PROGRAM B - Project 4.2 (*"Multi-scale analysis of patterns in ecological processes in relation to fire regimes"*)

AN IMAGERY BASED METHOD FOR CHARTING FIRE DRIVEN DYNAMICS OF SEMI-ARID GRASSLANDS

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Pointers

•State-and-transition models (STMs) are now widely used in the USA by rangeland managers in understanding how ecological dynamics are driven by complex interactions between ecosystem events such as fire and rainfall.

•Imagery data have natural appeal in rangelands due to ease of capture. Although images of 1m by 1m quadrats are used here to capture fine scale vegetation changes, the methodology may be extended to other forms of remote sensing.

•Our research shows how STMs may be constructed from a time series of images captured during the long-term monitoring of a semi-arid grassland.

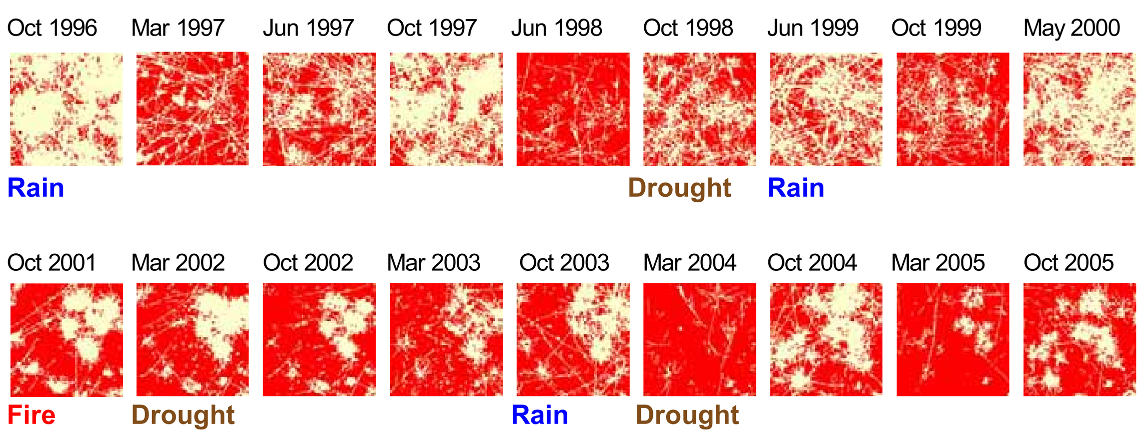

Figure 1 : Fine Scale Vegetation Pattern Dynamics

A time series of processed binary images represent the fine scale vegetation pattern dynamics of *T. triandra* grasslands. A major change in vegetation patterning occurred after an April 2001 fire, followed by drought.

Data

•*Themeda triandra* (Forskal) grasslands of the Pilbara region of NW Western Australia have been monitored twice a year since October 1996 (Figure 1).

•Image data were captured through very large scale aerial photography (VLSA) of 1m by 1m quadrats. However, the methodology may in principle be applied to any image data series, including other forms of remote sensing.

•Images were converted to binary (black and white) format and smoothed by removing all patches of less than 9 pixels size in a 250 by 250 pixel image.

•Metrics, such as proportion of "white" pixels and fractal dimension measures, characterised the patterning in the images as multivariate data. From these a state space may be constructed (Figure 2).

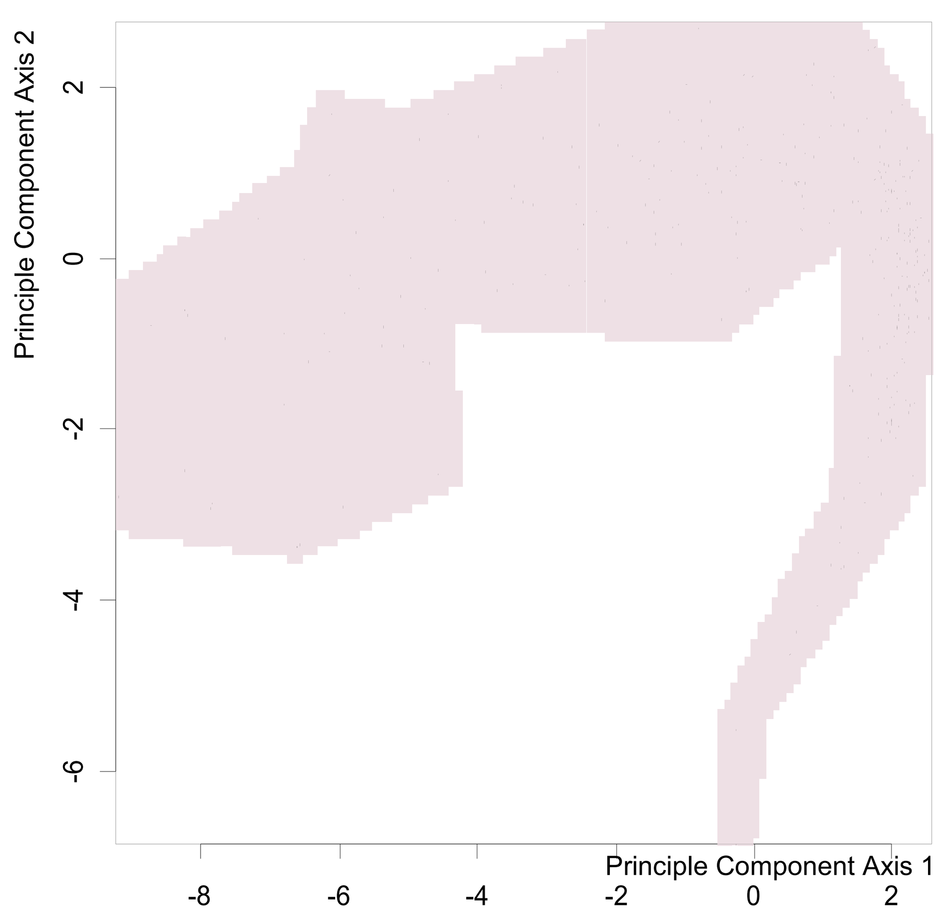

Figure 2 : The STM State Space

The state space is defined as the first two principle components of the multivariate metric data. Each point plotted represents an individual image in the time series.

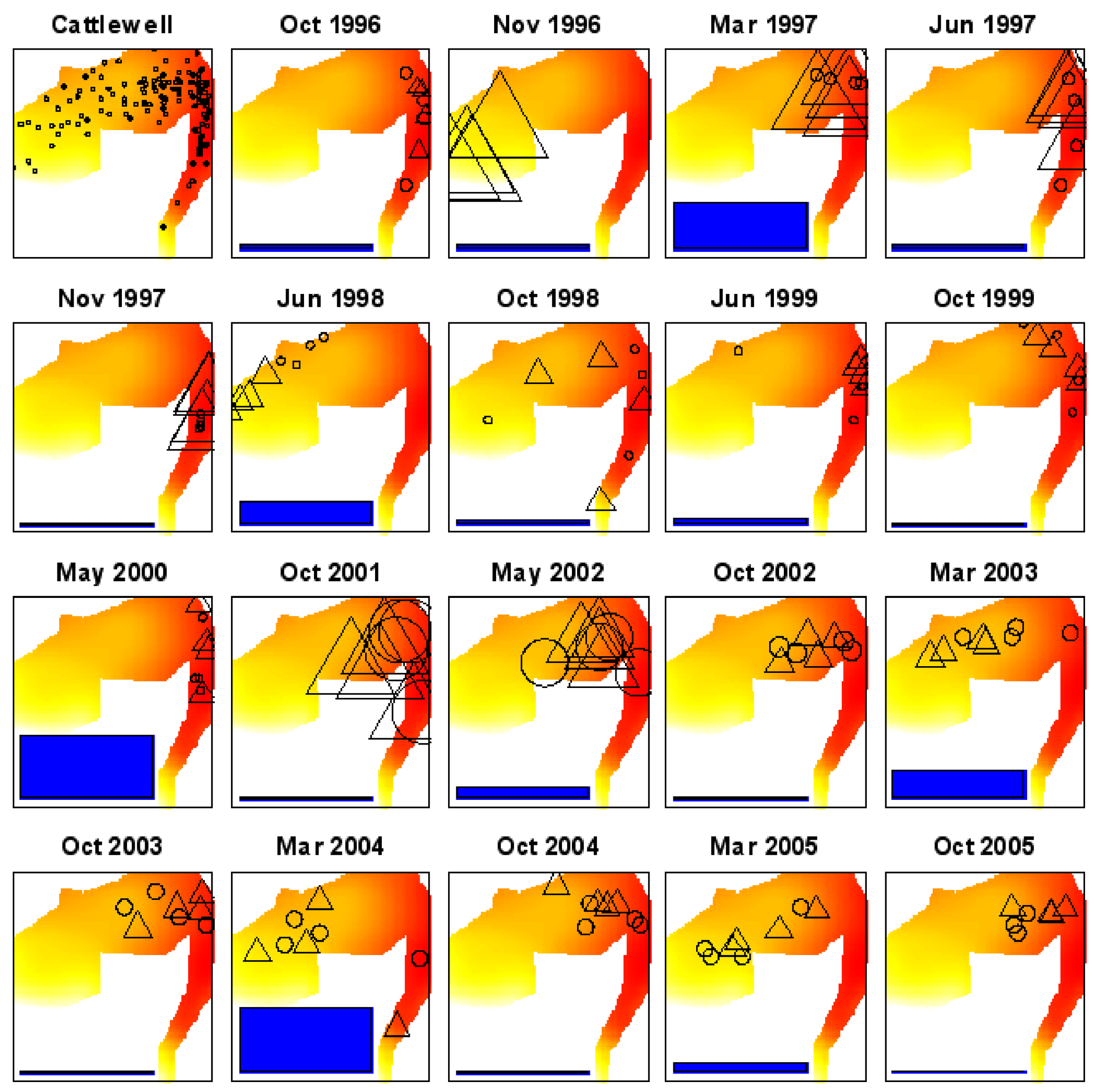

Figure 3 : Biomass, Events and the State Space

The state space may be described in terms of biomass using geo-additive spline regression. Red on the far top right image refers to increasing biomass, the blue bars represent rainfall in the previous six months, and large plotting symbols correspond to recent time since fire. Circular plotting symbols were control plots and triangular symbols were plots experimentally burnt in November 1996.

Constructing State-and-Transition Models

•A STM has several components: (i) a state space which bounds all possible expressions of the system (e.g. points representing images); (ii) ecological phases that are local regions of the state space representing different sets of stable ecological processes and patterns (e.g. a shrubland as opposed to a grassland); and (iii) transition pathways between these phases that are initiated by specific ecological events (e.g. from a shrubland to a grassland through fire)..

•The points in the state space were given an ecological meaning by relating them to biomass (Figure 3).

•Different ecological phases were hypothesized: "recently burnt" (e.g. Oct 2001); "green" (Mar 1997; Jun 1999); "dry" (May 2002 after the Oct 2001 fire; Mar 2005); "summer drought" (Jun 1998); "flood" (Mar 2004); and "indeterminate" (Oct 1998; Oct 1999) (Figure 4).

•Classification trees were used to understand what events were important in driving the system from one ecological phase to another. Event variables resulting in sensible classification of the hypothesized phases were: time since fire; Nov-Jan early season rain; and Feb-Mar mid season rain (Figure 5).

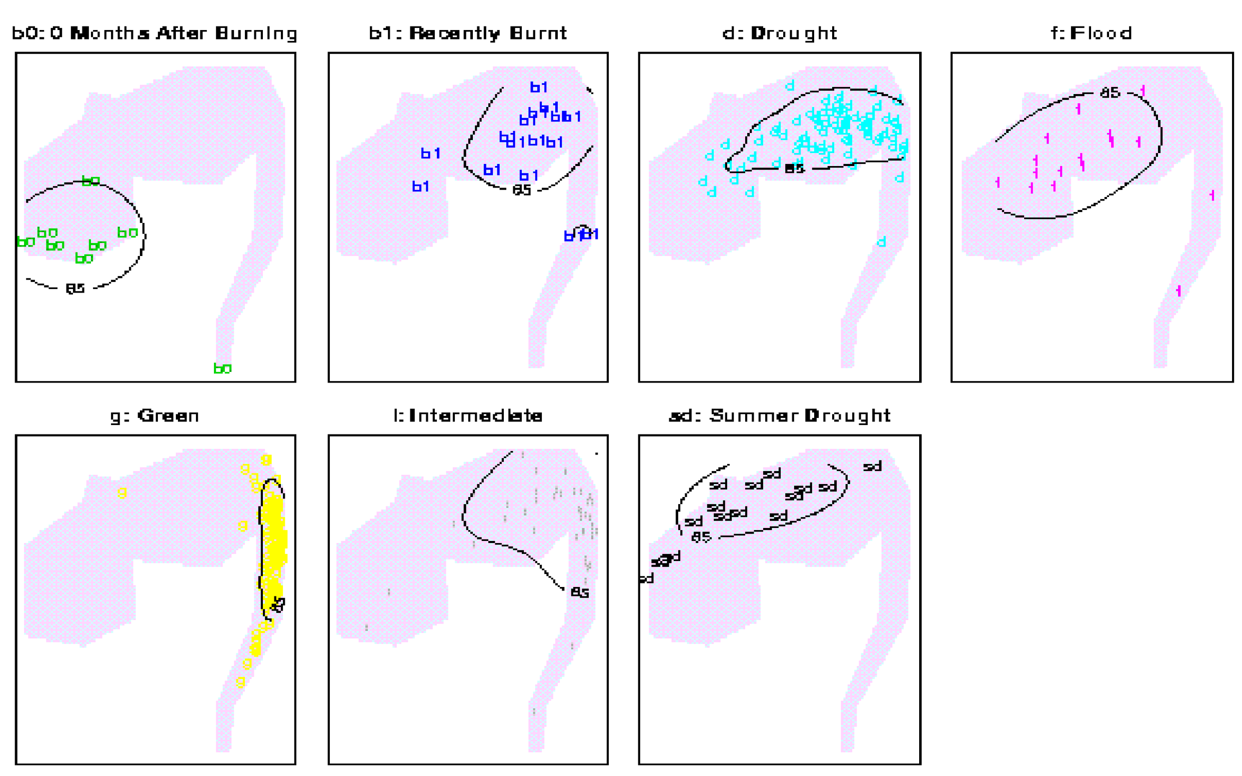

Figure 4 : Ecological Phase Boundaries

Phase boundaries of the hypothesized ecological phases were drawn using contours of kernel density estimates

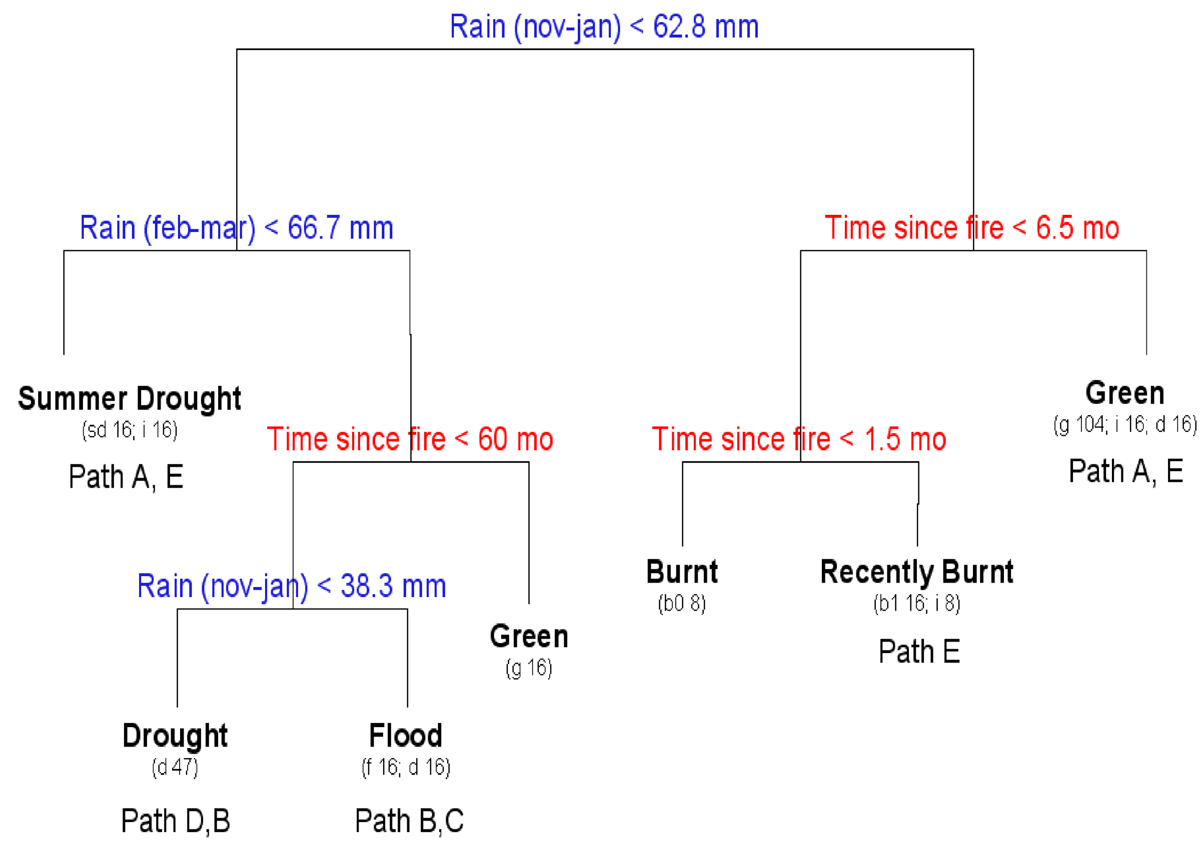

Figure 5 : Assigning Events to Phases

A classification tree identifies the combination of ecologically important events, and their threshold intensities, that individuate each ecological phase. These event combinations are used to define transition pathways amongst the ecological phases.

Sensible Results

•The "green" ecological phase depended primarily on early season rain; "drought" on poor early season rain (Figure 5).

• A "flood" phase is associated with low biomass and appears related to recent burning (within 5 years), poor early season rain, and high mid-season rain.

•The "indeterminate" phase disappeared, subsumed into the "green" phase.

•These results are used to "draw" the state-and-transition model by integrating Figures 4 and 5 to produce Figure 6. Divisions of the event space are used to define the transition pathways between different ecological phases. Example pathways are paths a-e.

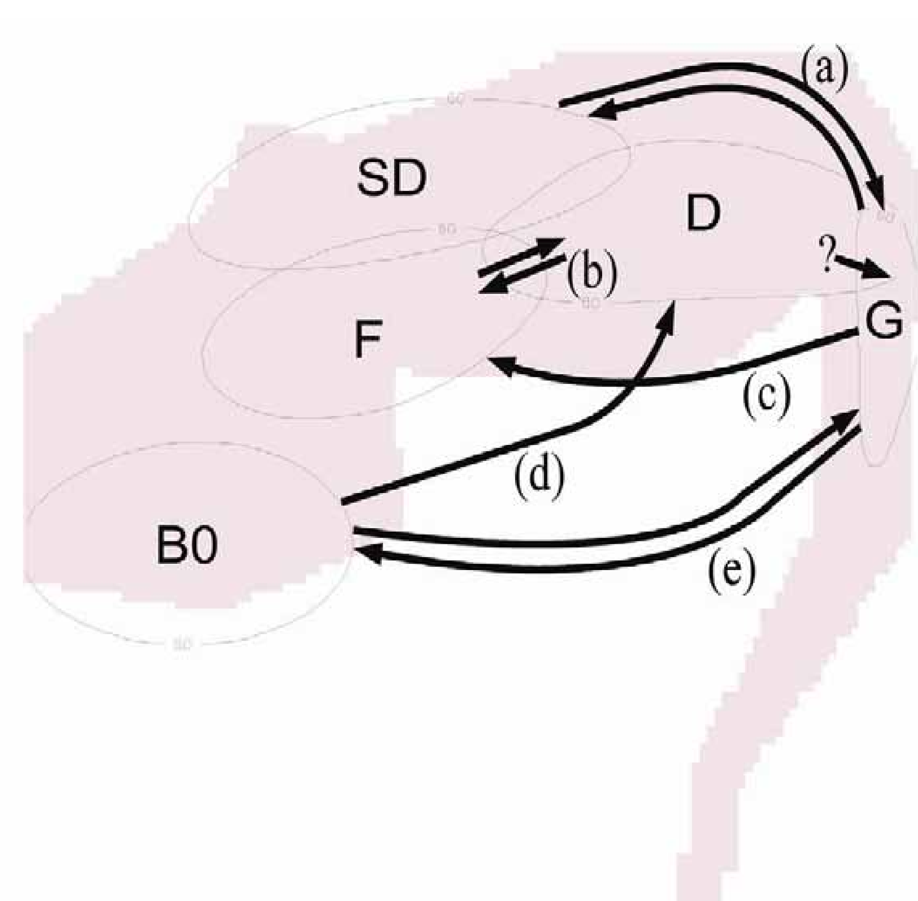

Figure 6 : The State-and-Transition Model

The state-and-transition model is constructed by integrating Figures 4 and 5. Examples a-e of transitional pathways between ecological phases of the system are associated with ecosystem events, e.g. path e from "Green" to "Burnt" requires fire, and from "Burnt" to "Green" requires early season rain.

Coda

•A state-and-transition model may be charted using imagery and accessible statistical tools to elucidate the role of fire in semi-arid grassland dynamics.

•Threshold intensities of ecological events (including fire) triggering transitions between different ecological phases of a grassland may be identified, including time since last fire.