomass production is being compared between various combinations of trees and grass under different rainfall and competition treatments.

Rooves have been built to simulate dry rainfall years by reducing the rainfall by half (50%).

The remaining water (50% rainfall) is added onto another treatment increasing the rainfall received by these plots by half (150%) simulating wet years.

These are compared to control plots that receive normal rainfall (100%). An additional treatment involves the removal of grass from plots to determine the competitive effect of grasses and trees.

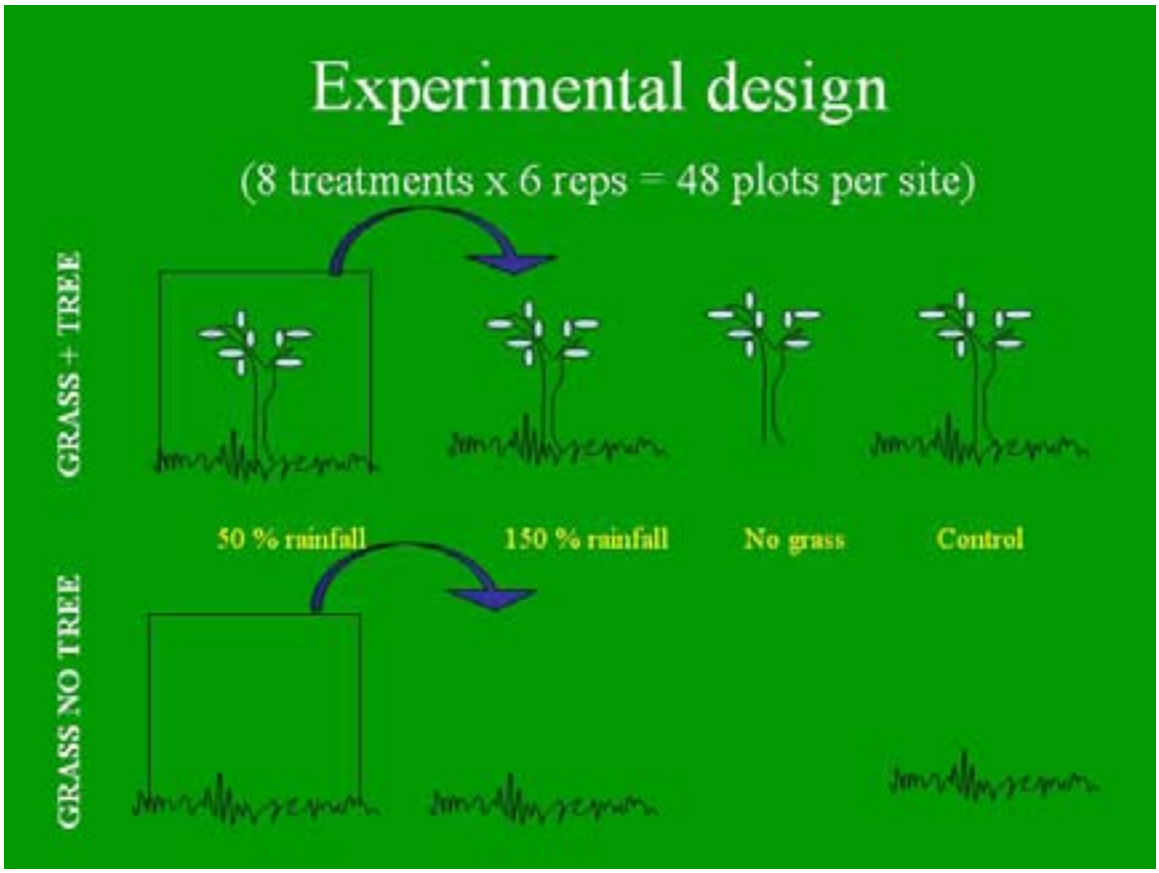
There are 6 replicates of each of the 8 treatments per site:

Treatments

(1) Tree plus grass control (normal rainfall)
(2) Grass control (no tree, normal rainfall)
(3) Tree plus grass plus roof (dry year 50 % of rainfall)
(4) Grass plus roof (no tree, dry year 50 % of rainfall)
(5) Tree plus grass plus irrigation (wet year 150 % rainfall)
(6) Grass plus irrigation (wet year 150 % rainfall)
(7) Tree no grass (grass removed, normal rainfall)
(8) No tree no grass (grass removed, normal rainfall)

Soil moisture is measured by means of a capacitance probe within each treatment plot (48 plots), to determine the belowground effects on soil moisture with the above ground change in rainfall regime. This will be linked to the relative growth rates of the plants within each respective treatment.

An automatic weather station and two sets of TDR soil moisture probes have been installed at each site in order to relate rainfall and water infiltration on an hourly basis.



The tree growth rate is measured under the various rainfall regimes within the experiment and will be used to predict how quickly trees would have grown under previous rainfall and fire regimes. This will be tested by modeling the existing woody data obtained from the experimental burn plots.

The rate at which adult trees are using water is being tested using sap-flow sensors. This may be extended to individuals of other size classes in the future for comparison.

Stable isotopes are being used to determine the probable water source of trees of a range of size classes using rain and ground water.

Tree/Grass Programme staff

The principle investigators on the programme are Dr Ed February, Prof William Bond and Dr Steve Higgins. On site operations are managed by Louise Rademan, assisted by Adolf Manganyi. Field assistants include Annoit Mashele, Patrick Ndhlovu and Mightyman Mashele. For more information on the Tree/grass Programme please contact Louise Rademan (louiser@sanparks.org).

Additional research projects within or associated with the TGP

There are a number of research projects running within or associated with the greater Tree/grass Programme all relating to savanna ecosystem dynamics in the Lowveld Bushveld.

- **Corli Coetsee:** PhD student, Department of Botany, University of Cape Town. "A study of the Interactions between fire, vegetation and nitrogen dynamics in the Kruger National Park" (ccoetsee@botzoo.uct.ac.za)

- **Susan Botha:** MSc student, Department of Botany, University of Cape Town. "The water requirements needed for seedling establishment of savanna woody species in the Kruger National Park" (sbotha@botzoo.uct.ac.za)

- **Patterson Khavhagali:** MSc student, Department of Botany, University of Cape Town "Forest colonization of savannas: Pattern and process" (pkhavhag@botzoo.uct.ac.za)

- **Joseph Craine:** Post-Doctoral research project. "The below-ground processes experiment" (crain010@edu.net)

- **Bradley Hancock:** Graduate student. "the impact of giraffe herbivory on *Acacia nigresens"* (Bradleyhancock@gmx.de)

- **Alex Schultz:** BSc Hons student, Department of Botany, University of Cape Town. "The effect of fire frequency, intensity and timing on savanna tree communities" (aschutz@botzoo.uct.ac.za)

- **Robert Taylor:** BSc Hons student, Department of Botany, University of Cape Town. "Can different sources of water explain tree/grass co-existence in savannas?" (rtaylor@botzoo.uct.ac.za)

- **Matthew Britton:** BSc Hons student, Department of Botany, University of Cape Town. "Where do various tree size classes source their water from?" (mbritton@botzoo.uct.ac.za)

- **Thomas Keretetse:** MSc student, Department of Botany, University of Cape Town. "Nitrogen mineralization and utilization between tree and grass under different water regimes" (thomask@sanaprks.org)

- **Richard Verweij:** PhD student, Department of Botany, University of Cape Town. "The importance of hydraulic lift for understory grass production on a South African savanna: Plant-water relations in different ecological conditions" (rverweij@botzoo.uct.ac.za)

- **Anthony Swemmer:** PhD student, Department of Ecology, Colorado State University. "Predicting the impacts of global climate change on grass primary productivity" (tbush@lamar.colostate.edu)

Contact details

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