5. THE CRITERIA – THE DESIGN

5.1. INTRODUCTION

The system (see chapter two) is a network of ecologically significant segments of landscape, efficiently distributed on the basis of functional and spatial criteria, covering biotic, hydrological, soil and relief conditions (Mackovčin 2000). An Ecological Network is a selection from this system, which needs to be protected to prevent the sixth extinction. In designing an ecological network many aspects need to be considered. The question is how to select what to include and what to exclude? The selection can be based on expertise and experience (e.g. Herzog and Lausch, 2001) or on statistical approaches (Lausch and Herzog, 2002). In this case the selection is based on expertise (from an expert knowledge base) and some statistical analysis. Once criteria have been selected they need to be arranged in order of importance for evaluation purposes. Once evaluated, the criteria are weighted accordingly.

In this chapter the criteria, gleaned from the case studies and literature review, are analysed and weighted. This analysis is primarily based on the response to the digital interviews (see Appendix 1), which was send to various experts in the field of ecological networks. This analysis serves as the input (criteria and weighting) to the model (chapter 6). An objective, quantitative and spatial approach is used to portray these criteria in the model.

5.2. METHODOLOGY

The methodology followed is loosely based on the outline developed by van der Sluis and Chardon (2001). The problem is defined in chapters one and two, with the systems methodology explained in chapter three. A set of exploratory interviews were held with a number of people in the Netherlands. This provided an initial perspective on some of the initiatives. In chapter four the initiatives in the form of case studies are discussed. From these case studies the initial criteria were extracted and arranged into a digital interview (see Appendix 1 for a summary of the results).

The digital interview was send to 145 organisations and/or persons for response. The approach used, was loosely based on the Delphi method[1], however the iterative process was not followed. The perspective respondents were selected on the bases of previous publications, conference attendance, expertise and known affiliation with ecological networks and GIS. In order to streamline the response process, an electronic questionnaire in the form of a digital interview was developed. This took the form of a stand-alone application. Enabling the user to rank criteria in terms of importance and then within the “level of importance”

[1] Delphi Method: a group of experts is identified and each person is sent a digital interview (Malczewski 1999, pp 111).

dynamically rank the sub-selection. These criteria were analysed by a multiple comparison method, using a pairwise comparison technique. A total of ten responses were received from the digital interviews. Of which seven were complete, and three were partially completed, complicating the analysis. In addition, 4 responses were received where persons did not use the digital interview. These (non interview) responses are incorporated in the general design and process of the model as they are very much qualitative responses. The results of the analysis can be seen as a "wish list" or an ideal list of requirements (weighted criteria) for the design of ecological networks. These criteria have to be spatially analysed (step 3 of van der Sluis and Chardon's (2001) design methodology). This is the role of the spatial model – ENDeM (chapter 6). As the model processes the criteria, they are transformed into a number of spatially descriptive scenarios of possible ecological networks. It is then up to the decision-makers to select the most viable option and implement it. The model will require extensive testing and refinement[2], before it is fully optimised and effective.

Due to the low response rate the initially planned analysis had to be adapted.

5.2.1. Establishing an Expert knowledge base.

To ensure that the results of the digital interviews hold water, an expert knowledge base was sourced. During the literature review it became apparent that there is a core group of experts in the field of designing and developing ecological networks. These people are mostly based in the Netherlands and Europe, with others scattered around the globe. The core group was confirmed though various conference proceedings where the names appear over and over again. These people were contacted with a request to respond to the digital interview.

The beginning of the digital interview was to establish the respondent's rate of familiarity with ecological networks and GIS, to reassess the expert knowledge base. In all cases, familiarity was rated above average for ecological networks, with 40% of the respondents claiming an excellent and 50% a good familiarity. This was confirmed with questions on the location, scale and state of development of known ecological networks. In terms of GIS, the rate of familiarity was more broadly spread with 40% of the respondents claiming to have a fair familiarity of GIS. This confirms that there is a certain level of expertise among the respondent group. Giving the results some weight despite of the low number of respondents.

[2] This is beyond the scope of this thesis. This model will be used as a basis for the spatial analysis and planning of the Gondwana Alive Corridors. It will be subjected to testing within that project.

5.3. CRITERIA

> *"…the challenge is to formulate criteria that will encompass existing national and internationally used criteria.*" (van Opstal 1998)

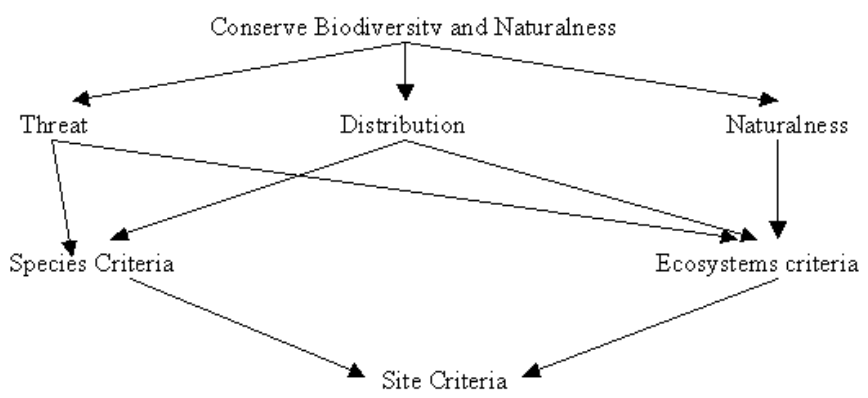
The criteria are the decision rules (van Opstal 1998) which, ultimately determine the result and structure of the model. Once these have been defined properly and their relationship to each other understood the model can be built.

5.3.1. General Criteria for Ecological Networks:

van der Sluis *et. al.,* (2001) give some insight to possible criteria for ecological networks: "Biological diversity is highly dependent on the quality, quantity and spatial cohesion of natural areas. Fragmentation severely affects the abundance of species." As established before a possible solution to fragmentation is the development of an ecological network.

The following figure (5.1) is an argumentation for the basis of criteria for the development of ecological networks. This basis was proposed to the expert knowledge base. Many (70%) of the respondents did not agree with the argumentation as shown.

Figure 5.1: An argumentation for criteria development



(From: National Reference Centre for Nature Management *cited in* van Opstal, 1998)

The suggested alterations are primarily to species criteria and ecosystems criteria. Changing species criteria, to include species dynamics such as dispersal and migration. Relating this to ecosystem criteria. Changing ecosystems criteria to include, defining the need for a network, and defining the minimum area for a viable population. The (meta)population criteria linked to species criteria. Naturalness was not considered entirely applicable, especially in cultural landscapes. The feeling that cultural criteria are missing is prevalent in this approach. Threat and distribution were regarded as equally important, as were species and ecosystems criteria, above naturalness and site criteria respectively.

An ecological network is constituted of basically three elements (described fully in chapter two, van der Sluis *et. al.,* 2001), the **core areas** (e.g. nature reserves, areas of high natural value & quality, low intensity land use) "…providing the optimal ecological space achievable, in quantity and quality" (Wenger, 2000); **corridors** (areas linking the core areas either in the form of stepping stones or a linear feature, low – medium intensity land use) "… ensuring appropriate interconnection between the core areas" (Wenger, 2000), and **buffer zones** (bridging the gaps between low/medium intensity land and the areas of high intensity land use which fall outside the ecological network) "…to protect the core areas and the corridors from potentially harmful; external influences."(Wenger, 2000) Each of these elements has their own specific criteria aligned with their purpose. Overriding these core element criteria are more general criteria (e.g. those in figure 5.1) These criteria apply to all the elements of the ecological network.

After investigating numerous initiatives, case studies and literature (see table 4.1 for a summary) regarding the development of ecological networks. Thirty criteria (see table 5.1) were selected and adapted for further investigation in terms of their importance in the design process. These were included in the digital interview for expert evaluation.

5.3.1.1. Ranking Procedure

Due to the large number of criteria, a two tier ranking procedure was used (Loubser, 1996). As a starting point the respondents were asked to rank each criterion in terms of their level of importance (Very Important, Important, Less Important and Not Important). The frequency table of criteria importance (table 5.1) shows that only two criteria (endemic and rarity) were regarded as not important (0,67%) by one respondent. The rest of the ranks were spread between the categories Very Important (25,67%), Important (45%) and Less Important (15,3%). 13,3 % of the criteria were not ranked.

Table 5. 1: Criteria importance frequency table

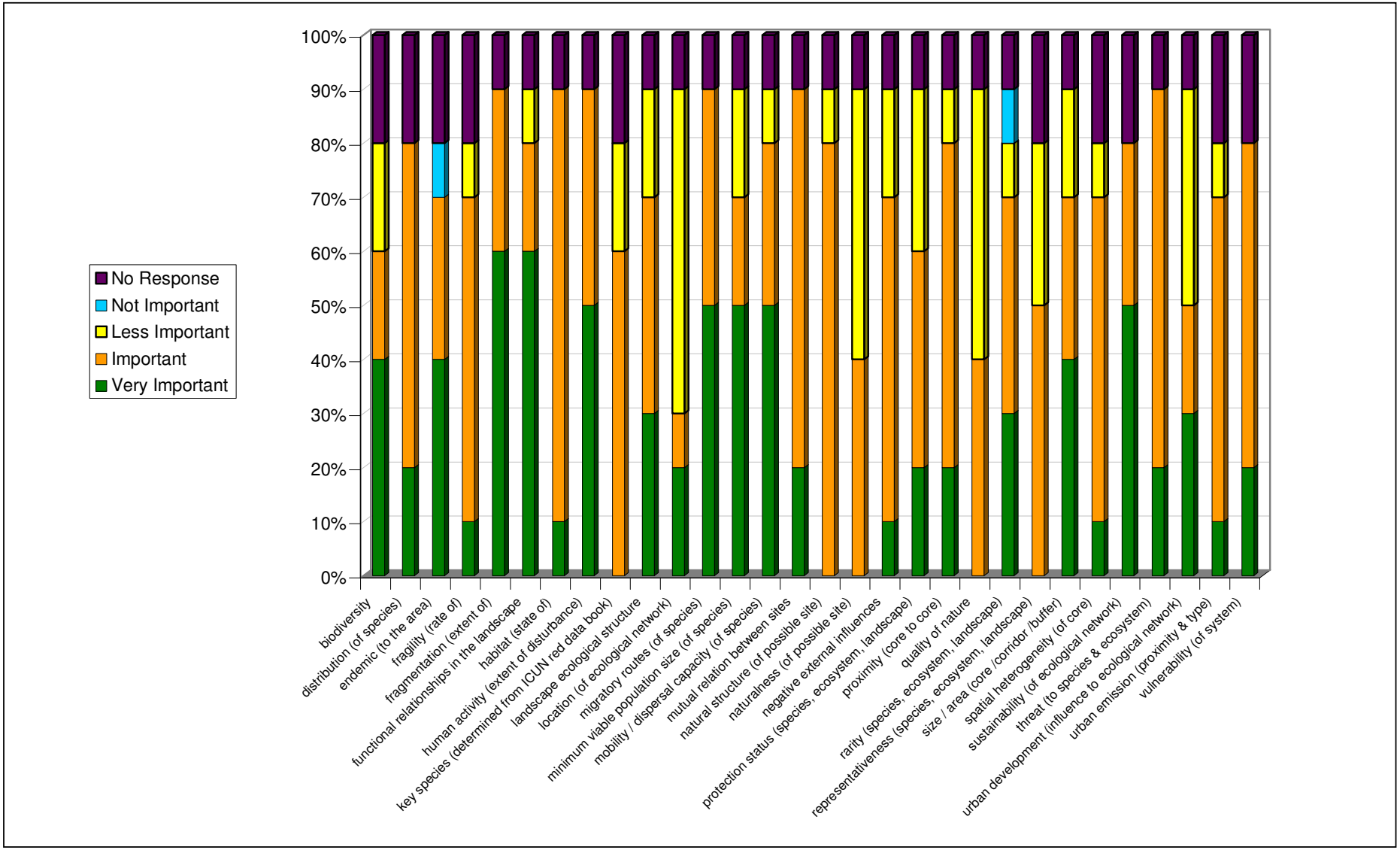
Criteria	Rank				
	Very important	Important	Less Important	Not Important	No Response
Biodiversity	4	2	2	0	2
Distribution (of species)	2	6	0	0	2
Endemic (to the area)	4	3	0	1	2
Fragility (rate of)	1	6	1	0	2
Fragmentation (extent of)	6	3	0	0	1
Functional relationships in the landscape	6	2	1	0	1
Habitat (state of)	1	8	0	0	1
Human activity (extent of disturbance)	5	4	0	0	1
Key species (determined from ICUN red data book)	0	6	2	0	2

Landscape ecological structure	3	4	2	0	1
Location (of ecological network)	2	1	6	0	1
Migratory routes (of species)	5	4	0	0	1
Minimum viable population size (of species)	5	2	2	0	1
Mobility / dispersal capacity (of species)	5	3	1	0	1
Mutual relation between sites	2	7	0	0	1
Natural structure	0	8	1	0	1
Naturalness (of possible site)	0	4	5	0	1
Negative external influences	1	6	2	0	1
Projection status (species, ecosystem, landscape)	2	4	3	0	1
Proximity (core to core)	2	6	1	0	1
Quality of nature	0	4	5	0	1
Rarity (species, ecosystem, landscape)	3	4	1	1	1
Representativeness (species, ecosystem, landscape)	0	5	3	0	2
Size / area (core / corridor / buffer)	4	3	2	0	1
Spatial heterogeneity (of core)	1	6	1	0	2
Sustainability (of ecological network)	5	3	0	0	2
Threat (to species & ecosystem)	2	7	0	0	1
Urban development (influence to ecological network)	3	2	4	0	1
Urban emission (proximity & type)	1	6	1	0	2
Vulnerability (of system)	2	6	0	0	2
TOTAL	**77**	**135**	**46**	**2**	**40**
Percentage	**25,67%**	**45%**	**15,3%**	**0,67%**	**13,3 %**

In order to assess the relative weights of the criteria according to the initial (first stage) of ranking, a cumulative frequency of importance was calculated (figure 5.2). The criteria, fragmentation and functional relationships in the landscape, both feature as the criteria which were selected most frequently as *Very Important* criteria. Five Criteria (Natural Structure, Naturalness, Quality of Nature, Representativeness and most notably Key Species) were not once selected as *Very Important* Criteria.

A number of respondents (Jongman, *Pers comm.*, 2003; van der Sluis, *Pers comm.,* 2003) state that an ecological network should be species specific, suggesting that the design of ecological networks is not possible without the selection of key species. Yet it is virtually impossible to create an ecological network for every single species. The number of all currently known living species stands at approximately 1,413,000. (Wilson, 1992). According to Wilson (1992) the grand total for all species is somewhere between 10 and 100 million species. As such the “standard” method is to select a key- or keystone-species to base the design of the ecological network on. Rubino & Hess (2003) suggest that because of the need to act quickly a number of short cuts have been developed. One of these is relying on

Figure 5.2: Cumulative frequency of Importance



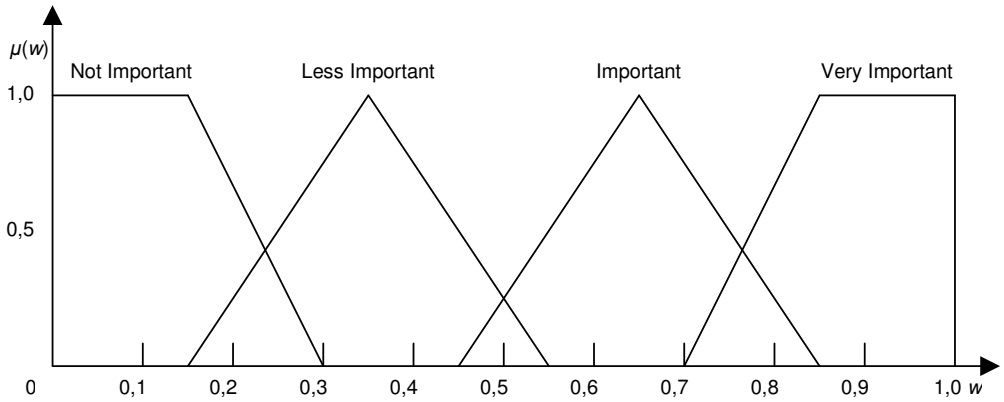
identifying key species for planning efforts. This approach is supported by Store's (nd) comment that "…it is extremely difficult, even with detailed models, to include all the factors affecting [ecologically related] decisions." The issue lies with the selection of just such key species. Jorda´n and Scheuring (2002) suggest that "the search for keystones should happen at a scale between local interactions and global network properties ..." —meso scale.

Almost a third (9) of the criteria were not regarded as *Less Important* by any of the respondents. However the criterion, which has the highest frequency, as *Less Important*, is that of Location.

5.3.1.1.a. Fuzzy Numbers

The linguistic ranking can be converted into fuzzy sets (Malczewski 1999). Since there are four categories of linguistic ranking, there needs to be four sets of fuzzy numbers. A set of standard membership functions (trapezoidal, triangular, L-R trapezoidal, L-R triangular) or standard fuzzy numbers are used (figure 5.3).

Figure 5.3: Converting the linguistic terms to fuzzy numbers



The Fuzzy Numbers are:		
Not Important:	f_n (0, 0, 0.15, 0.3)	(1)
Less Important:	f_n (0.15, 0.35, 0.35, 0.55)	(2)
Important:	f_n (0.45, 0.65, 0.65, 0.85)	(3)
Very Important:	f_n (0.7, 0.85, 1, 1)	(4)

The Fuzzy Numbers were adapted to a scale of four linguistic terms from Chen and Hwang (*cited in* Malczewski, 1999). Given the conversion to fuzzy numbers, the criterion may be weighted accordingly. This however, is a very general weighting scheme, applicable for weighting whole groups of criteria. It is not effectual in determining which criterion is the most important over all nor does it provide for the weighting of individual criterion. These numbers are used within ENDeM for standardisation of certain infinite criteria.

5.3.1.1.b. Sub-ranking

The respondents were further asked to sub-rank the criteria. That is, within each group of *Very Important Criteria,* the criteria were ranked again. This made it possible to draw up a list of criteria in order of preference for each respondent. In effect, each criteria was weighted according to preference. This was converted into an independent pairwise comparison for each respondent. The set of resulting values are given in table 5.2 (Results of Pairwise Comparisons of the thirty evaluation criteria by seven respondents). The comparison could only be calculated for seven of the ten respondents, as only 7 responses were complete. An entry in the table shows the number of respondents who preferred a given attribute, to another. For example, 3 of the 7 experts regarded distribution more important then fragility. Thus implying that 4 of the 7 experts regarded fragility more important than distribution. Comparisons like these are made for each pair of criteria (Malczewski 1999). Once these comparisons are made, the criteria weights should be assessed by a multiple comparison method (described fully in Malczewski, 1999, pp192). The multiple comparison method calculates the criterion weights as follows:

$$W_i = (r_j / c) / \sum(r_j / c)$$

and

$$c = nk - n$$

Where:

r_j = the sum of each column (rank).

c = range

n = number of decision makers

k = number of criteria

W = weight

The results of the multiple comparison should be used to weight the criteria for input into the model – ENDeM. The frequency tables can be used to group the criteria into 4 groups (very important, important, less important and not important). The distribution of the grouping follows that of the expert knowledge base selection of these criteria. Both are in a ratio of 9:16:5:0 once reduced to a total of 30.

Those criterion that may be regarded as very important are:

- fragmentation (extent of)
- functional relationships in the landscape
- human activity (extent of disturbance)
- minimum viable population size (of species)
- migratory routes (of species)
- mobility / dispersal capacity (of species)

Table 5.2: Results of Pairwise Comparisons of the thirty Criteria by 7 Decision Makers.

Criterion	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1 biodiversity	-	3	3	4	5	4	4	4	1	2	1	4	4	4	3	2	2	4	2	2	1	2	2	3	2	4	4	2	2	4
2 distribution (of species)	3	-	4	2	5	5	4	5	1	3	1	5	5	4	4	2	1	4	1	1	1	2	1	3	3	6	4	3	1	4
3 endemic (to the area)	3	2	-	4	5	4	3	4	2	3	1	3	4	5	2	2	2	2	3	2	2	3	2	3	3	4	2	2	1	3
4 fragility (rate of)	3	3	3	-	5	4	2	5	1	2	1	5	4	4	3			3	2	1		3	1	3	3	5	3	4	2	4
5 fragmentation (extent of)	1	1	1	1	-	3		2		2		2	3	3					1			2	1	2	1	4	1			1
6 functional relationships in the landscape	2	1	2	2	4	-	1	2	1	2		1	3	3	1	1		1	2	1		2			1	5	3	2		2
7 habitat (state of)	2	2	3	5	7	6	-	6		4	1	4	5	5	3			3	2	1		4	1	3	2	7	3	3	1	4
8 human activity (extent of disturbance)	2	1	2	1	5	5	1	-		2		4	5	4	3			1	2		1	4		3		5	4	2	1	2
9 key species (determined from ICUN red data book)	5	5	4	6	6	5	6	6	-	4	2	5	5	5	4	3	1	6	4	5	3	4	3	5	5	6	6	4	1	6
10 landscape ecological structure	2	2	2	3	5	5	2	4	1	-		4	4	4	2	2		2	3	1		3	1	3	2	5	3	3	1	4
11 location (of ecological network)	2	5	5	5	7	7	6	7	4	6	-	7	7	6	6	6	3	6	4	4	5	5	4	5	5	6	6	6	2	5
12 migratory routes (of species)	2	1	3	1	5	6	3	3	1	2		-	5	5	3	1	1	3	2	1	1	3		3	1	6	3	2	1	4
13 minimum viable population size (of species)	2	1	2	2	4	4	2	2	1	3		2	-	2	1	1	1	2	2	2		2	1	2	2	3	2	1		2
14 mobility / dispersal capacity (of species)	2	2	1	2	4	4	2	3	1	3	1	2	5	-	2	1		2	1	1		2	1	2	2	4	2	3	1	2
15 mutual relation between sites	3	2	4	3	7	6	4	4	2	4	1	4	6	5	-			3	3	1		4	1	5	3	6	3	4	1	4
16 natural structure (of possible site)	4	4	4	7	7	6	7	7	3	4	1	6	6	6	7	-		4	4	4	2	5	3	5	5	7	6	5	2	6
17 naturalness (of possible site)	4	5	4	7	7	7	7	7	5	6	4	6	6	7	7	7	-	7	6	6	5	5	4	7	5	7	7	5	3	6
18 negative external influences	2	2	4	4	7	6	4	6		4	1	4	5	5	4	2	1	-	3	2	1	4	1	3	1	7	4	3	1	3
19 protection status (species, ecosystem, landscape)	4	5	3	5	6	5	5	5	2	3	3	5	5	6	4	3	1	4	-	2	2	5	3	5	3	6	5	3	3	5
20 proximity (core to core)	4	5	4	6	6	5	5	6	1	4	2	5	4	5	5	2		3	4	-		4	2	4	4	6	5	4	1	5
21 quality of nature	5	5	4	7	7	6	7	6	3	6	2	6	7	7	7	5	2	7	5	6	-	5	3	6	5	7	5	5	2	6
22 rarity (species, ecosystem, landscape)	4	4	3	4	5	5	3	3	2	3	2	4	5	5	3	2	2	3	2	2	2	-	2	4	3	5	3	3	2	4
23 representativeness (species, ecosystem, landscape)	4	5	4	6	5	6	5	6	3	4	2	6	5	5	5	3	2	5	3	4	3	4	-	6	3	6	6	5	3	6
24 size / area (core /corridor /buffer)	3	3	3	4	5	7	3	4	1	3	2	4	5	5	3	1		4	2	2	1	3		-	1	7	3	4	1	5
25 spatial heterogeneity (of core)	4	3	3	4	5	5	4	6	1	3	1	5	4	4	3	1	1	5	3	2	1	3	3	5	-	6	5	4	1	6
26 sustainability (of ecological network)	2		2	1	3	2		2		1	1	1	4	3	1				1			2				-	1	2		
27 threat (to species & ecosystem)	2	2	4	4	6	4	4	3		3	1	4	5	5	4	1		3	2	1	1	4	1	3	1	6	-	1		1
28 urban development (influence to ecological network)	3	3	4	2	7	5	4	5	2	3	1	5	6	4	3	2	2	4	3	2	2	5	1	3	2	5	6	-	1	4
29 urban emission (proximity & type)	3	5	5	5	6	6	5	5	5	4	4	5	6	5	5	4	3	5	3	5	4	4	3	5	5	6	6	5	-	5
30 vulnerability (of system)	2	1	3	3	5	4	2	4		1	1	2	4	4	2			3	1	1		2		1		6	5	2	1	-

- sustainability (of ecological network)
- threat (to species & ecosystem)
- vulnerability (of system)

the bulk of the criteria are regarded as important:

- biodiversity
- endemic (to the area)
- fragility (rate of)
- habitat (state of)
- landscape ecological structure
- mutual relation between sites
- natural structure (of possible site)
- negative external influences distribution (of species)
- protection status (species, ecosystem, landscape)
- proximity (core to core)
- rarity (species, ecosystem, landscape)
- representativeness (species, ecosystem, landscape)
- size / area (core / corridor / buffer)
- spatial heterogeneity (of core)
- urban development (influence to ecological network)

those that are considered less important:

- key species (determined from ICUN red data book)
- location (of ecological network)
- naturalness (of possible site)
- quality of nature
- urban emission (proximity & type)

and lastly those criterion that are considered not important:

- no criterion were considered not important by all of the respondents.

Key species is again within the *Less important* group of criteria, despite what Jongman (*pers. Comm.,* 2003) and van der Sluis (*pers. Comm.,* 2003) state. The criteria, rarity and endemic, which were ranked by one respondent as not important, are ranked after analysis, in the *important* group. This would suggest that these two criteria cannot be ignored. It is unanimously agreed that fragmentation needs to be combated. This is substantiated by the fact that it falls into the *very important* group, with sustainability, which is considered fundamentally important (Blagovidov, *Pers. Comm.*, 2003).

5.3.1.2. Concerns

Some concerns were raised about the criteria. Firstly biodiversity, this is very much dependent on the definition, and method of measurement. Biodiversity is usually, measured by the number of different species in an area. However some areas, low in species (e.g. high bogs) must be preserved to preserve the overall diversity. It is still unknown to what extent biodiversity is linked to the co-existence of humans and other species within their own habitat (Schneider-Jacoby, *Pers. Comm.*, 2003). The second concern was the lack of cultural and historical criteria. Many species are linked to cultural landscapes and human activities (Schneider-Jacoby, *Pers. Comm.*, 2003; Pretorius, *Pers. Comm.*, 2003).

These general criteria are the overriding ones, they determine the general aim of the ecological network and the sensitivity of the ecosystem. If emphasis needs to be laid on a certain aspect then the weight needs to be increased. Besides these, there are the element specific criteria.

5.3.2. Core areas

Core areas are, by definition, areas of high natural value and, quality, and low intensity land use. The problem is, how to define these as spatial criteria. As a starting point, a list of types of core areas were proposed to the expert knowledgebase. These types range from Ramsar and World Heritage sites, to multi-functional areas covering ecosystems or species that are threatened and which are larger than 1000 hectare. 90% of the expert base disagreed with the list in that they did not select any of the options.

It is their respondent's opinion, that core areas should be selected from natural areas, of which the size is based on minimum viable population of the target species. A problem arises if there is no target species. As there is no consensus on the maximum or minimum size, or shape for a core area. The respondents are of a strong (50%) opinion that spatial dimensions are species specific. The natural areas may or may not already be protected in some form or another. Ramsar and other such sites may be included in the selection, but do not form the bases of the selection. The core areas are not bound to natural areas, but may be vacant land in urban areas, or agricultural land with wildlife habitat value.

In an African context it would be feasible to include national parks and conservation areas in an ecological network. These should augment the network, but the core areas should not be limited to already proclaimed reserves.

According to the expert base, if based solely on the criteria of scenic beauty, it is not beneficial for these areas to be included. If an area of scenic beauty fulfils the criteria to sustain a minimum viable population (if a target species is selected) or is of significant ecological and biological value, then it may be included. The criterion, natural value, invoked

a positive response from all the respondents (excluding those who did not respond to the question). The respondents however, agreed that it was not sufficient to measure natural value by the total number of ecosystems and species in the region. This method of evaluation of natural value would not necessarily result in a spatially coherent system, nor provide any information on sustainability.

Areas of significant ecological, geological, cultural, biodiversity, and or landscape importance, should be included, provided that these areas are in a state, which may augment the network as core areas. If not, these areas may be included as corridors or buffer zones.

5.3.3. Corridors

Corridors are defined as areas linking the core areas. These occur in many forms: stepping stones; linear features; or landscape corridors; having generally low – medium intensity land use (as described previously). The landscape corridor was selected favourably by 50% of the respondents. Irrespective of form, corridors have different functions. The three major ones are: migration, commuting, and dispersal. These functions were deemed equally important by 70% of the respondents.

The spatial dimensions of corridors cannot be defined generically as this is dependent on context, site and circumstance. The respondents proposed a range of widths and lengths, each of whom listed a context and species, along with the dimensions. There is very little known about the minimal corridor requirements of any species (Schneider-Jacoby *pers. Comm.* 2003). Despite this, it is the opinion of the respondents (80%), that corridors are beneficial for specie conservation. An optimally functioning corridor is specie and ecosystem specific.

As a starting point, rivers form good corridors through various biomes. There is normally existing natural vegetation and space surrounding the river. These may need buffering from encroaching human activities.

5.3.4. Buffers:

Buffers are bridging the gaps between low/medium intensity land use and the areas of high intensity land use, which fall outside the ecological network. These generally fall adjacent to the core areas and corridors. Buffer zones are thought to be necessary by 80% of the respondents. Their aim is to reduce adverse local influences to the core area. Helping to stabilize and guarantee habitat quality of the core areas. As such, 50% of the respondents state that the buffer zones should be core area specific. Thus, the activities allowed in the buffer zone, are also core area dependent.

There are some invasive activities like mining, excavation, industry and polluting activities, which should not be allowed in buffer zones. Essentially no intensive land use activities

should be allowed within the buffer zone. Activities, which affect the habitat and ecosystem qualities adversely, should also be disallowed.

5.3.5. Further Considerations:

The above-mentioned criteria of the core elements are those, which are critical to the design of the ecological network. However these are not the only aspects, which affect the design of an ecological network. The effect of barriers and scale also need to be considered.

5.3.5.1. Barriers:

The concept of Ecological Networks promotes connectivity though the corridors. This connectivity needs to be optimised, despite the presence of barriers. Barriers can take on many forms, but are mostly man-made features such as transport networks, urbanisation, and dams. One feature might pose as a barrier to a particular species but might be a corridor to another. A prime example is a river. The degree of the barrier's effectiveness or permeability is primarily dependent of the type of motion the species utilises. To a species utilising "flight" as a type of motion, a river is not a barrier. In contrast, a species utilising only "walking" as it's type of motion will at the very least be hindered by a river. The extent of which, depends on the species size and the width of the river. These barriers, can however, be bridged by greenways and alternative design techniques. Barriers, like the elements of an ecological network, are both species and scale dependent.

5.3.5.2. Scale:

Scale is inherent across the board. The ecological networks described by the respondents, function at various levels from local to global scales. Some ecological networks function at multiple scales, in a nested approach. The broad, general ideas are used at the smallest scale (global) getting increasingly more specific as the scale gets larger (local level). "It is the observation of changing dynamics with scale that formed the basis for the development of hierarchy theory in ecology" (O'Neill and King, 1998). These changes must be incorporated in the model, in an effort to represent reality as closely as possible.

5.3.6. Inter Criteria Relationships:

The criteria have been identified and the method for assessing their weights described. The results of the rest of the digital interviews were analysed. The goal was to find objective approaches and quantitative methods for characterising (Jorda´n and Scheuring, 2002) the relationships between the criteria, to serve as input into the model. Building the relationships between the criteria forms a major core of the model.

"In the field of natural sciences it is extremely difficult, even with detailed models, to include all the factors affecting decisions." (Store; nd). Multi criteria evaluation (MCE) comes a long way

to including the numerous factors (criteria), Store mentions, but this is not always the ideal solution. Note, that any spatial model provides an indicator map as a guide to support and assist the decision, but does not provide the definitive choice. One cannot do away with expert knowledge.

5.4. SUMMARY

After extensive literature review, a digital interview was drawn up. This was sent to an (previously determined) expert knowledge base. The interview included questions about general criteria and element specific criteria. From the response (despite low), a group pairwise comparison matrix was drawn up of the general criteria. The method to calculate the specific weights for these criteria was mentioned. Those criteria (sustainability, fragmentation and functional relationships in the landscape), which were deemed most important, by the most respondents, should carry the most weight in the model to ensure success of the ecological network. The element criteria (those directly applicable to the core areas, corridors and buffers) were more difficult to assess. The respondents are generally of the opinion that these are species, or at the very least ecosystem, specific. The spatial dimensions of these elements are not excluded from this opinion. The consensus is that quality and functioning are more important than quantity and location, with scale being the all-encompassing factor. These criteria and analyses there of, form the input to the model discussed in chapter six.