

Setting Thresholds of Potential Concern for Heterogeneity / Aggregation.

Rationale

This integrated TPC is required to track a loss or potential loss of biodiversity. As heterogeneity is the ultimate source of biodiversity (Pickett 1998), this TPC at this stage concentrates on detecting an undesirable loss of heterogeneity. To detect a change in heterogeneity it must be able to detect any loss of combinations of species and structural components in the different landscapes represented in the KNP. The ideal would be to use a complementarity approach (Pressey et al. 1994) which could identify unique combinations and the loss there of. Such a TPC would thus incorporate the most important aspects of diversity into a single overall index that links complex interactions between biota and their environment (Woinarski et al. 2005). However, the complementarity approach requires the examination of many interacting and dynamically changing taxonomic and structural groups which is very difficult. We decided to test this aggregation approach by simplifying the issue of concern to the loss of heterogeneity rather than loss of complementarity.

We propose to initialise the development of this complex process by evaluating the extent of homogenization at three different scales where possible. The coarse scale accounts for different morphological areas across the KNP, the intermediate scale accounts for areas with similar geology, soil type and rainfall, and the fine scale accounts for differences in terrain unit from crest to valley bottom within each landtype (Venter 1990). Homogenization is at this stage evaluated as a loss of dissimilarity in the most important components of this ecosystem at the three different scales. To be able to evaluate the potential homogenization or loss of diversity for the entire system each component is evaluated against a predetermined threshold of expected dissimilarity (based on the best available theoretical threshold) and either passes or fails the test. The number of failed components is then aggregated in the final evaluation of the exceedance of the TPC.

Categories of concern to be examined in the homogenization TPC:

Structure

Patchiness and diversity in woodland structure have been shown to influence biodiversity significantly e.g. (August, 1983; Cumming et al. 1997). The loss of vertical structural components (complexity) according to August (1983) such as tree height, canopy size, canopy height, and height of herbaceous vegetation should track habitat loss, as well as the recruitment of woody seedlings. Patchiness (the distribution of herbaceous and woody patches horizontally) (heterogeneity as defined by August (1983)) also accounts for loss of habitat, predation risk and should detect degradation of the herbaceous layer. The most efficient method for the estimation of patchiness still needs to be evaluated but some form of remote sensing will probably prove to be most practical. Complexity will be evaluated at all three scales, but patchiness will probably not be evaluated accurately enough at the finest terrain unit scale

Composition

Diversity of woody, herbaceous and large mammalian species are included as separate components. Smaller species will be incorporated by using both horizontal and vertical vegetation structure as well as data from biodiversity surveys, the presence of two important habitats: termite mounds and dead logs will also be noted.. Ants may be valuable ecological and biodiversity indicators (Andersen et al. 2004), and will probably be included as a separate layer once sufficient data becomes available.

Function

At this stage only vegetation (herbaceous as well as woody) will be examined at the fine catenal scale, thus, only for vegetation can we address the three scales necessary for understanding processes as suggested by Gillson (2004). Furthermore, function is difficult to measure as a specific entity and will at this stage be evaluated implicitly by taking woody and herbaceous composition into account in the aggregate. This will thus reflect system changes associated with the convex relationships between woody and herbaceous species Scholes (2003) as well as changes in grassland function and stability as reflected by changes in herbaceous composition e.g. (Kennedy et al. 2003; Sankaran & McNaughton 1999). This aspect needs to be developed further before it can be included as a separate layer.

For each classification at the coarse and medium scale 11 components will initially be evaluated. These will incorporate the various elements of woody and herbaceous vegetation, aggregated surrogates for vertebrate and invertebrate species as well as large herbivores. The dissimilarity in each individual component will be evaluated against the limit in number of similar and dissimilar sites for each classification unit, which will be calculated using historic reference surveys. Each component will either pass or fail depending on whether these limits are exceeded. The TPC for homogenization will finally be exceeded if:

1. The woody structure component fails (The reason for this strict criterion is the importance of woody structure for biodiversity (Cumming et al. 1997))
2. If any other two layers fail.

At the finest scale, this TPC will not include large herbivores as these animals can at this stage not be monitored at this fine scale. This finest scale will however, take an extra dimension of habitat diversity into account by including specific habitat surrogates (Margules et al. 2003). This aspect will be developed further as information becomes available and the relationship between habitats and species makes it possible to replace habitat diversity with species diversity .

This TPC still has certain drawbacks:

This TPC is about preserving the spatial dissimilarity (heterogeneity) we historically had (according to the Gertenbach surveys) which may not be ideal.

We usually have no idea whether the current values are desirable but in general we don't want decreases.

This TPC may tend to constrain temporal heterogeneity within the analysis unit, though allowing dynamism between sampling points in a unit

It must be kept in mind that under certain circumstances degradation can be associated with an increase in heterogeneity. However some of the other TPCs should cover this possibility.

If required a maximum cutoff level for dissimilarity can be included in the calculation (i.e. putting a lid on heterogenisation).

This TPC needs to be developed in more detail to exploit the richness of the underlying data and possibly to address indicators of system function such as nitrogen fixation rather than just species diversity.

Scale

Coarse scale:

As discussed under scale, the KNP will be classified into 5 classes of topographical richness (Fig. 1).

Medium scale:

The existing landtype classification of Venter (1990) will be used at this scale resulting in 56 classes. The TPC's here will be set by not only using the historical data, but also by taking the sensitivity of the zone to species loss into account (Fig. 3)

Fine scale:

Each landtype has been classified into different terrain units (catenal position) by Venter (1990). This consists mostly of 4 classes or terrain units: upper slope, midslope, footslope, riverine and specialized sites such as sodic site and koppies.(Fig. 4)

Future

At this stage the TPC has 11 layers which incorporate elements of woody vegetation, herbaceous vegetation, herbivores and habitats for smaller creatures. These layers were each given a score of either 1 if it passed or 0 if it failed. All the scores were then summed to determine whether the TPC was exceeded or not. We will be refining this scoring system by classifying the layers into three categories namely structure, function, and composition. For each one of these we will have the same number of parameters and then use a multiplicative scoring approach. If we attempt to include the habitat layers into this analysis we will need to convert them into dissimilarities as the other layers currently are. As this TPC aims at giving us a handle on patchiness, we would like to include some sort of visibility index (as related to predation) into it. This will either be calculated from existing data or from actual visibility measures.

TPC

Components to be evaluated

To evaluate homogenization various themes that are important contributors to heterogeneity are evaluated, namely:

Woody vegetation

Herbaceous vegetation

Herbivore diversity

Species diversity

Woody vegetation

The woody structure is evaluated at three levels:

Variation in heights of woody species in the analysis unit

Variation in canopy volume in the analysis unit – this aspect will be re-evaluated as data on species associations with different canopy densities become available.

Variation in visibility associated with vegetation structure

Woody patchiness

The patchiness will be taken into account by looking at the variation in different patch types (patches at different heights and sizes; patch = similar height class with touching canopies)

Woody species diversity:

Variation in species assemblage between sites in a classification unit

Herbaceous vegetation

Variation in herbaceous structure (different heights and densities of the height classes)

Patches of herbaceous vegetation at the same height (patch = touching grass canopies)

Species diversity: Variation in species assemblage between sites

Large herbivores

Species diversity: Variation in species assemblage between 1km² cells in landtypes covered sufficiently by the aerial census.

Small herbivores

These are covered by using biodiversity surveys and by the vegetation layers as well as:

Invertebrate and vertebrate species are recorded during surveys (These will be examined in separate layers when sufficient data is available). Because of the limited data sets available other approaches to decide on the cut-off points for similar and dissimilar pairs will have to be investigated.

Evaluation of dissimilarity

To detect spatial diversity at each classification unit, the dissimilarity index is used.

For the dissimilarity index each site within classification unit will be compared with each other site. The dissimilarity of each pair will be compared using the Bray-Curtis measure:

$$\sum |X_{ij} - X_{ik}|$$

$$B = \frac{\sum |X_{ij} - X_{ik}|}{\sum (X_{ij} + X_{ik})}$$

B_{ij} = Bray –Curtis measure of dissimilarity ranges from 0 (similar) – 1 (dissimilar)

X_{ij}, X_{ik} = Number of individuals of species i in each sample

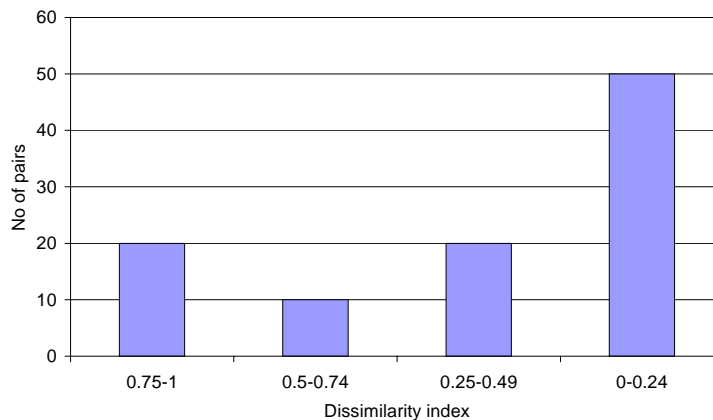
n = number of species in samples

This measure ignores cases in which species is absent in both community samples and it is dominated by the abundant species, so rare species add very little to the value of the coefficient.

Each combination of pairs will thus have a dissimilarity value. These values will be combined to calculate the percentage of pairs in each analysis unit which are above 0.75 (very different from each other) and below 0.25 (very similar to each other).

There are big differences in the distribution function of dissimilarities in most themes when comparing different analysis units (see Fig. 2).

Figure 5 . Example of distribution of dissimilarity indices in a classification unit



The dissimilarity values are relative and only indicate the dissimilarity between the compared sites in a **single analysis unit** (polygon). Dissimilarity scores can thus not be compared between analysis units for an indication of variability.

Evaluation of homogenization of each component

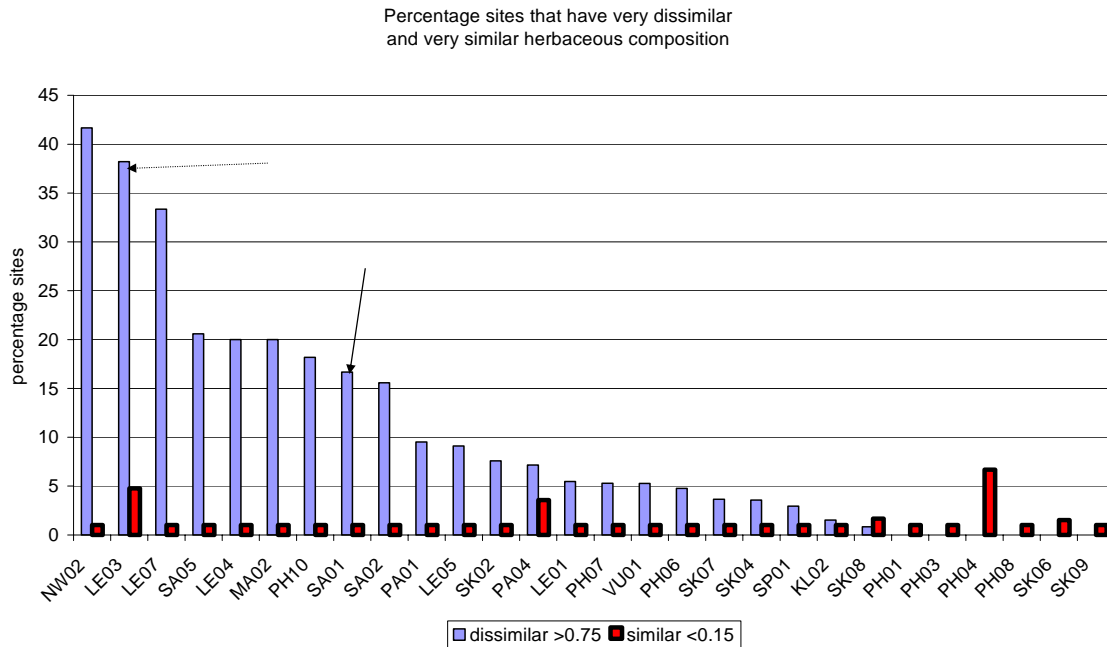
For each component (e.g. woody structure) the percentage of pairs of sites in each classification unit that is very dissimilar (index >0.75) and very similar (index <0.25) will be calculated. This will be compared to the percentage of sites expected to fall in the very dissimilar class and very similar class from historical data collected by Gertenbach (which must still be analyzed). Some analysis units are expected to have a much larger percentage of dissimilar sites than others, and cutoff points will be calculated for classification unit.

Table 4. Example of cutoff points for three landtypes classes indicating the % of dissimilarity scores that should be above and below cutoff points for herbaceous species.

	Northern plains Le3	Satara Sa1	Lebombos K12
Maximum % similar sites (index <0.25)	3	1	0
Minimum % dissimilar sites (index >0.75)	35	15	2

Figure 6. An example of evaluation of the cutoff points for land types

The % sites with dissimilar and similar herbaceous composition for each land types for a specific year. From the table above it can be seen that the Satara landtype (Sa 1) will pass the evaluation of the herbaceous layer. The Mooiplaas landtype on the northern plains (Le3) will fail the evaluation of the herbaceous layer as more than 3% of paired sites have a similar herbaceous composition indicating homogenization.



Homogenization will be evaluated for each classification unit at each of the three scales as discussed above.

It is important to note that the set limits for similar and dissimilar sites only evaluate loss of dissimilarity between pairs of sites in a classification unit. If structure or species is uniformly lost over the entire classification unit, this cut off point will not reflect it.

As a start, each component will be examined independently at each of the three scales (thus woody structure, woody composition, herbaceous structure, herbaceous composition etc. will be evaluated for 5 classes at the course scale, 56 classes at the medium scales and 56 x 4 at the fine scale).

Each component (e.g. woody composition) will pass in its contribution to the overall score evaluated in this TPC, if the percentage of pairs of dissimilar sites are above the minimum allocated in the theoretical threshold and the percentage of similar sites are below the maximum allocated. The layer will fail the test, if the percentage of sites that are dissimilar is below the minimum cutoff point and the percentage of similar sites above the cutoff point.

Table 5 The homogenization TPC for a single classification

Layer to be examined	outcome	
Woody structure	Pass or fail	Must pass. If this layer fails, a TPC is tabled as exceeded
Woody canopy	Pass or fail	
Woody structure below canopy	Pass or fail	
Woody patchiness	Pass or fail	
Woody diversity	Pass or fail	
Herbaceous diversity	Pass or fail	
Herbaceous patchiness	Pass or fail	
Herbaceous diversity	Pass or fail	
Herbivore species	Pass or fail	Not at terrain unit
Small vertebrates & invertebrates	Pass or fail	May not apply in all analysis units
Total	Max of all 10 passes possible	A TPC will be exceeded if woody structure fails, or if any other TWO layers fail

This TPC will be evaluated for 10 components at the coarse and medium scale & 9 components at the fine, terrain unit scale as herbivore data can not be collected at the finest scale.

Table 6. As example of a homogenization, the Satara landtype is evaluated... Values for layers from 2001 woody and herbaceous survey are used for the assessment. The benchmark is arbitrary.

Layer to be examined	Cutoff min % dissimilarity To be calculated these figures are only illustrative	Cutoff max % similar To be calculated these figures are only illustrative	% sites index>0.75 from 2001 survey	% sites index<0.25 from 2001 survey	Pass/fail
Woody structure	10	15	5	48	fail
Woody canopy	7	20			
Woody structure below canopy	15	10			
Woody patchiness	20	12			
Woody diversity	9	20	10	0	pass
Herbaceous structure	15	10			
Herbaceous patchiness	18	13			
Herbaceous diversity:	12	15	16.7	0	pass
Herbivore diversity	30	10	39	2.7	pass
Invertebrate & small vertebrate diversity	To be surveyed				
Total	Woody structure fails thus TPC exceeded				

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