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RESPONSES OF SAVANNAS TO STRESS AND DISTURBANCE

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RESEARCH PROCEDURE AND EXPERIMENTAL DESIGN FOR SAVANNA ECOLOGY AND MANAGEMENT

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EXPERIMENT 3, HYPOTHESIS 4

THE EFFECT OF SEASONAL TIMING AND PATTERN OF STRESS ON COMMUNITY STRUCTURE AND FUNCTION

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INTRODUCTION

The hypothesis to be tested is as follows:

H4. Changes in savanna structure and function arise from changes in the seasonal timing and pattern of one or more environmental stresses, independently of the degree of stress.

The relevant assumptions, experimental hypotheses and null hypothesis are represented symbolically in Table 3.3. They are discussed below.

Assumptions

The effects of stresses such as fire, frost and herbivory depend on the phenological state and physiological condition of the plants. For example, plants which are dormant are usually less affected than plants which are growing actively at the time of the stress. Since plant species differ phenologically, it is expected that a stress at any particular time will affect some species more than others.

Further, stress can vary in terms of the pattern of the impact it imposes. For example, the stress might be rapidly increasing, pulsing, steadily renewed, constant or rapidly decreasing (Price, 1984). The vital attributes of different plant species equip them differently to tolerate these various patterns of stress.

Predictions

On the basis of the above assumptions it is predicted that a given community will respond differently to the same pattern of stress at different seasons, or to different patterns of stress in the same season.

IMPLICATIONS

There are evidently certain times when some parts of the system or some species are more sensitive than others to impacts such as grazing. A knowledge of system functioning and the timing of these critical conditions might facilitate control over productivity and species composition, for example by strategic exposure or protection of the system to precipitate or prevent desirable or undesirable changes.

PROCEDURE

Null hypothesis

An appropriate null hypothesis is that species compositional and productional response does not differ under either the same pattern of stress imposed in different seasons, or different patterns of stress imposed in one season.

Approach

This null hypothesis can be tested by applying a stress such as grazing, experimentally in which both the seasonal timing and the pattern of stress are varied independently and in combination.

Design and treatments

A minimum design to test the null hypothesis is suggested as follows:

Suppose that the stress to be applied experimentally is grazing. The timing can be varied depending on the type of environment in which the experiment is to be conducted. For example, where the seasons are predictable, an 'early' and 'late' application are possible, involving grazing early in the growing season, when growth is being initiated by the early-season producers, and grazing in mid- or late season when the late season producers are active. In an unpredictable environment, the 'early' grazing can be timed immediately after rain, while the 'late' treatment should be applied some time after rain. The pattern of stress can be varied by, for example, stocking 10 beasts on 0.1 ha for 1 day, and stocking 1 beast on 0.1 ha for 10 days. Combined with a control, the experiment takes the form of a 3 x 3 factorial ANOVA. The treatments should be replicated at least 3 times, with each block of replicates located independently.

The species composition should be determined in mid-growing season before the treatments are applied, and annually thereafter. Similarly, primary production should be indexed before treatment starts and annually thereafter by measuring the peak green biomass.

Since the treatments are likely to have significantly different effects (the null hypothesis being refuted), the underlying processes are of particular concern. The 'processes' of chief importance relate to the individualistic behaviour of the major plant species. A few of the major species should therefore be identified and their populations studied intensively, focusing particularly on fecundity, survivorship and recruitment.

Although meaningful results may be obtained from this experiment over a 5-year period, it is also possible that the species composition will not adjust to the experimental treatments in such a limited time.

This experiment could be expanded to include a test of hypothesis 5(a) (see experiment 5). This expansion involves the inclusion of another treatment, namely stocking rate at, say, 2 levels (light and heavy). With the control treatment, this now gives a 3 x 3 x 3 factorial ANOVA.

Data analysis and interpretation

Separate 3 x 3 factorial ANOVAs can be performed for responses of species composition and production to the experimental treatments. For the species composition, data reduction can be used to obtain scalars for input into the ANOVA. This can be done in several ways. For example, the species compositional data for each of the treatments in each replicate can be subjected to ordination to yield plot scores along the major ordination axis. Such scores would then be the relevant scalars. If the first one or two ordination axes do not account for most of the variation, then the scalars might be yielded by distance measures (*e.g.* Euclidean distance, Bray-Curtis measure) for pre- and post-treatment differences between individual plots.

With the experiment spanning, say, 5 years, there will almost certainly be some variation in species composition and production in response to between-year variations in rainfall.

The amount of change in these parameters occurring on the control plots can be accommodated by covariance analysis.

The null hypothesis will be refuted if (1) the same pattern of stress imposed at different seasons leads to differences in species composition or production in response to the experimental treatments, and (2) different patterns of stress applied in the same season result in differences in species composition or production of the vegetation.

If the null hypothesis is refuted, the main contributory factors should be identified. Since these factors are likely to relate to the vital attributes and population responses of the major species, a demographic analysis (*e.g.* use of Leslie matrices to show population response under each of the treatments) should be carried out.

Table 3.3 Symbolic representation of the assumptions, experimental hypotheses and null hypotheses for experiment 3.

<u>Assumptions</u>

Let S(1)-S(2), P(1)-P(2) = f (T, F) (3.1)

where,

S(1) is the initial or pre-treatment plant species composition,
S(2) is the post-treatment plant species composition,
P(1) is the initial or pre-treatment primary production,
P(2) is the post-treatment primary production,
T is the seasonal timing of stress, and
F is the pattern of stress.

<u>Experimental hypotheses</u>

For a given timing of stress,

$Se(1)-Se(2) \neq Sl(1)-Sl(2)$ (3.2)

and

$Pe(1)-Pe(2) \neq Pl(1)-Pl(2)$ (3.3)

where,

e is the early season incidence of stress, and
l is the late season incidence of stress.

For a given pattern of stress,

$Sr(1)-Sr(2) \neq Sc(1)-Sc(2)$ (3.4)

and

$Pr(1)-Pr(2) \neq Pc(1)-Pc(2)$ (3.5)

where,

r is an amount, x, of stress extended over a long period and,
c is an amount, x, of stress extended over a short period.

<u>Null hypotheses</u>

The null hypothesis now becomes the negation of expressions (3.2) to (3.5), viz

$Se(1)-Se(2) = Sl(1)-Sl(2)$ (3.6)

$Pe(1)-Pe(2) = Pl(1)-Pl(2)$ (3.7)

$Sr(1)-Sr(2) = Sc(1)-Sc(2)$ (3.8)

and

$Pr(1)-Pr(2) = Pc(1)-Pc(2)$ (3.9)
