CHAPTER 4

Is geographical zone surrogacy effective for selection of representative biodiversity, or is the fixed percentage rule counterproductive? *

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Is geographical zone surrogacy effective for selection of representative biodiversity, or is the fixed percentage rule counterproductive?

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Conserving representative biodiversity has become a common goal among scientists and conservation planners alike. The question is how to achieve this goal effectively, both in terms of costs and land-use. Since very little accurate abundance data exists, the heuristic and iterative algorithms which are frequently employed, rely on presence/absence data as input, and the resultant output is less than ideal. The only alternative proposed thus far, is to conserve a fixed percentage of each biome in a country. Here, the practical conservation implications of this rule are contemplated, analysed and discussed. We conclude that the fixed percentage rule is counterproductive in conserving biodiversity, and that the most cost-effective way to conserve species across a landscape is to base analyses on thoroughly sampled data.

Introduction and background

A common approach towards the selection of representing biodiversity in a region is to select say 10% of the area of every class in a particular classification system (e.g. vegetation types). Indeed, this is recommended by the Rio Convention (IUCN,1992). During a recent study conducted in the Kruger National Park (KNP), examining how successful randomly selecting a fixed percentage of each of the classes of different classification systems (e.g. landscape, geological area, vegetation type) might be including Minimum Viable Populations (MVP) of 12 large herbivores in the KNP, a seemingly paradoxical result emerged. Instead of one classification system giving more efficient results than another (i.e. combined MVP's of all 12 species in a smaller area), all seemed to perform similarly. The graphs relating the number of individuals per species to the surface area selected, appeared linear (Figure 1), implying that the species might be evenly spread across the Park at the scale of our examination.

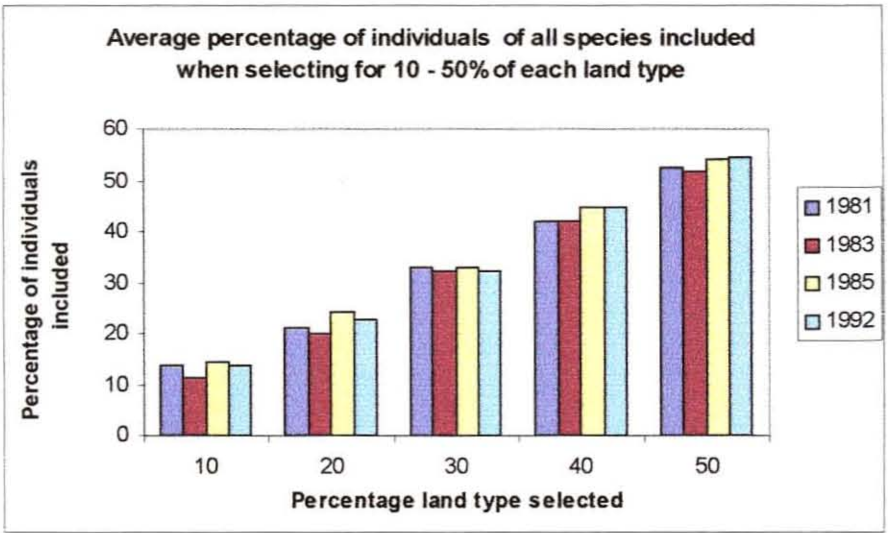

Figure 1: The average percentage of individuals included when 10 - 50% of each land type is selected in the KNP.

Methods

This question led us to set up a simple model to determine the driving factor behind the linear relationship between number of individuals and size of area. In this model one can distribute an alterable/changeable number of individuals of different species in different ways across a hypothetical reserve, consisting of a variable number of zones.

In the model, population sizes of the hypothetical species could be varied to test the influence of varying levels of population densities in different classes. The species were invariably distributed unevenly across the zones, but randomly within them with different degrees of overlap between classes (Figure 2).

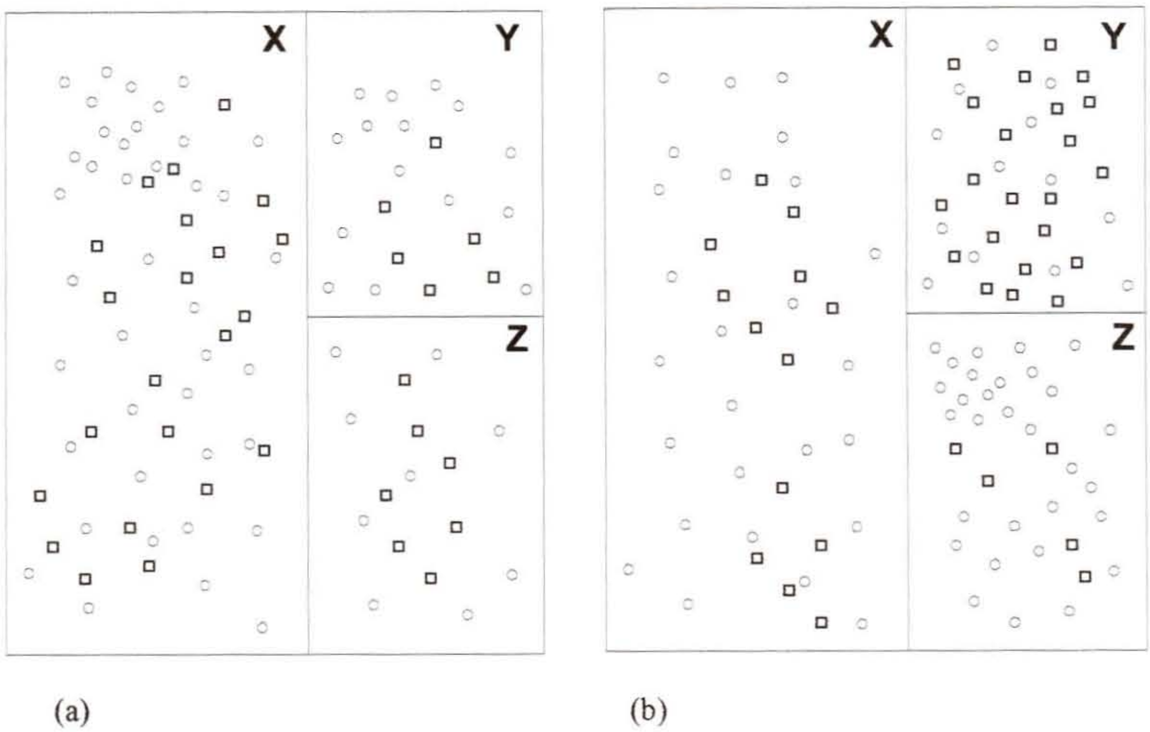

Figure 2: The distribution of two hypothetical species distributed at varying densities across a landscape comprising of three hypothetical zones.

The number of zones as well as the zone sizes could also be altered. The only constant was that a uniform percentage of each zone was always selected for that particular run, in accordance with the Rio convention recommendation. An algorithm was coded where the user has to specify a fixed percentage of each zone that has to be selected. The algorithm always starts out at a random point, and proceeds to find the next grid cell of the first, randomly selected zone, or of a zone that is still underrepresented. It continues until the specified percentage of each zone has been reached, and the numbers of individuals fortuitously included through this selection is then quantified.

The objective of this paper is to quantitatively evaluate the use of the fixed percentage rule using the model described above. In developing the model, we recognised a number of potential shortcomings and extended the model to incorporate these. These emergent themes will become clear as the argument develops.

Results

Regardless of how each variable was changed and in what combination it was used with other variables, the model continued to generate linear responses (Figure 3). This seemingly trivial result, similar to the observed system in Figure 1, is seen to be due to the "random" species distribution within each polygon and the fact that a fixed percentage of each surrogacy zone was chosen. Varying the number of polygons, and thereby changing the scale of the classification system, had no significant influence on the results. The final test result sought (combined area selected to give MVP's of all species) differed only in that this total percentage was reached as soon as (usually) the MVP for the rarest species was reached.

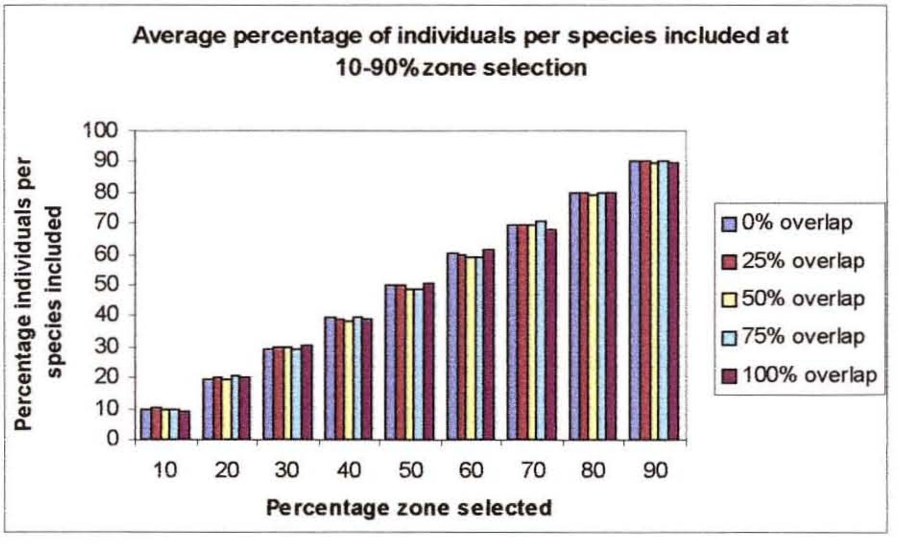

Figure 3: The average number of individuals of all species fortuitously included through the fixed percentage zone selection.

Assuming that this hypothetical system consists of three polygons when a single land classification system is used, and with individuals of a species being distributed across the polygons as shown in Figure 4 (a). Irrespective of where the selection process starts, selecting 10% of each of these polygons will obviously only result in a single outcome in terms of proportional zone sizes associated with that selection process, and the percentage individuals will be proportional to that specified area.

Now, assume another land classification system used with polygon boundaries as shown in Figure 4 (b), where the distribution of individuals in space remains the same. We can now either proceed with surrogacy selection on the three polygons, and the starting point will determine whether a larger or smaller (or perhaps similar density) population is included for that zone. If the starting point happens to be in a high density cluster, a larger number of individuals will be included when a fixed percentage of each polygon is selected. If the selection started in a medium density cluster, the outcome will be very similar to the outcome in Figure 4 (a). If, however, the selection process started in a low density cluster, fewer individuals will be included through the selection process. Presumably the formalisers of the "Rio concept" were assuming, at least implicitly, that each species is randomly distributed at different densities in each polygon or biome (the different species in these polygons are not necessarily distributed at the same densities). If they were not assuming this, they were certainly running the risk of the starting and/or subsequent follow-up points severely influencing the result in a positive or negative way as outlined above.

Alternatively, we can re-define the system. When turning the areas of species richness hotspots into homogenous polygons (Figure 4 (c)), and adding this to the data set as a new type, i.e. when delimiting the areas containing the clusters and making those new polygons of a new type - if this is feasible - the two arguments converge. Now, when selecting 10% of each type under these conditions, one will still only select 10% of each population, since these clusters containing most individuals are now a new type, and selecting 10% of this type will include 10% of the individuals.

Optimally we would want to be able to select individuals disproportionately to area (i.e. pick out those areas which will give us efficient selection - more "value for money" in terms of area selected).

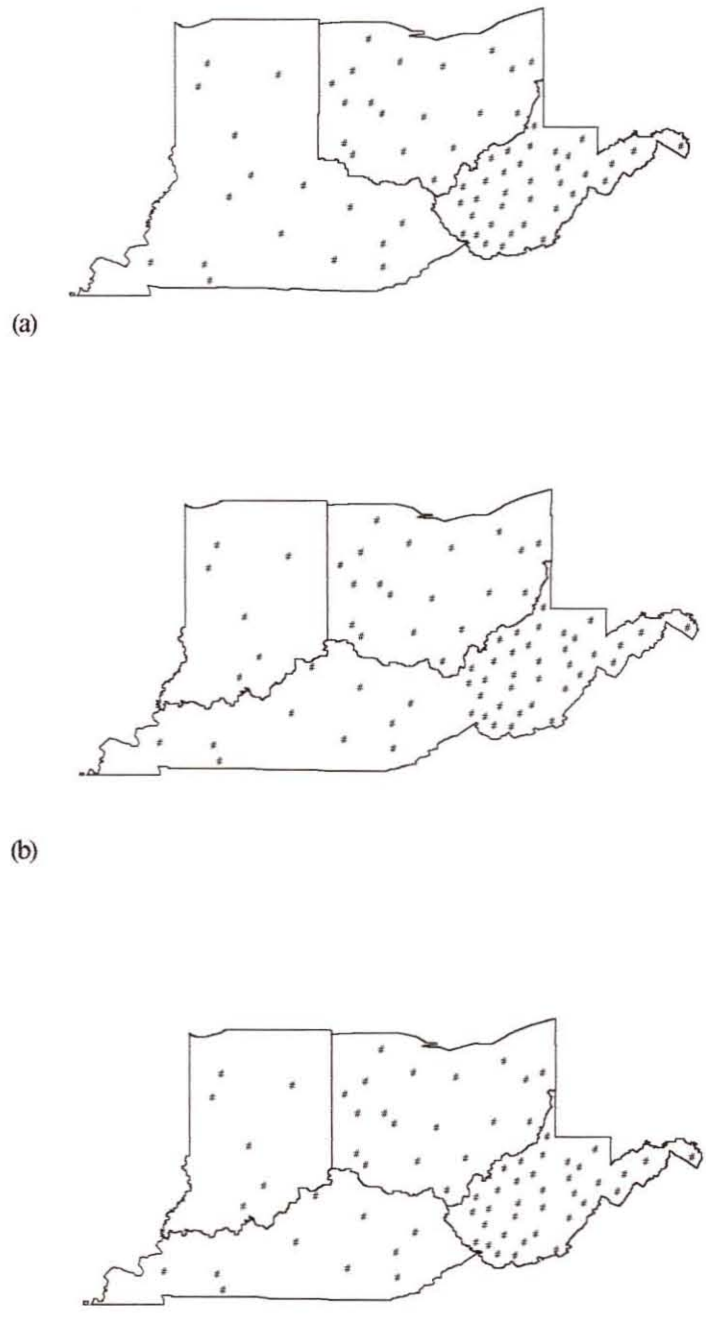

Figure 4: A reclassification of zones across the landscape with species distributions remaining constant.

Discussion

Under these circumstances a major corollary which is obvious, is that it will not help to use one broad-scale classification system rather than another (as long as they meet the two assumptions), since varying the number and sizes of zones did not change the results (Figure 1). The assumptions are that a uniform percentage is selected in each run, and that there is a relatively homogenous distribution of each species within each area.

Note that under the fixed percentage rule, there is no way to increase the efficiency of selection of the smallest amount of land to encompass a MVP. We also examined the influence of scale (pixel size) within the extent of the study area and found it to be negligible.

A re-projection of any clustered system thus appears to be able to be conceptualised as a system with more polygons, each one now with a homogeneously-spaced population within itself. In doing this, we no longer have the original classes of the classification system, but rather a new pseudo-class of homogenous density. Richness-based algorithms (Nicholls & Margules 1993; Pressey *et al.* 1996; 1997) usually do not start with a known classification system, but by selecting the richest cells or cells containing the rarest biota. In order to increase the efficiency of selection, i.e. include more individuals than a number proportional to the percentage area selected, one can either try to influence the starting point and subsequent rules to select clusters of high species density in a polygon (Figure 4 (b)) or select higher percentages of the high-density polygons in Figure 4 (c). The difference here is that the fixed percentage rule is not applied in the first step of identifying the homogenous high density areas, i.e. species rich spots are selected out of proportion to moderately low or species poor spots. This disproportional selection of areas in polygons is the only solution to move away from the linear relationship between percentage area selected and the percentage of individuals fortuitously incorporated through this area selection. According to the source-sink argument (Pulliam, 1988) there exist areas where the within-habitat reproduction is insufficient to balance local mortality (referred to as "sink" areas), and these areas only subsist because they are being locally maintained by continued immigration from more-productive "source" areas nearby. If these source areas can be captured through a selection process, rather than sink areas, a positive deviation from linearity will be obtained.

Conclusion

These are the results of a theoretically linear system with homogenous species distributions within each land class, and there appears to be no way to improve the effectiveness of a fixed percentage land area surrogacy system. All combinations of density and distribution, and the scale of the selection process, appear to make no significant difference. Although the formalism we have illustrated is straightforward and obvious once demonstrated, we believe it to be somewhat counter-intuitive. It seems attractive to believe that a fixed percentage (say 10%) of the world's surface may protect all species, but if the assumptions laid out in this paper are explicitly (or more usually inadvertently) made, whether or not this is true will depend on whether that fixed percentage may be including MVP's of the rarest species. In practice, this percentage turns out to be far higher than the 10% recommended (IUCN, 1992). The minimum percentage area required for adequate conservation will simply turn out, under these rules, to be the percentage area needed to yield a MVP of the rarest species.

We conclude that geographical surrogacy is, at least when argued in these terms, thus almost a non-concept, with the area required to support an MVP of the rarest species requiring conservation, actually becoming the deciding factor. We consequently suggest that the fixed percentage rule be seriously reconsidered, possibly to be replaced with a system differentially concentrating on areas with higher conservation potential (source areas). Even knowing all the difficulties associated with richness and rarity based algorithms, it seems that there is no practical, cost effective alternative to selecting higher percentages of areas which carry higher biodiversity. Since conservation actions are only as good as the quality of the data on which they are based (Koch, 1999), it is imperative that biodiversity surveys be invested in. Although compiling biodiversity inventories is very costly in terms of time and money, it has been shown by Balmford and Gaston (1999) that using well-sampled data, obtained from detailed surveys, results in the requirement of smaller representative reserve networks than when incomplete data are used. Furthermore, since conservation actions are only as good as the quality of the data on which they are based, it is imperative that biodiversity surveys be invested in. It is believed that only once the abundance-related stratification of species across a landscape is known, or if the location of source populations can be established, that the most cost-effective MVP's can be selected.

The argument in this paper rests on the number of individuals per species, aiming at viable populations. Even if the goal of conservation planning and conservation area selection procedures is only to represent as many species as possible in the limited land surface areas available to conservation possible (ignoring viability), the 10% proposed by the World Conservation Union (WRI, 1994) is an encouraging target but not adequate if these areas are indeed the only areas where populations or subpopulations are being conserved. In a study in South Africa evaluating the use of vegetation types as a possible surrogate for biodiversity using presence/absence data for 7 faunal taxa, it was found that at 10% vegetation type selection 56.2% of all species in the database were represented, and this figure increased to 87% species representation at a 50% vegetation type selection level (Figure 5).

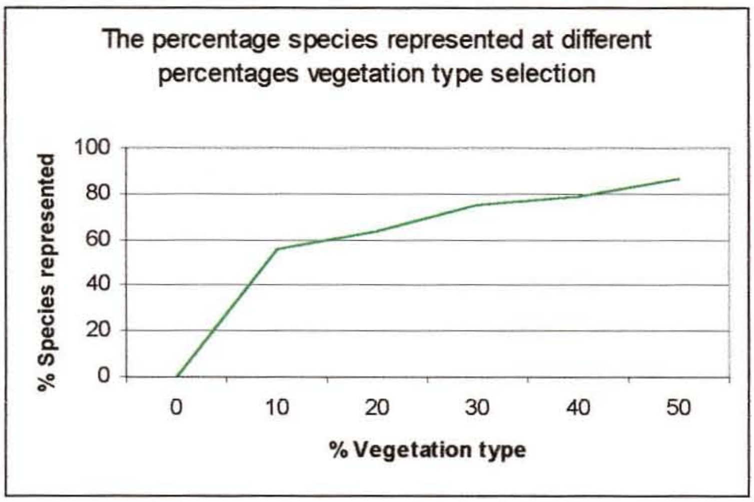

Figure 5: The percentage of 7 faunal species included at increasing percentages vegetation type selection

Similar results were obtained by Soulé and Sanjayan (1998) where they found that if only 10 - 12% of the Earth's ecosystems are afforded protection, more than half of all terrestrial species will be vulnerable to extinction in the near future.

Moreover, if national and international conservation goals are to conserve viable populations of all species, thereby securing all species' long-term persistence and survival, the fixed percentage rule appears ineffective and should be reconsidered.

Acknowledgements

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