

**Landscape functionality and plant diversity of  
grassland fragments along an urban-rural gradient  
in the Tlokwe Municipal area, South Africa.**

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*“Look deep into nature, and you will understand everything better.” – Albert Einstein.*

## **Abstract**

Urbanisation is an ever-growing global phenomenon which creates altered environments characterised by increased human habitation, exotic species, impermeable surfaces, artificial structures, landscape fragmentation, habitat loss, and modified energy– and resource pathways. The vulnerable Rand Highveld Grassland vegetation unit in the Tlokwe Municipal area, South Africa, has been extensively degraded and transformed by urbanisation and agriculture. Only 1% of this endangered ecosystem is currently being actively conserved. Grassland fragments in urban areas are considered to be less species rich and less functional than their more “natural” counterparts, and are therefore not a priority for conservation.

In this study the effects of landscape matrix quality on intra patch variables, namely plant species diversity and functional diversity, and fine-scale biogeochemical landscape function (as determined by Landscape Function Analysis or LFA) of 30 fragments of the Rand Highveld Grassland vegetation unit were explored. Four urbanisation measures (percentage urban land cover, percentage grass land cover, edge density, and density of people), acting as indicators for patterns and processes associated with urban areas, were calculated for matrix areas with a 500m radius surrounding each selected grassland fragment to quantify the position of each grassland remnant along an urban-to-rural gradient. Using the specific urbanisation measures, the grassland fragments were objectively classified into two classes of urbanisation, namely “rural/peri-urban” and “urban”, to allow for statistical comparisons between intra-patch variables for grassland remnants exposed to similar urbanisation pressures. Plant species composition and diversity were determined in the selected grassland fragments and nine functional traits were described for each species. Plant functional diversity was determined by five functional diversity indices, namely functional richness, evenness, divergence, dispersion, and specialisation. Fine-scale biogeochemical landscape function was determined by executing the LFA method. LFA assesses fine-scale landscape patchiness and 11 soil surface indicators to produce three main LFA parameters (stability, infiltration, and nutrient cycling), which indicates how well a system is functioning in terms of resource conservation and soil processes. Possible relationships between fine-scale biogeochemical landscape function and plant species- and functional diversity were also investigated. NMDS ordinations and basic statistics were used to determine trends and effects within the data.

The results indicated that urban grassland remnants had lower mean plant species richness, Shannon species diversity (significantly), and Pielou species evenness than rural/peri-urban grassland fragments. Urban grassland fragments also contained significantly higher percentage of exotic species. Correlations were found between the four urbanisation measures and percentage species of the total species richness possessing certain functional attributes. This indicated that increased

urbanisation may influence the species composition and the occurrence of certain plant traits in the selected grassland fragments.

Urbanisation seems to have no effect on fine-scale landscape heterogeneity of the selected grassland fragments. Rural/peri-urban grassland fragments had higher infiltration capacity, nutrient cycling potential, and total SSA functionality (although not significantly), which may be ascribed to differences in management practices, such as mowing in urban areas and grazing in rural areas.

Rand Highveld Grassland fragments in the urban landscape matrix of Potchefstroom city are just as conservable in terms of plant species diversity and functional diversity, as well as on a biophysical function level involving soil processes than rural/peri-urban grassland fragments. High plant species diversity and the presence of certain plant traits did not contribute to high soil surface stability, infiltration capacity, nutrient cycling potential and total soil surface functioning.

**Keywords:** Rand Highveld Grassland; fragmentation; urban-rural gradient; plant functional traits; functional diversity indices; Landscape Function Analysis.

## Opsomming

Verstedeliking is „n toenemende, wêreldwyd proses wat omgewings verander deur „n toename in menslike bewoning, uitheemse spesies, ondeurlaatbare oppervlakke, mens-gemaakte strukture, landskapsfragmentering, habitatsverlies, en gewysigde energie- en hulpbron weë, te skep. Die Randse Hoëveld Grasveld plantegroei tipe in die Tlokwe Munisipale gebied, Suid-Afrika, is uitermatig gedegradier en getransformeer deur verstedeliking en landbou-aktiwiteite. Slegs 1% van die bedreigde ekosisteem word tans aktief bewaar. Gefragmenteerde grasvelde in stedelike omgewings word gewoonlik beskou as minder spesieryk en funksioneel as meer “natuurlike” grasvelde, en is dus gewoonlik nie „n prioriteit vir bewaringspraktyke nie.

Die invloed van die kwaliteit van die landskapsmatriks op veranderlikes, soos plantspesiediversiteit en funksionele diversiteit, en landskap funksie (soos vasgestel deur *Landscape Function Analysis* (LFA)), in 30 fragmente van die Randse Hoëveld Grasveld plantegroei tipe is bestudeer. Vier landskapsmetings (persentasie stedelike landbedekking, persentasie grassveld landbedekking, rand digtheid, en digtheid van mense), wat patrone en prosesse geassosieër met verstedeliking aandui, is bereken vir matriksgebiede met „n radius van 500m om elke grasveldfragment, om gevolglik die posisie van elke fragment langs „n verstedelikingsgradiënt vas te stel. Die spesifieke landskapsmetings is gebruik om die grasveldfragmente objektief in twee klasse van verstedeliking te klassifiseer, naamlik “landelik” en “stedelik”, sodat statistiese vergelykings tussen intra-fragment veranderlikes wat aan eenderse verstedelikingsdrukte blootgestel is, uitgevoer kon word. Plantspesiesamestelling en -diversiteit van die grasveldfragmente is vasgestel en nege funksionele kenmerke vir elke spesie is beskryf. Plant funksionele diversiteit is beskryf deur vyf funksionele diversiteitsindekse, naamlik funksionele rykheid, gelykheid, afwyking, verspreiding, and spesialisering. Fyn-skaal biogeochemiese landskapsfunksie is vasgestel deur die LFA metode. LFA assessee fyn-skaal landskap heterogeniteit en 11 grondoppervlak indekse om drie hoof LFA parameters (stabiliteit, infiltrasie, en nutrient-sirkulering) te produseer, wat gevolglik aandui hoe goed „n sisteem funksioneer in terme van hulpbronbewaring en grondprosesse. Moontlike verbande tussen fynb-skaal biogeochemiese landskapsfunksie en plantspesie- en funksionele diversiteit is ook ondersoek. NMDS ordeninge en basiese statistiek is toegepas om patrone in die data te ondersoek.

Die resultate dui aan dat stedelike grasveldfragmente laer gemiddelde plantspesierykheid, Shannon spesiediversiteit (betekenisvol), en Pielou spesiegelykheid as landelike grasveldfragmente gehad het. Stedelike grasveldfragmente is ook gekenmerk deur „n betekenisvolle hoër persentasie uitheemse spesies. Korrelasies tussen die vier landskapsmeting en die persentasie spesies wat sekere funksionele eienskappe het, is ook gevind, wat aandui dat toenemende verstedeliking spesiesamestelling en die voorkoms van spesifieke plant kenmerke van gefragmenteerde grassvelde tot „n mate beïnvloed.

Dit blyk dat verstedeliking dus geen effek op fyn-skaal heterogeniteit of biogeochemiese landskapsfunktionaliteit van die grasveldfragmente het nie. Landelike grasveldfragmente het hoër infiltrasie, nutriënt-sirkulering en totale SSA funksionaliteit as stedelike grasveldfragmente getoon (nie betekenisvol nie), wat toegeskryf kan word aan bestuurspraktyke, soos grassny in stedelike gebiede en beweiding in landelike gebiede.

Randse Hoëveld Grasveldfragmente in die Potchefstroomse stedelike landskapsmatriks het dus dieselfde potensiaal om bewaar te word in terme van plant spesiediversiteit en funksionele diversiteit, asook biogeochemiese funksie aangaande grondprosesse as landelike grasveldfragmente. Hoë plant spesierikheid en die voorkoms van sekere plant funksionele kenmerke het nie bygedra tot hoër grondoppervlak stabiliteit, infiltrasie, nutriënt-sirkuleringsvermoë en total grondoppervlak-funksionering nie.

**Kernwoorde:** Randse Hoëveld Grasveld; fragmentering; verstedelikingsgradiënt; plant funksionele kenmerke; funksionele diversiteitsindekse; *Landscape Function Analysis*.

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## Table of Contents

Abstract.....	i
Opsomming.....	iii
Acknowledgements.....	v
List of Abbreviations .....	xiii
List of Figures .....	xiv
List of Tables .....	xx

### Chapter 1: General introduction

1.1 Introduction.....	1
1.2 Research objectives.....	3
1.2.1 General objective .....	3
1.2.2 Specific objectives .....	3
1.2.3 Hypotheses.....	3
1.3 Study area.....	4
1.3.1 Selected grassland fragments .....	4
1.4 Exposition of dissertation.....	6
1.5 References.....	9

### Chapter 2: Literature review

2.1 Introduction.....	12
2.2 Urban ecology following landscape ecological principles.....	13
2.3 Grasslands and grassland ecology.....	14
2.3.1 The Rand Highveld Grassland .....	15
2.3.1.1 Climate.....	15

2.3.1.2 Land type and soil .....	15
2.3.1.3 Vegetation .....	16
2.4 Urban ecosystems .....	17
2.4.1 Urbanisation .....	17
2.4.2 The urban physical environment .....	17
2.4.3 Urban vegetation .....	18
2.4.4 The urban-rural gradient approach .....	20
2.5 Landscape change .....	20
2.5.1 Fragmentation .....	21
2.5.2 Landscape context: the importance of the matrix .....	22
2.6 Plant species– and functional diversity .....	23
2.6.1 Plant species diversity .....	23
2.6.2 Plant functional diversity .....	24
2.6.2.1 Plant functional traits .....	25
2.6.2.2 Plant functional types (PFT"s) .....	27
2.6.2.3 Functional diversity indices .....	27
2.7 Landscape functionality .....	28
2.7.1 The Trigger-Transfer-Reserve-Pulse Framework .....	29
2.7.2 The landscape functionality continuum .....	31
2.7.3 The importance of vegetated patches .....	32
2.7.4 Landscape functionality in urban landscapes .....	33
2.8 Biodiversity and ecosystem functioning .....	34
2.8.1 Biodiversity and the stability of ecosystem functioning .....	36
2.9 Summary .....	37

2.10 References.....	38
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### **Chapter 3: Land cover classification**

3.1 Introduction.....	63
3.1.3 Digital image classification.....	64
3.2 Methods.....	64
3.2.1 Classification procedure.....	66
3.2.2 Accuracy assessment .....	66
3.3 Results and discussion .....	67
3.4 Summary .....	71
3.5 References.....	71

### **Chapter 4: Quantifying an urbanisation gradient**

4.1 Introduction.....	74
4.1.1 Objectives .....	75
4.2 Methods.....	75
4.2.1 Determining matrix size.....	77
4.2.2 The selection of relevant urbanisation measures .....	77
4.2.3 Calculation of urbanisation measures .....	82
4.2.4 Data analysis .....	82
4.2.4.1 Factor analysis.....	82
4.2.4.2 Cluster analysis for determining urbanisation classes.....	83
4.3 Results and discussion .....	83
4.3.1 The selection of landscape metrics .....	83
4.3.2 Quantification of entire landscape urbanisation gradient.....	85

4.3.4 Position of grassland fragments along an urbanisation gradient.....	89
4.4 Summary.....	95
4.5 References.....	96
<b>Chapter 5: Plant species diversity and functional diversity</b>	
5.1 Introduction.....	104
5.1.1 Plant species diversity.....	104
5.1.2 Plant functional diversity.....	105
5.1.2.1 Functional diversity indices.....	105
5.1.3 Objectives and hypotheses.....	106
5.2 Methods.....	107
5.2.1 Vegetation survey.....	107
5.2.2 Plant functional traits.....	107
5.2.3 The selection of functional diversity indices.....	110
5.2.4 Data analysis.....	114
5.2.4.1 Plant species diversity.....	114
5.2.4.2 Plant functional diversity.....	115
5.3 Results and discussion.....	116
5.3.1 Plant diversity.....	116
5.3.2 Plant functional diversity.....	120
5.3.2.1 Plant functional traits.....	121
5.3.2.2 Quantification of plant functional diversity.....	140
5.4 Summary and conclusions.....	145
5.5 References.....	149

## **Chapter 6: Landscape functionality**

6.1 Introduction.....	160
6.1.1 Scale considerations.....	161
6.1.2 Objectives and hypotheses.....	161
6.2 Methods.....	162
6.2.1 Landscape organisation.....	162
6.2.2 Soil Surface Assessment (SSA).....	164
6.2.2.1 The eleven soil surface indicators reflecting landscape functionality.....	164
6.2.3 Data analysis.....	167
6.3 Results and discussion.....	169
6.3.1 Fine-scale landscape heterogeneity.....	169
6.3.1.1 Patch descriptions and specific SSA function scores.....	169
6.3.1.2. Physical landscape attributes.....	175
6.3.2 Soil Surface Assessment.....	183
6.3.2.1 Stability.....	185
6.3.2.2 Infiltration.....	186
6.3.2.3 Nutrient cycling.....	187
6.3.2.4 Total SSA functionality.....	188
6.3.3 Correlating SSA indices and physical landscape attributes.....	190
6.3.4 Can high patch quality compensate for low patch size: outcomes from differential management?.....	191
6.4 Summary and conclusions.....	193
6.5 References.....	195

## **Chapter 7: Synthesis and conclusions**

7.1 Introduction.....	202
7.2 Exploring “plant diversity-biogeochemical function” relationships.....	202
7.3 Quantification of an urbanisation gradient.....	206
7.3.1 Key results overview.....	206
7.4 Plant species richness and functional diversity.....	207
7.4.1 Aim and hypotheses.....	208
7.4.2 Key results overview.....	208
7.4.3 Recommendations.....	209
7.5 Landscape functionality.....	210
7.5.1 Aim and hypotheses.....	210
7.5.2 Key results overview.....	211
7.5.3 Recommendations.....	212
7.6 Summary.....	213
7.7 References.....	215
Appendix A: Annotations of landscape metrics equations.....	A-1
Appendix B: Box-Cox transformations (normality).....	A-2
Appendix C: Landscape metrics correlation matrix.....	A-7
Appendix D: SPOT satellite– and in-field images of the 30 selected grassland fragments.....	A-8
Appendix E: Annotations of plant functional diversity indices equations.....	A-14
Appendix F: Plant species list and plant functional traits.....	A-15
Appendix G: Multiple regression analysis results for plant species richness, functional traits, and functional diversity.....	A-23

Appendix H: Tukey’s HSD test (ANOVA) results for plant species richness, functional traits, and functional diversity.....	A-27
Appendix I: Scoring method and ranges of the eleven Soil Surface Assessment (SSA) indicators. ....	A-31
Appendix J: Multiple regression analysis results for landscape function .....	A-34
Appendix K: Tukey’s HSD test (ANOVA) results for landscape function .....	A-36
Appendix L: Multiple regression analysis results for plant diversity-landscape function .....	A-37

## List of Abbreviations

ANOVA:	Analysis of Variance	PCA:	Principle Component Analysis
BSI:	Bare soil interpatch	PFT:	Plant functional type
CBD:	Central business district	PGRALC:	Percentage grass land cover
CBDm:	Distance to central business district	PURBLC:	Percentage urban land cover
DENSPEOP:	Density of people	RND:	Road network density
FA:	Factor Analysis	SGP:	Sparse grass patch
FP:	Forb patch	SIDI:	Simpson's diversity index
FDIs:	Functional dispersion	SSA:	Soil surface assessment
FDiv:	Functional divergence	TTRP:	Trigger-transfer-reserve-pulse
FEve:	Functional evenness		
FRic:	Functional richness		
FSpe:	Functional specialisation		
GFP:	Gassy forb patch		
GLP:	Grassy litter patch		
GP:	Grass patch		
LCR:	Land cover richness		
LFA:	Landscape Function Analysis		
LOI:	Landscape organisation index		
LP:	Litter patch		
LPI:	Largest patch index		
LSI:	Landscape shape index		
NMDS:	Non-metric multidimensional scaling		
NP:	Number of patches		

## List of Figures

Figure 1.1: The connection between human activities and global change through alteration of biotic and abiotic aspects of an ecosystem, which influences the ecosystem properties and processes.....	1
Figure 1.2: Map of the selected grassland patches in the study area in the Rand Highveld Grassland vegetation unit, situated in the Tlokwe Municipal area. The overview map (bottom right hand corner) indicates the location of the study area within the North West Province, South Africa. ....	5
Figure 1.3: Summary of the elements constituting this study.....	9
Figure 2.1: Major environmental problems representing the degradation of natural capital (adapted from Miller, 2005, and Vitousek <i>et al.</i> , 1997).....	12
Figure 2.2: Soft traits (a) and their response to (2a) /effect on (2b) environmental conditions, as well as the correlating hard traits (3a & 3b) (adapted from Lavorel & Garnier, 2002).....	26
Figure 2.3: The “TTRP”-framework: processes representing the capture and loss of resources from a system (after Ludwig & Tongway, 1997; Tongway & Hindley, 2003; Tongway & Hindley, 2004).....	31
Figure 2.4: Biodiversity – ecosystem functioning framework (after the Millennium Ecosystem Assessment (2003) as well as Naeem <i>et al.</i> (2009). ....	34
Figure 3.1: The Tlokwe Municipal area was situated at the convergence of four SPOT 5 (a, b, c and d) satellite images which were used in the land cover classification of the study area .....	65
Figure 3.2: SPOT5 satellite image (421 RGB band combination) of the study site in the Tlokwe Municipal area.....	67
Figure 3.3: Land cover map of the study area in the Tlokwe Municipal area. ....	70
Figure 4.1: Map of a section of the study area indicating the 500m <sup>2</sup> landscape grid. There are a total of 5846 500m <sup>2</sup> cells in the 1756.25km <sup>2</sup> study area. ....	76
Figure 4.2: Three of the selected grassland fragments within the study area are shown to indicate their variability in size and shape, resulting in subsequent matrix area differences for which to calculate landscape metrics. ....	79

Figure 4.3: Landscape grid exhibiting the ED values for the study area in the Tlokwe Municipality.	86
Figure 4.4: Landscape grid exhibiting the PGRALC values for the study area in the Tlokwe Municipality	87
Figure 4.5: Landscape grid exhibiting the PURBLC values for the study area in the Tlokwe Municipality	88
Figure 4.6: Landscape grid exhibiting the DENSPEOP values for the study area in the Tlokwe Municipality	89
Figure 4.7: Cluster analysis results (dendrogram – complete linkage) for the urbanisation measure values of the selected grassland fragments (based on Bray-Curtis similarity index).	90
Figure 4.8: NMDS ordinations to express the selected grassland fragments classified as rural/peri-urban based on the values of the four main urbanisation measures	92
Figure 4.9: SPOT 5 satellite image of the study area indicating the rural/peri-urban and urban selected grassland fragments	93
Figure 4.10: SPOT 5 satellite image and in-field photograph of a & b) rural/peri-urban, and c & d) urban selected grassland fragments	94
Figure 5.1: Guide to choosing the correct functional diversity indices (adapted from Pla <i>et al.</i> , 2012).	110
Figure 5.2: Visual representation of estimation of functional diversity indices. The points represent species according to their trait values and the size of the points represents species abundance. The species are distributed in a hypothetical trait niche. a) functional richness (Fric); b) functional evenness (FEve); c) functional divergence (FDiv); d) functional dispersion (FDis) (after Villéger <i>et al.</i> , 2008 and Laliberté & Legendre, 2010).	112
Figure 5.3: NMDS ordination of species recorded in each plot within each selected grassland fragment	117
Figure 5.4: Mean species richness for rural/peri-urban and urban selected grassland fragment. The selected grassland fragments are arranged in the direction of increasing percentage impervious surfaces.	118
Figure 5.5: Mean species richness for rural/peri-urban and urban grassland fragments	119

Figure 5.6: a) Mean Shannon diversity index (H') and b) mean Pielou evenness index (E) for rural/peri-urban and urban grassland fragments.....	120
Figure 5.7: Cluster analysis (group average) based on the Bray-Curtis similarity index of the functional trait composition of each species recorded during this study.....	122
Figure 5.8: NMDS ordination of each plant species based on functional trait composition within the study area.....	125
Figure 5.9: NMDS ordination of species functional trait composition for the sample plots within selected rural/peri-urban (green) and urban (red) grassland fragments.....	126
Figure 5.10: Status – mean percentage exotic plant species for rural/peri-urban and urban grassland fragments.....	129
Figure 5.11: Growth form – mean percentage a) graminoids, b) forbs, c) shrubs, d) trees, e) succulents, f) vines, and g) parasitic plants for rural/peri-urban and urban grassland fragments.....	132
Figure 5.12: Life form – mean percentage a) phanerophytes, b) hemicryptophytes, c) chamaephytes d) therophytes, and e) geophytes for rural/peri-urban and urban grassland fragments.....	133
Figure 5.13: Life span – mean percentage perennial species richness for rural/peri-urban and urban grassland fragments.....	134
Figure 5.14: Clonality – mean percentage a) non-clonal, b) clonal belowground, c) clonal aboveground, and d) clonal above- and belowground for rural/peri-urban and urban grassland fragments.....	135
Figure 5.15: Spinescence – mean percentage plant species with spines for rural/peri-urban and urban grassland fragments.....	136
Figure 5.16: Leaf periodicity – mean percentage a) deciduous, b) evergreen, and c) semi-evergreen species for rural/peri-urban and urban grassland fragments.....	137
Figure 5.17: Dispersal mode – mean percentage a) unassisted, b) wind, and c) internal animal, d) external animal, and e) unassisted / internal animal dispersed plant species for rural/peri-urban and urban grassland fragments.....	138
Figure 5.18: Pollination vector – mean percentage biotic pollination of plant species for rural/peri-urban and urban grassland fragments.....	139

Figure 5.19: Mean functional richness (FRic) (Villéger <i>et al.</i> , 2008) functional diversity index for rural/peri-urban and urban grassland fragments .....	141
Figure 5.20: Mean functional evenness (FEve) (Villéger <i>et al.</i> , 2008) functional diversity index for rural/peri-urban and urban grassland fragments .....	142
Figure 5.21: Mean functional divergence (FDiv) (Villéger <i>et al.</i> , 2008) functional diversity index for rural/peri-urban and urban grassland fragments .....	143
Figure 5.22: Mean functional dispersion (FDis) (Laliberté & Legendre, 2010) functional diversity index for rural/peri-urban and urban grassland fragments. ....	144
Figure 5.23: Mean functional specialisation (FSpe) (Villéger <i>et al.</i> , 2010) functional diversity index for rural/peri-urban and urban grassland fragments .....	145
Figure 6.1: The first step of LFA namely landscape organisation. Patches and interpatches, under the gradsect line (oriented in the direction of resource flow), are identified as discrete units (after Tongway & Hindley, 2004) .....	163
Figure 6.2: Summary of the eleven soil surface indicators used in the Soil Surface Assessment (SSA) and the main LFA parameters, namely stability, infiltration capacity and nutrient cycling potential, to which they contribute (adapted from Tongway & Hindley, 2004). ....	168
Figure 6.3: Examples of the different patch types encountered within the gradsects in the selected grassland fragments a) Bare soil interpatch (BSI), b) Forb patch (FP), c) Grass patch (GP), d) Grassy forb patch (GFP), e) Grassy litter patch (GLP), f) Litter patch (LP), and g) Sparse grass patch (SGP).....	171
Figure 6.4: Percentage cover of the patch/interpatch types recorded in each gradsect within the 30 rural/peri-urban and urban selected grassland fragments arranged in the direction of increasing percentage impervious surfaces.....	172
Figure 6.5: a) Specific stability, b) infiltration, and c) nutrient cycling SSA index scores of the most commonly encountered patch and interpatch types in rural/peri-urban and urban selected grassland fragments arranged in the direction of increasing percentage impervious surfaces .....	174
Figure 6.6: Mean Landscape organisation index (LOI) for rural/peri-urban and urban selected grassland fragments .....	176

Figure 6. 7 a) Dense litter present in site 6 (urban) due to mowing. No bare soil interpatches recorded; b) Dense tufts of <i>Elionurus muticus</i> recorded in site 25 (rural/peri-urban). No bare soil interpatches recorded. ....	176
Figure 6.8: Mean patch width for rural/peri-urban and urban selected grassland fragments.....	177
Figure 6.9: a) Wide, densely “matted” GFP’s recorded in site 9 (urban), and b) patches which mainly consisted of single grass tufts, which were not very wide, surrounded by interpatches (recorded in site 5 (urban)). ....	178
Figure 6.10: Mean total patch area for rural/peri-urban and urban selected grassland fragments.....	178
Figure 6.11: Mean interpatch length for rural/peri-urban and urban selected grassland fragments ...	179
Figure 6.12: Mean a) shortest and b) longest interpatch lengths for rural/peri-urban and urban selected grassland fragments. ....	181
Figure 6.13: NMDS ordination of the physical landscape attributes (LOI, mean patch width, total patch area, average interpatch length, and shortest / longest interpatch length) for the representative gradsect in each selected rural/peri-urban and urban grassland fragment. A possible resource conserving gradient is indicated. ....	183
Figure 6.14: Total SSA functionality (consisting of the three main SSA indicator components namely stability, infiltration and nutrient cycling SSA indices) for rural/peri-urban and urban selected grassland fragments, arranged according to increased percentage impervious surfaces .....	184
Figure 6. 15: Mean stability SSA index for rural/peri-urban and urban selected grassland fragments. .....	185
Figure 6.16: Mean infiltration SSA index for rural/peri-urban and urban selected grassland fragments. .....	187
Figure 6.17: Mean nutrient cycling SSA index for rural/peri-urban and urban selected grassland fragments. ....	188
Figure 6.18: Mean total SSA functionality index for rural/peri-urban and urban selected grassland fragments. ....	189

Figure 6.19: NMDS ordination of the stability, infiltration, and nutrient cycling SSA indices for rural/peri-urban and urban selected grassland fragments. A possible SSA functionality gradient is indicated. .... 190

Figure 6.20: NMDS ordination presenting the positions of selected grassland fragments along possible a) resource-conserving- and b) SSA functionality gradients for the study area. .... 192

## List of Tables

Table 1.1: The 30 selected grassland fragments under observation during the current study. ....	7
Table 2.1: Common grass, forb and woody species occurring in the Ba-land type (Bezuidenhout & Bredenkamp, 1991).....	16
Table 2.2: Literature summary of the effects of urbanisation.....	19
Table 2.3: Literature summary of some functional diversity studies.....	24
Table 2.4: Some functional diversity indices that have been proposed. ....	28
Table 2.5: Hypotheses concerning the relationship between species diversity and ecosystem function. ....	36
Table 3.1: Spectral band information for the SPOT 5 satellite (Spot Image, 2005). ....	63
Table 3.2: Information on the four SPOT 5 satellite images that collectively represented the study area.....	65
Table 3.3: Output classes generated by the MLC classification procedure for 12 and 15 classes for the RGB band combinations of each of the four SPOT 5 images.....	68
Table 3.4: Error matrix for the land cover map of the Tlokwe Municipal area. ....	69
Table 4.1: Review of studies observing the effects of the landscape matrix on plant species.....	78
Table 4.2: Urbanisation measures used in the study of Du Toit (2009) that were considered for use in this study.....	79
Table 4.3: Description of the final eight selected urbanisation measures that will be used to describe the landscape structure and demographic- and physical properties and quantify an urbanisation gradient for the study area.....	81
Table 4.4: Range of values for the various urbanisation measures of the 500m <sup>2</sup> grid cells within the study area. ....	83
Table 4.5: Factor Analysis results for the first two components of the calculated urbanisation measures (varimax raw rotated).....	84
Table 4.6: The specific urbanisation measures scores (acting as indicators for certain anthropogenic disturbances) for the 30 selected grassland fragments along the urbanisation gradient as determined by the selected urbanisation measures .....	91

Table 5.1: Table presenting some of the most common functional diversity indices (after Casanoves <i>et al.</i> , 2010).....	106
Table 5.2: Attributes of the 30 selected rural/peri-urban and urban grassland fragments within the study area, arranged in the direction of increasing percentage impervious surfaces. ....	108
Table 5.3: List of traits and their categorical units determined for the species encountered in selected grassland fragments (adapted from Cornelissen <i>et al.</i> (2003) and Aronson <i>et al.</i> (2007)). .....	109
Table 5.4: Plant traits and the ecological mechanisms they represent that will be observed during this study (after Cornelissen <i>et al.</i> , 2003 and Aronson <i>et al.</i> , 2007).....	109
Table 5.5: Concise description of the five functional diversity indices (Villéger <i>et al.</i> , 2008; 2010; Laliberté & Legendre, 2010) used to characterise the functional diversity of the selected grassland fragments .....	113
Table 5.6: Species diversity indices calculated for the selected grassland fragments in the study area. .....	114
Table 5.7: Correlation matrix and multiple regression analysis results for species richness and – diversity indices with the selected four urbanisation measures (representing pattern/process associated with urbanisation).....	117
Table 5.8: Properties of the plant functional composition for the selected grassland fragments in the Tlokwe Municipal area. ....	121
Table 5.9: Plant functional groups (based on 90% Bray Curtis similarity cut-off point). “Keystone” species are functionally distinct from all other species that were recorded during this study. .....	123
Table 5.10: The occurrence and mean percentage cover of native and exotic “keystone” species in the selected rural/peri-urban and urban grassland fragments.....	124
Table 5.11: Correlation matrix and multiple regression analysis results for the plant functional traits with the selected four urbanisation measures (representing pattern/process associated with urbanisation) .....	128
Table 5.12: Range of values for the various functional diversity indices calculated for rural/peri-urban and urban grassland fragments in the study area. ....	140

Table 5.13: Correlation matrix and multiple regression analysis results for functional diversity indices with the selected four urbanisation measures (representing pattern/process associated with urbanisation) .....	140
Table 6.1: Patch types recorded in selected grassland fragments during the Landscape Organisation step of the LFA method. ....	170
Table 6.2: Summary of the physical landscape heterogeneity of the rural/peri-urban and urban selected grassland fragments, arranged according to increasing percentage impervious surfaces. ....	182
Table 6.3: Correlation matrix and multiple regression analysis results for the soil surface indicators and total SSA functionality with the selected four urbanisation measures (representing pattern/process associated with urbanization).....	184
Table 6.4: Correlation matrix and multiple regression analysis results for selected physical landscape attributes and SSA indices .....	191
Table 7.1: Correlation matrix and multiple regression results for LFA variables and plant species diversity .....	205
Table 7.2: The four selected urbanisation measures used to quantify an urbanisation gradient in the study area and the processes / patterns associated with urban areas which they represent. ....	207