INTRODUCTION TO THE USE OF FRAMEWORKS FOR KNOWLEDGE MANAGEMENT AND CONFLICT RESOLUTION

A. GAYLARD

n.b. The ideas for this introduction are based largely on a manuscript currently in review: Gaylard, A., M.L. Cadenasso and S.T.A. Pickett. *In review*. Heterogeneity shaped by African elephants in semi-arid savannas: the significance of space and scale. Submitted to BioScience.

INTRODUCTION

There is a long history of conflicting opinion regarding elephant management issues in Africa. However, although a large amount of elephant research has been carried out over the last few decades, there have been few attempts to synthesize a common understanding of the role of elephants in savanna ecosystems, placing elephants and their activities in context of all other components processes and scales. This lack of common understanding is exacerbated by the fact that contemporary ecology has recently experienced a major paradigm shift away from equilibrium or "Balance of Nature" ideas towards concepts embracing the importance of heterogeneity or "Flux of Nature". An important implication of this paradigm shift is that the interpretations of these elephant studies are directly influenced by the particular paradigm underpinning the research. Consequently, attempts to build a common understanding regarding the role of elephants in savannas have been unsuccessful, largely because the proponents "speak a different language". A cross-cutting tool that can act as a Knowledge Management system is therefore required to collate our collective understanding regardless of the underlying paradigm.

A recently developed framework for heterogeneity (Pickett et al. 2000, 2003) can be used to synthesize organize a more complex, sophisticated understanding of elephant interaction with landscape structure (see Gaylard et al. in review). The framework is abstract and inclusive and, once the components of the system and the scales of concern are articulated, it 1) allows for multiple influences on and impacts from elephant activity, 2) can recognize these interactions across multiple scales and 3) can be spatially explicit. Using such a conceptual framework to organize and guide research is compatible with the Strategic Adaptive Management (SAM) approach adopted by KNP. SAM and conceptual frameworks are both open systems of understanding that are intended to evolve and respond to new knowledge. In particular, SAM is an open style of management that evolves as new understanding is achieved. Therefore, new information and perspectives are welcomed, and scientific understanding and management are in constant dialogue. The use of scientific frameworks operates in much the same way. The components of frameworks can be emphasized differently, modified, or added to as testing increases understanding of the system the framework addresses (Pickett et al. 1994). By using the heterogeneity framework we can increase understanding of the spatial relationships of elephants to resources and test potential mechanisms of elephant impact on diversity. Because the framework approach from ecology and the SAM approach to management are parallel, scientific understanding of elephant spatial dynamics can provide information for refining elephant management plans.

The framework developed for the purpose of knowledge management for this workshop is a refinement of that developed by Gaylard et al. (in review), in which the flux of nature paradigm was applied to the understanding of elephant-generated heterogeneity. It employs the heterogeneity framework (Pickett et al. 2000, 2003), highlighting the specific agents affecting heterogeneity and the factors that control those agents.

USEFULNESS OF THE FRAMEWORK (SEE GAYLARD ET AL. IN REVIEW)

The framework is useful because it provides a clear and common means of describing the components of a traditional, scale-neutral view of how elephants influence biodiversity with a more encompassing, spatially explicit view. Consequently, our knowledge of the role of elephants in savannas is managed in a manner inclusive of our collective understanding, rather than excluding information simply because it originates from a past paradigm.

Pickett et al's (2000) framework of organism-generated heterogeneity, as modified from the flow chain modelling approach, can be viewed as a Knowledge Management System for the transfer of knowledge between scientists and managers (see Biggs & Rogers 2003; (National 1986). Since it is inclusive of past approaches, use of this framework improves our understanding of ecosystem processes by adding the new insights gained to our existing understanding. As such, the approach used here is a dynamic approach true to the Strategic Adaptive Management framework – as more is learned about a system, additional controllers and feedbacks, or links, can be added to the flow chains to increase our understanding. In addition, the framework approach also represents a tool for conflict resolution.

This approach can also be used to understand how other organisms influence heterogeneity – specifically, whether the organism's impacts are spatially explicit in relation to a particular environmental characteristic. But it can also be used more generally for other ecosystems, since it is inclusive of homogeneous environments where spatial explicitness may not be as important. Since the model includes both spatially explicit and non-spatially explicit pathways, it assists in determining whether the particular organism in question should be examined by means of hierarchical patch dynamics or not.

Structure of the framework: Ecological flow chain models (taken from Gaylard et al. in review)

To explore the role of elephants as agents of heterogeneity, we make use of Ecological Flow Chains and Ecological Systems as defined by Shachak and Jones (1995): An Ecological Flow Chain is a series of organizational states connected by a measurable flow of materials, energy, structure, information, numbers, or any currency of interest. Changes in organizational states along a flow chain functionally describe the flow of the currency. An Ecological System is a set of at least two flow chains and their controlling interconnections that functionally describe and explain the flow(s) of interest along at least one of the component flow chains. Interconnections among flow chains are necessary to explain the flows, and represent the control by an organizational state in one flow chain on an organizational state change in a different flow chain. As such, the ecological system has multiple flows, multiple currencies and multiscalar properties that are determined by the collective scalar boundaries of each component flow chain and the scales at which the controlling interconnections operate.

The flow chain modelling approach forms the basis of the heterogeneity framework employed here. The goal of the framework is to understand the creation, maintenance or change in heterogeneity or biodiversity. The framework consists of an agent and a substrate, both of which are affected by a suite of controllers. Any model constructed to apply the general concept of heterogeneity in a particular system must identify the key controls on the interaction between the agent and the substrate (Pickett et al. 2003). The agent creates, maintains or transforms structural or functional features of the focal system. The substrate occupies a spatial arena specified by the researcher, and has three-dimensional structure. Substrates vary in their susceptibility to transformation, and the spatial distribution of different substrates will determine how subsequent layers of heterogeneity can be created or maintained (Pickett et al. 2003). Controllers affect the spatial dispersion of the agent and the intensity of its action, as well as the sensitivity and dispersion of the substrate. The final component of flow chains required to understand heterogeneity in ecological systems is some entity or process that responds to the spatial differentiation in an arena. This responder should be carefully related to the scale of the spatial heterogeneity, since what is an agent of heterogeneity at one scale may be a substrate, or controller of, or a responder to heterogeneity at another scale (Allen & Hoekstra 1992, Pickett et al. 2003).

This is a systems modelling approach that is appropriate to any kind of ecological entity. Moreover, it accommodates the wide variety of ways in which organisms contribute towards heterogeneity, both structurally and functionally (Pickett et al. 2000). Flow chains and ecological systems are therefore useful for:

1. comparing ecosystems or approaches to viewing the same ecosystem,
2. understanding the dynamics of ecosystems, and
3. exploring multiple causalities within ecosystems.

Important elements of the framework

Because of the spatial explictness, multiple scales and multiple causes inherent in elephant impacts, a complex model which is a composite of appropriate component flow chains encompassing these considerations, is required:

1. Three flow chains essential for a first draft of the model are those of surface water abundance and distribution, the elephant population and savanna vegetation.
2. The elephant is the agent of change, and the substrate the savanna vegetation undergoing a state change from savanna woodland to shrubveld (in KNP).
3. The flow chains of the elephant population and savanna vegetation are linked by means of the flow chain for surface water abundance and distribution. The model is therefore spatially explicit in relation to the locality of surface water , since surface water focuses elephant feeding in particular areas of the landscape. In addition, surface water is linked to the elephant population flow chain because surface water distribution and abundance potentially influences components of elephant population dynamics such as adult mortality and juvenile survival.
4. The model is multi-scaled since elephant feeding activities are focused by characteristics of individual trees (i.e. at fine scales), as well as by characteristics of the landscape related to the presence of surface water (i.e. at broader scales).
5. Broadly the model represents a state change from savanna woodland to shrubveld. However, in the savanna vegetation flow chain a third state, i.e. “piosphere patches” recognises the potential contribution to landscape vegetation diversity of areas of localised elephant impact, by providing sacrifice zones or areas where impact-tolerant vegetation may thrive.

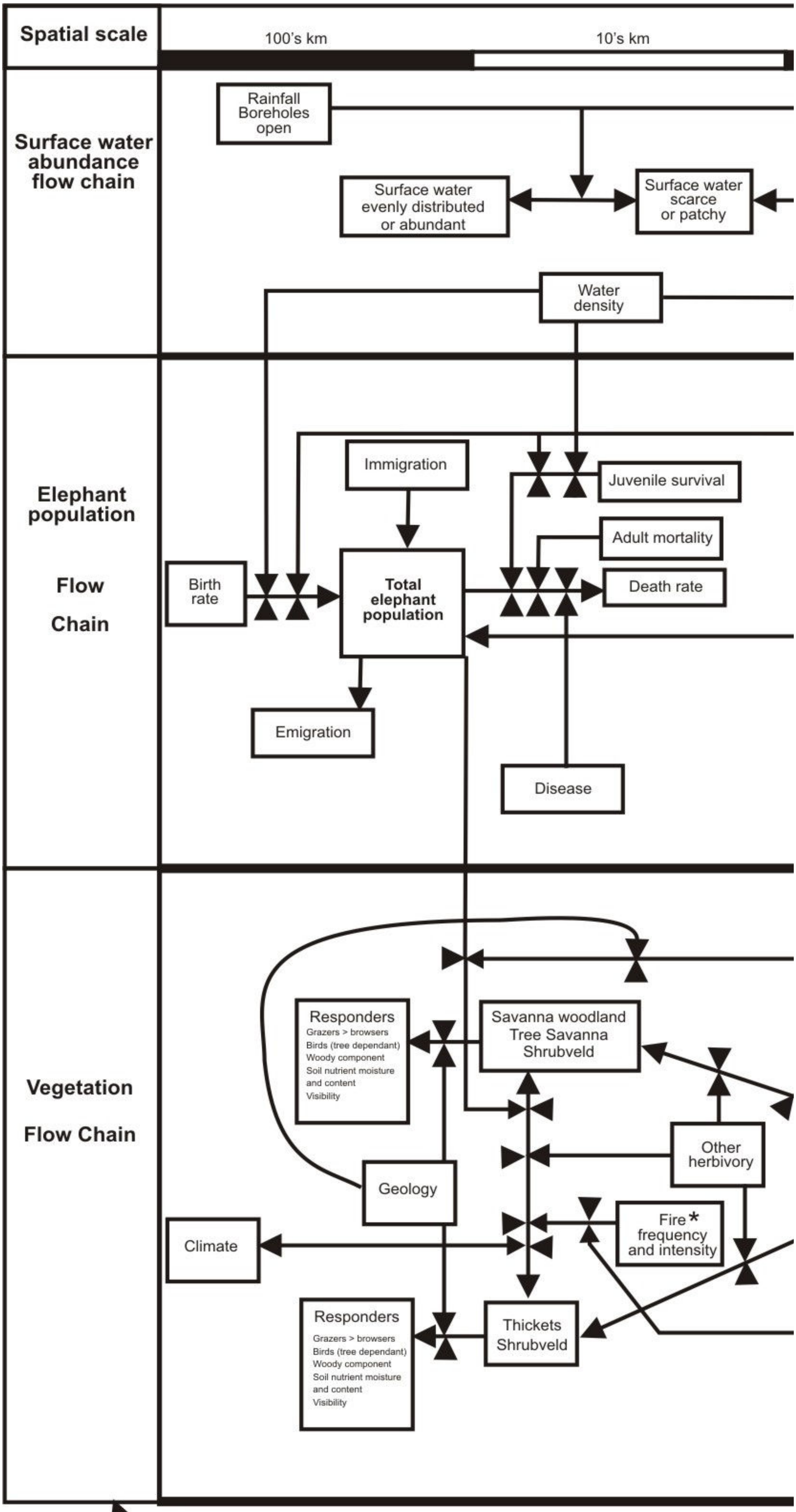
CONTROLLERS PRESENT IN THE MODEL

1. At the finest scale considered (metres), elephant dietary preferences for particular tree species and size classes (height) determines the intensity of impact on individual plants.
2. Species- and size-specific susceptibility to elephant impacts determines whether the individual will survive the elephant impact or simply be knocked back into a smaller size class by the removal of biomass. Mortality of individual trees changes the relative abundance of tree species (compositional diversity), while mortality and removal of biomass contribute indirectly to changed compositional diversity by changing the size class distributions, and hence directly to changes in structural diversity, of species.
3. At the local (10s of kilometers) scale, the presence of surface water controls the local density of elephants and the precise localities at which they feed in the landscape – points in the landscape close to water have higher impacts than points remote from water, creating piosphere patches of altered compositional and structural diversity of woody species;

4. Along with the distance to water, the degree of isolation of a particular surface water pool from other pools controls the local density, and hence feeding intensity, of elephants at any point in the landscape. For instance, the local density of elephants is higher near to an isolated waterpoint than midway between isolated waterpoints. In contrast, the local density of elephants at a point in the landscape that is near to a closely-spaced waterhole will be roughly equal to a point midway between two closely-spaced waterholes
5. At the broadest scale examined (100's of km), rainfall and the number of boreholes kept open by management controls whether surface water is abundant, and therefore homogeneously distributed across the landscape, or whether it is more patchily distributed and therefore present or absent at any particular point in the landscape;
6. Geology and climate are also broad-scale controllers of the rate at which elephants potentially change savanna woodland to shrubveld. For the sake of simplicity, and since geology and climate change over much longer time-scales than the timescale overwhich elephants change diversity, geology and climate were not given their own flow chains as was surface water.
7. Other herbivores also control the rate at which vegetation is changed from one state to another, and can work in concert with elephant impacts to bring about these state changes (for example impala browse on seedlings, slowing down the regeneration of trees, as reported by recent Chobe studies). This controller could potentially have its own flow chain in order to elaborate upon the mechanism by which other herbivores control savanna vegetation state changes. However, for simplicity it was simply included in the vegetation flow chain.
8. Finally, fire is a very important controller of the rate of vegetation state change both on its own, and in concert with elephant feeding. As such it probably deserves to have a flow chain of its own, linked to the vegetation flow chain in a similar manner as the surface water flow chain. Time did not allow for such an elaboration in this draft framework. However, this is a good example of how the framework can serve as a Knowledge Management tool, as a fire flow chain can easily be incorporated at a later stage (as indicated on the diagram).

BIODIVERSITY RESPONDERS IN THE MODEL

1. Responders represent the "knock-on" effects to biodiversity that result from the changes to savanna vegetation brought about by elephant feeding activities;
2. Biodiversity responders occur at multiple spatial scales corresponding to the particular state and scale of the substrate (savanna vegetation);
3. The responder component of the framework highlights a surprising lack of research directed at the "knock-on" biodiversity consequences of elephant impacts on vegetation to date, given the amount of concern for such consequences.



* Since fire is a major driver of vegetation change, a more detailed fire flow chain could