CHAPTER 2

The spatial implications of incorporating viable populations into conservation area selection procedures

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1. INTRODUCTION

Although there is broad agreement about the need to conserve as much biodiversity as soon as possible, the most appropriate mechanism for achieving this objective has a protracted history. Meyers (1990) and Reid (1998) suggested that the conservation of hotspots (areas high in species richness, containing numerous endemic species or vulnerable species) would conserve the most species in the smallest area. These components are also frequently evaluated independently from one another (Gaston & Davis, 1994; Lombard, 1995; Mittermeier *et al.,*1998; Reid, 1998). In contrast, Margules *et al.* (1988) argued that in order to preserve maximum biological diversity in a given area, every possible species should be included in conservation area networks. They suggested that the goal of biodiversity representation can best be achieved by employing iterative algorithms that aim to represent all natural features using the principle of complementarity (Nicholls & Margules, 1993; Pressey *et al.,* 1993). Williams *et al* (1996) effectively demonstrated how the complementarity approach was significantly more land-use efficient at sampling regional features (species) than richness hotspots or rarity hotspots.

Binary data (presence/absence) form the platform for most iterative studies aimed at identifying representative conservation area networks (Nicholls & Margules, 1993; Sætersdal *et al.,* 1993; Williams *et al.,* 1996; Howard *et al.,* 1998; Van Jaarsveld *et al.,* 1998). Since abundance data are generally unavailable for most species (Davis *et al.,* 1990), the focus in conservation area network design is frequently to include at least one, or possibly more, representations per species. Freitag and Van Jaarsveld (1995) used a criterion of 3-5 records per species, whereas Williams *et al.* (1996) pursued at least 6 representations per species. More recent studies have aimed at incorporating notions of viable populations by selecting increasing numbers of individuals using abundance data (Nicholls,

1998) or by adding the criterion of viability indirectly into area-selection methods (Williams, 1998). For example, at the preselection step, one possible measure of viability - albeit very crude - is to only include records with evidence of breeding (breeding birds - Wessels *et al.,* 1999). Furthermore, niche-based modelling of the local habitat suitability can be used to exclude records for certain species from all areas where they have a poor viability prognosis. Probability models can be used to seek out "viability centres" for required species by interpolating the expected distribution of relatively well-known species and relatively widespread species where spatial information is used to model some aspects of "niche space". In this manner expected distributions and the potential viability of species can be predicted for unsampled areas (Williams, 1998).

In the present study we aim to examine the spatial implications of selecting viable populations of large herbivore species (acting as umbrella species) using the Kruger National Park annual aerial census data. These census data were collected in a spatially explicit manner (Joubert, 1983; Viljoen, 1989; Viljoen and Retief, 1994; Viljoen, 1996). The aims of the study are (1) to quantify the spatial implications of jointly selecting viable populations of 12 large herbivore species as opposed to single species representations, (2) to evaluate the impact of habitat quality, and (3) the impact of varying species densities on the distribution patterns and spatial requirements of viable populations.

2. METHODS

a) Study area

The study area comprises the Kruger National Park (KNP) situated in the Northern and Mpumalanga Provinces of South Africa, encompassing an area of roughly 20 000km^2. It is situated in the Savanna biome of South Africa, and consists of seven different Savanna vegetation types (Low and Rebelo, 1996). The mean annual rainfall for this area, measured over a period of 73 years (1919/20 – 1992/93), is 534mm. Long-term mean temperatures in the Park range between 15.8°C and 29.7 °C over the same period of time (Zambatis and Biggs, 1995).

## b) Animal abundance and distribution data

The present study investigates the spatial implications of selecting and incorporating large herbivore populations into conservation area planning. Point data obtained from the annual ecological aerial census for 12 unmanaged large herbivore populations in the KNP, that were obtained for the period 1981-1992, were reclassified into grid cell networks of $4km^2$, $12.5km^2$ and $25km^2$ respectively. The twelve large, unmanaged herbivore species occurring in the KNP used in the study, are impala *(Aepyceros melampus)*, blue wildebeest *(Connochaetes taurinus)*, zebra *(Equus burchelli)*, white rhinoceros *(Ceratotherium simum)*, giraffe *(Giraffa camelopardalis)*, kudu *(Tragelaphus strepsiceros)*, sable antelope *(Hippotragus niger)*, eland *(Taurotragus oryx)*, warthog *(Phacochoerus aethiopicus)*, waterbuck *(Kobus ellipsiprymnus)*, tsessebe *(Damaliscus lunatus)* and the roan antelope *(Hippotragus equinus)*.

c) Land classification systems

Within the KNP a variety of differently scaled land classification systems have been developed, namely: land systems (Venter, 1990), land types (Venter, 1990) and landscapes (Gertenbach, 1983). These classifications, together with vegetation types (Low and Rebelo, 1996), were employed to explore the spatial consequences of conserving viable populations of large herbivores (Figure 1). The land system classification (Venter, 1990), comprising 11 land systems was developed on the basis of geology, geomorphology and broad climatic attributes. These land systems were further classified according to soil type, vegetation type and landform into 56 land types (Venter, 1990), with the land types nesting naturally within the borders of the land systems. Each land system comprises of between one and 12 land types. Thirty-five landscapes (Gertenbach, 1983) were identified according to specific geomorphology, climate, soil, vegetation pattern and associated fauna. Vegetation types (Low and Rebelo, 1996) are defined as those units that have a similar vegetation structure, sharing important plant species and having similar ecological processes.
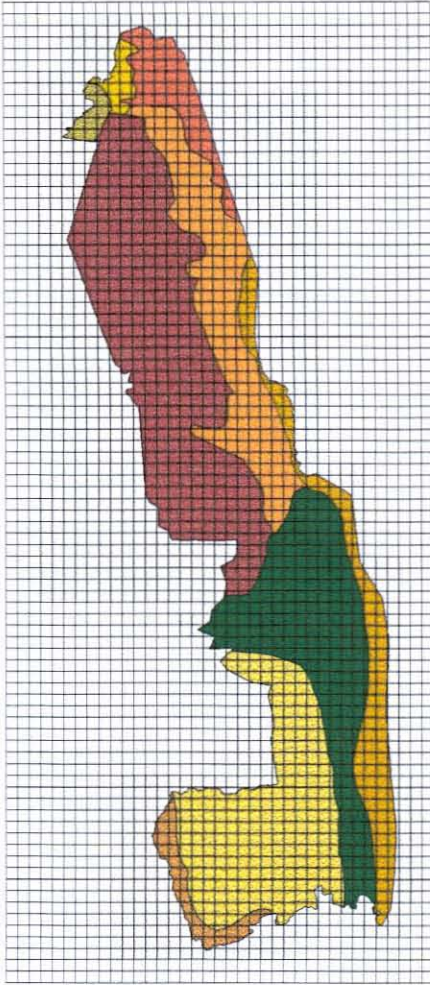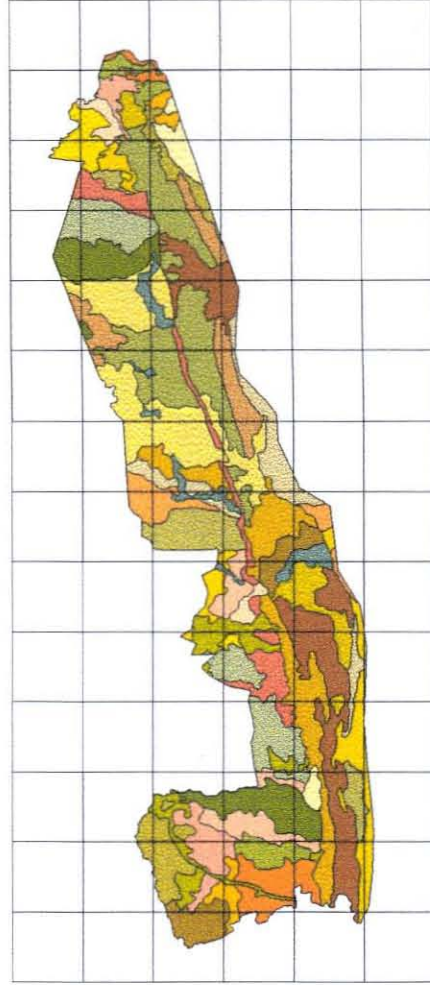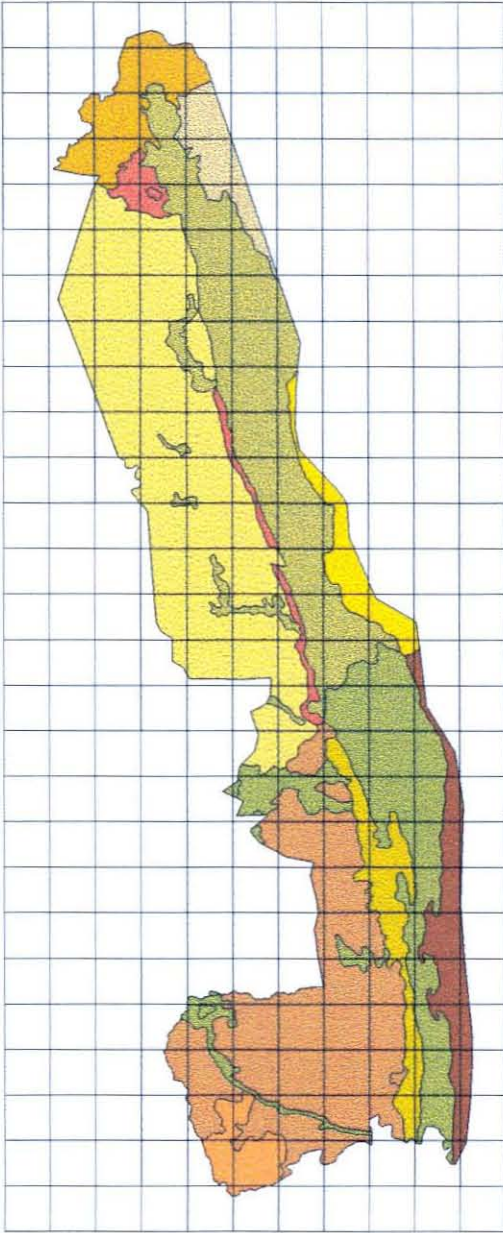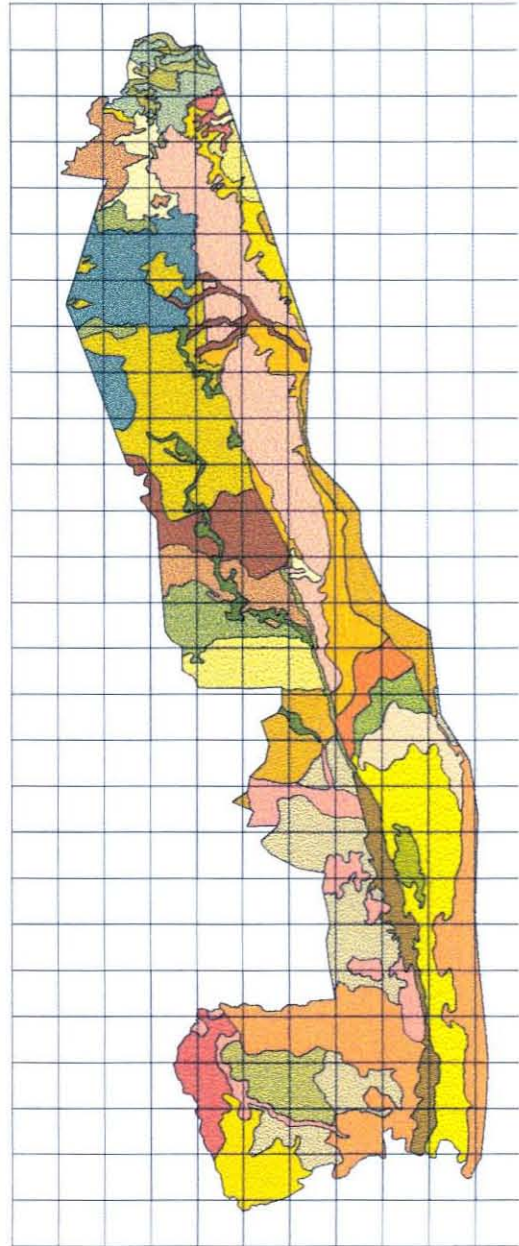
i)　　　　　　　　　　　　ii)

Figure 1: i) The broadest scaled land classification system, vegetation types, intersected with the 4km^2 grid cell network, and

ii) the finest scale land classification system, land types, intersected with the 25km^2 grid cell network.

iii)

iv)

Figure 1: iii) Land systems, an intermediate scaled land classification system, intersected with the 12.5km^2 grid cell network.

iv) Landscape classification intersected with the 12.5km^2 grid cell network.

d) Scaling

In the present study fine, intermediate and broad scale grains were used (Wiens, 1989), namely: a $4km^2$, a $12.5km^2$ and a $25km^2$ grid cell network. These grids cell networks were intersected with each of the four land classification systems respectively, using ArcInfo® GIS (ESRI, Inc., Redlands, California, USA). This resulted in 12 scale combinations (Table 1), and for each of these, information on the area of every land classification unit within a particular grid cell.

Table 1: A summary of the scale combinations used.

Land type	Land system
Land type and $4km^2$ grid	Land system and $4km^2$ grid
Land type and $12.5km^2$ grid	Land system and $12.5km^2$ grid
Land type and $25km^2$ grid	Land system and $25km^2$ grid
Vegetation type	Landscape
Vegetation type and $4km^2$ grid	Landscape and $4km^2$ grid
Vegetation type and $12.5km^2$ grid	Landscape and $12.5km^2$ grid
Vegetation type and $25km^2$ grid	Landscape and $25km^2$ grid

e) Population selection

An algorithm was coded that selects increasing target population sizes of all herbivore species, and then quantifies the area of each land classification unit fortuitously included by the selection of these target populations (see Appendix 1 for selection rules). The numbers of individuals selected are related to the grid cells in which they occur, and these grid cells, in turn, are related to the area of each classification unit within the chosen grid cells. The study was not restricted to one possible MVP size, but extended to incorporate a spectrum of possible population sizes. This was done in order to quantify the impact of increasing

population sizes on conservation area selection procedures. Population sizes of 50, 100, 200, 500, 1000, 2000, 5000 and 10000 individuals were used successively. Each algorithm was run 500 times for each of the 12 scale combinations, and for each of the four years, in order to evaluate the outcomes statistically.

f) Habitat quality

Ecological aerial census data from four years were used. Two years had an above average rainfall recorded (1981, 1985; $\bar{x}$ = 774mm) and two years had a below average rainfall (1983, 1992; $\bar{x}$ = 267mm). This was to determine the possible spatial effects of varying habitat quality on the spatial distribution patterns of these herbivore species.

To determine whether changes in habitat quality affect the spatial distribution of individuals across the study area, we tested for significant differences between the data derived from the four years. As habitat quality and species density in one year influences following years, these data are not independent. Kendall's Coefficient of Concordance (Zar, 1996) was therefore used.

$$W = \frac{\sum R_i^2 - [\sum(R_i)^2]/n}{[M^2(n^3 - n)]/12}$$

Correlation, or association, between more than two variables can be measured nonparametrically by Kendall's coefficient of concordance. Ranks for each of the variables have to determined from frequency distributions, and these distribution data ranked according to Kendall's method to obtain R_i values, where R_i is the sums of ranks, M is the number of variables being correlated and n is the number of data points (number of classes in frequency distribution) per variable. A W-value close to one indicates high concordance (association) between the different data sets, and the closer this value gets to 0, the less association exists between the data sets.