CHAPTER 5: RESULTS

5.1 Desktop study

5.1.1 Plant taxa richness

The Flora of Southern Africa (FSA) is known as an area of remarkable plant diversity; however, most biodiversity analyses in the past focused on the description of exceptionally rich and unique floristic areas, while neglecting remote and less species rich regions like the western Central Bushveld (Cowling & Hilton-Taylor, 1994).

For that reason the phyto-diversity of the western Central Bushveld (WCB) and the two conservation focus areas (Heritage Park and Impala Platinum) has been analysed and compared with the plant diversity documented for the Flora of Southern Africa (FSA) region (table 5.1). Conclusions on the conservation importance of those areas will be discussed in chapter 6.

Table 5.1: The plant taxa richness of the western Central Bushveld (WCB) and the two specific study areas Heritage Park and Impala Platinum in comparison to the Flora of Southern Africa (FSA) region.

Plant Taxa	FSA	WCB	Heritage Park	Impala Platinum	Heritage Park & Impala Platinum	Overlap Conservation Areas
Species and infraspecific taxa	24035	2368	1143	1410	1710	845
Species	21817	2245	1065	1347	1616	796
Genera	2639	839	468	609	633	414
Families	369	204	121	171	174	118
Area (km^2)	2,500,000[1]	33,750	2,800	300	3,100	3,100
Species/area relationship (Species/km^2)	0.01	0.07	0.41	4.70	-	-

Source: [1] Goldblatt (1978)

Table 5.1 illustrates that the WCB harbours an important portion of the plant diversity of the Southern African Flora (FSA). Although the study area represents only about 3% of the FSA region, it holds each 10% of the species and infraspecific species diversity, 32% of the genus diversity and 55% of the family diversity of the total Flora.

These plant taxa are an integral part of the unique vegetation types that are endemic to the Central Bushveld Bioregion. Several of these extraordinary vegetation types and their floristically important taxa are endangered and need to be conserved. These include especially the **SVcB 6** Marikana Thornveld, **SVcB 7** Norite Koppies Bushveld and **SVcB 15** Springbok Vlakte Thornveld.

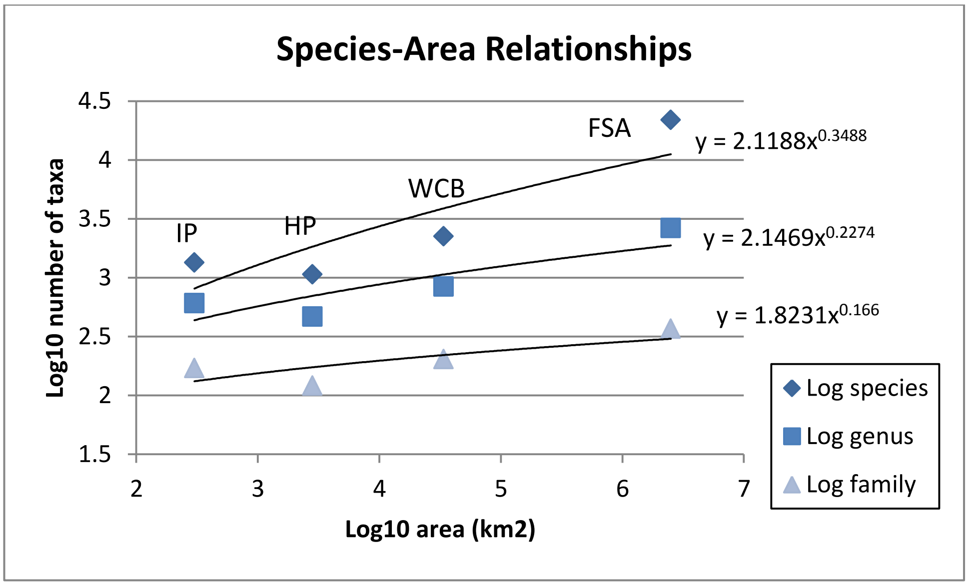

Figure 5.1: Log (taxa) - log (area) relationship for Impala Platinum (IP), Heritage Park (HP) and the western Central Bushveld (WCB).

The species-area relationship of the study area follows a lognormal distribution as expected for continuous areas by the power function log S = zlogA + logc (Arrhenius equation) (figure 5.1), where S is the number of species, c is a constant representing the number of species in the smallest sampling area, A is the area and z is the slope of the species-area relationship in log-log space (Rosenzweig, 1995; Mitchell, 2001; Desmet & Cowling, 2004). According to Hadly & Maurer (2001) the power function describes the relationship between the pattern of distribution and abundance of species in space and time.

The relationship between log (taxa) and log (area) clearly shows an increasing trend that is well approximated by the linear form of the model. It is one of the fundamental ecological principles that the number of species increases with increasing area and so does the number of genera and families (Hadly & Maurer, 2001; Mitchell, 2001).

However, the species-area curves also indicate the importance of the habitat contribution to the regional biodiversity as proposed by Chong & Stohlgren (2007). The species-area relationship of the Impala Platinum mining area has a comparable higher number of taxa per area than the Heritage Park (figure 5.1). Species-area relationships can be explained by a wide range of fundamental eco-evolutionary processes (e.g. migration, speciation and extinction) that are driven by mechanisms such as niche availability and species ranges (Pontarp, 2011). Habitat diversity plays an important role in how many species can be supported by a given habitat patch.

5.1.2 Floristic Important Taxa

The presence of floristic important plant taxa gives important information about the conservation status of an area. Thus, the evaluation of these taxa will be especially beneficial for the WCB, as it appears to be of low biodiversity value and thus is under severe threat by increasing transformation of natural vegetation to other land-uses (Wessels *et al*., 2003).

Several of the floristic important taxa identified in the study area are endemics that are only found within some of the biogeographically unique vegetation types of the Central Bushveld Bioregion: **SVcB 3** Zeerust Thornveld, **SVcB 4** Dwarsberg-Swartruggens Mountain Bushveld, **SVcB 5** Pilanesberg Mountain Bushveld, **SVcB 9** Gold Reef Mountain Bushveld, **SVcB 12** Central Sandy Bushveld, **SVcB 17** Waterberg Mountain Bushveld and **SVcB 19** Limpopo Sweet Bushveld.

About 50% of the 21 recorded endemic plant species are restricted in their occurrence in the Central Bushveld Bioregion and the North-West Province (figure 5.2) (see chapter 6). Some of the endemic plants are also listed as Red Data and/or Protected Tree species (*Aloe peglerae*, *Frithia pulchra*, and *Erythrophysa transvaalensis*). A total of 43 Red Data and ten Protected Tree species are found in the WCB, many of them facing a high risk of extinction due to human activities (figure 5.2).

Figures 5.2 to 5.4 indicate that the study area provides an important habitat for a large variety of useful and medicinal plants. A total of 367 useful and medicinal plant species were recorded for the WCB (figure 5.2), of which 64% and 71% were identified as occurring in the proposed Heritage Park and Impala Platinum lease area respectively (figure 5.3 and 5.4).

But on the other side, the study area displays signs of vegetation change due to high numbers of problem plants and bush encroachers. A total of 246 weeds and invader plants have been identified for the WCB (figure 5.2), 60% of which occur in the Heritage Park and the Impala Bafokeng Mining Complex (figure 5.3 and 5.4). Problem plants make up a large proportion of the plant floras in the WCB region ranging from 10% to 13% (figure 5.2, 5.3b and 5.4b).

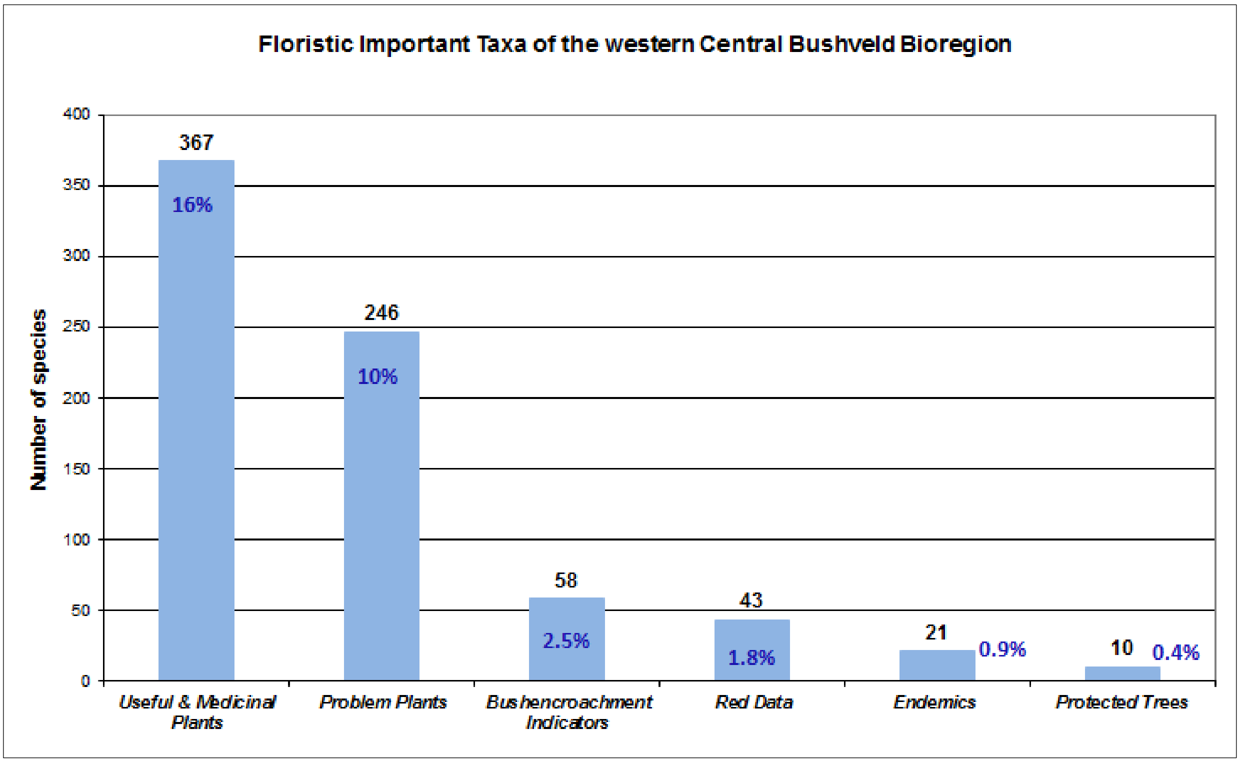

Figure 5.2: The number of floristically Important Taxa recorded for the western Central Bushveld.

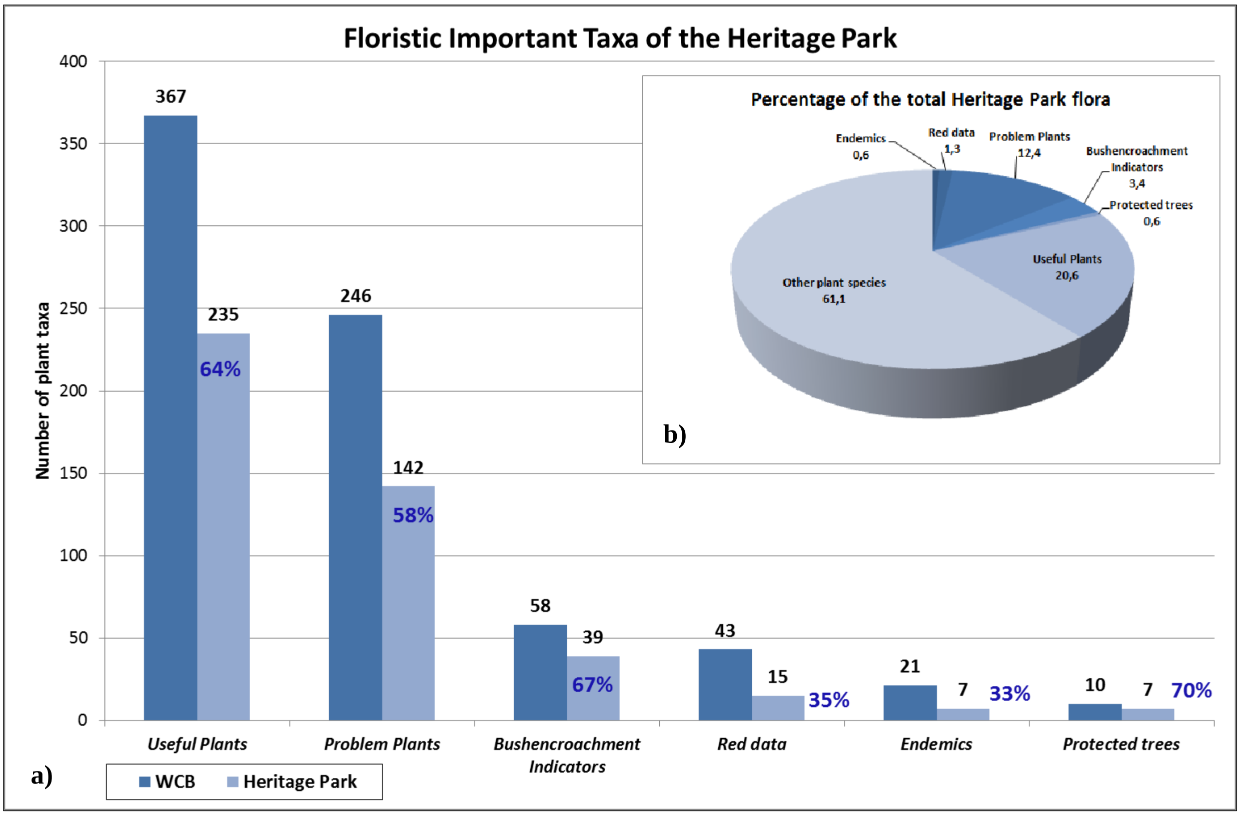

Figure 5.3: a) The number of floristically Important Taxa recorded for the Heritage Park compared to those occurring in the western Central Bushveld (%), b) and their percentage of the total Heritage Park flora.

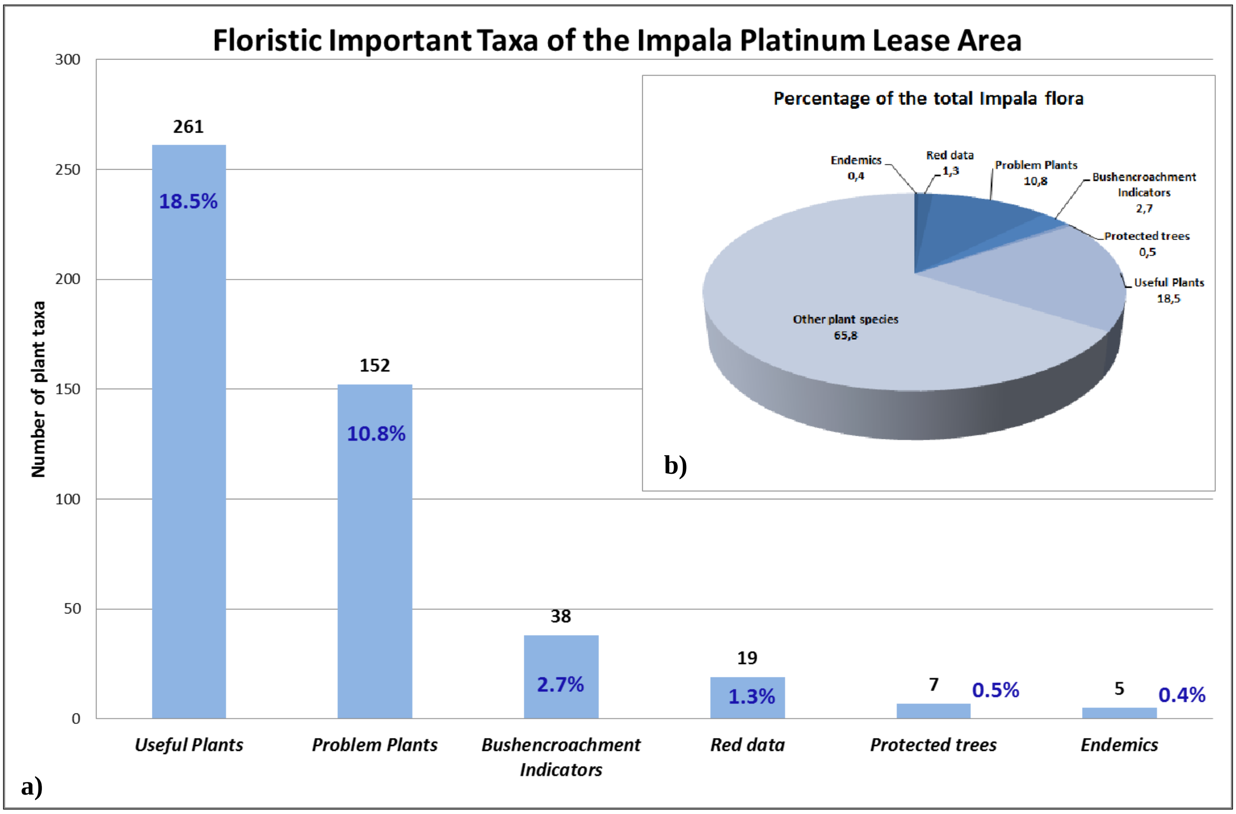

Figure 5.4: a) The number of floristically Important Taxa recorded for the Impala Platinum Lease Area compared to those occurring in the western Central Bushveld (%), b) and their percentage of the total Impala flora.

5.1.3 Largest genera and families

The ten most dominant genera and families of the Heritage Park and Impala Platinum show a strong correlation with those of the WCB (figures 5.5 to 5.10), with the Impala Platinum flora showing the highest analogy to the WCB flora on both genus and family level.

For the genus level, especially the five most dominant taxa show significant relationships (figure 5.5, 5.7 and 5.9): *Acacia* (tree species), *Cyperus* and *Eragrostis* (grass species), and *Helichrysum* (except Heritage Park) and *Indigofera* (herbs). In addition, the three other genera shared by the study areas are the herb species *Ipomoea*, *Hibiscus* and *Rhynchosia*.

The grass species *Aristida* has been found to be a dominant genus in the Heritage Park and Impala Platinum area. Furthermore, the Heritage Park differs from the WCB in two other genera, namely the herb species *Tephrosia* and *Solanum*.

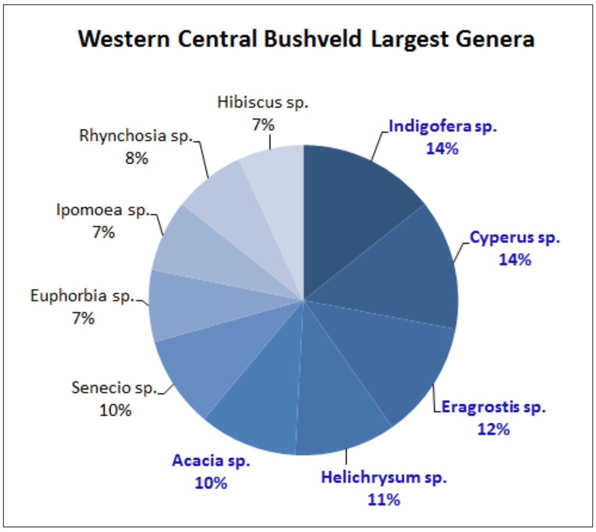

Figure 5.5: The 10 largest genera of the western Central Bushveld flora.

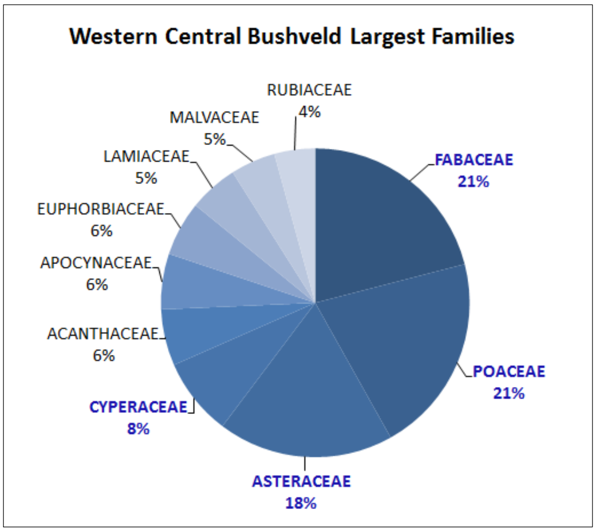

Figure 5.6: The 10 largest families of the western Central Bushveld flora.

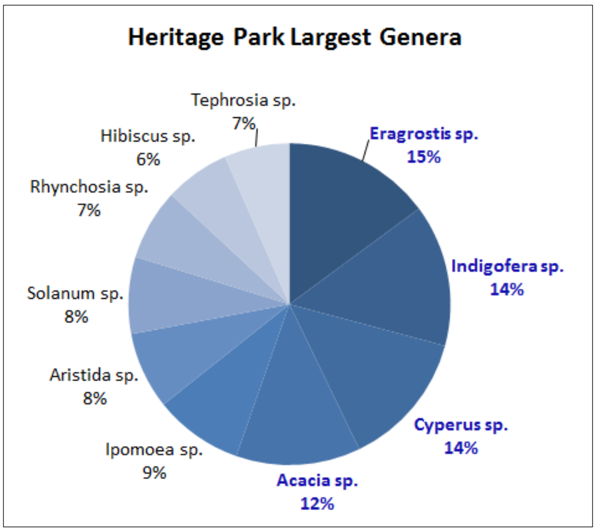

Figure 5.7: The 10 largest genera of the Heritage Park flora.

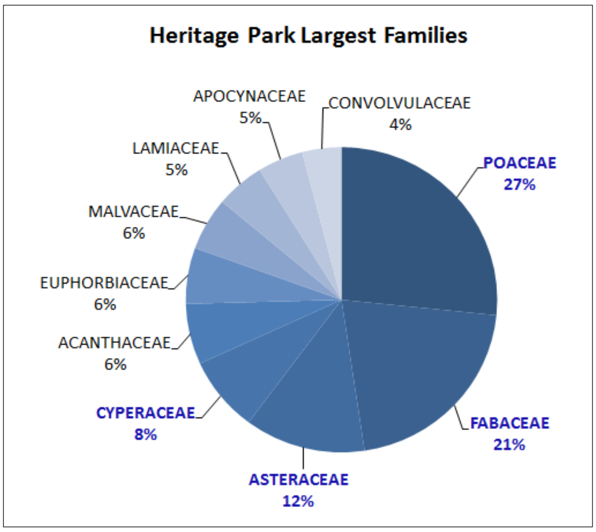

Figure 5.8: The 10 largest families of the Heritage Park flora.

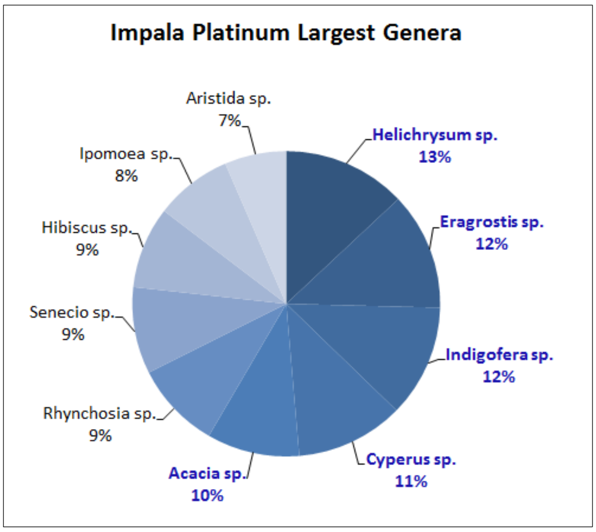

Figure 5.9: The 10 largest genera of the Impala Platinum flora.

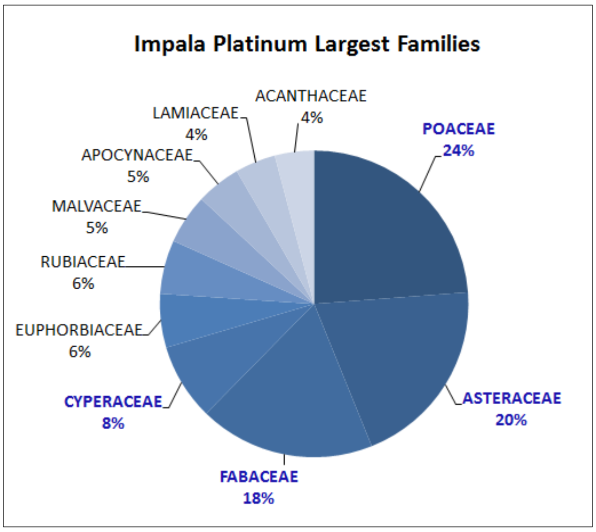

Figure 5.10: The 10 largest families found in the western Central Bushveld Bioregion.

A higher level of similarity exists between the WCB, Heritage Park and Impala Platinum flora at family than on genus level (figures 5.6 to 5.10). The four largest families are significantly correlated among the study areas: the Asteraceae (daisy family), the Cyperaceae (the sedge family), the Fabaceae (leguminose family) and the Poaceae (grass family).

5.2 Ordination

5.2.1 Principal Component Analysis (PCA)

The PCA's of the western Central Bushveld plant taxa show clear floristic groupings for each of the three plant datasets (unstandardized, Centroid and 'Integrated Grid' Profile). The spatial arrangement of these floristic groups in the landscape has been illustrated by representing them in a diagram.

Five floristic groups could be identified for the unstandardized species data (figure 5.11), but six floristic groups for the unstandardized genus and family data since the fifth group splits up into two groups on higher taxonomic level (figure 5.17 and 5.23). The presence of this sixth floristic group in the study area was confirmed by the spatial grouping of standardized taxa in the PCA ordination graph.

The ordination graphs commonly contain one (two) varying outlier sample(s) that cannot be exactly grouped with one of the recognized floristic groupings. But decisions on a possible grouping can be made with the aid of the spatial diagrams. The outlier 2425DC in the ordination graph of the 'Centroid Grid' species data for instance (figure 5.13), can be most probably grouped with group 3 as indicated by figure 5.14.

The floristic groups of each dataset show a high congruence across the three taxonomic levels. Furthermore, standardization generally resulted into spatially more distinct floristic groupings, particularly with increasing taxonomic level. For example the spatial grouping of families shows a very diffuse floristic pattern for the unstandardized data (figure 5.24), but display clear floristic groups for the standardized data (figure 5.26 and 5.28).

5.2.1.1 Species-level analyses

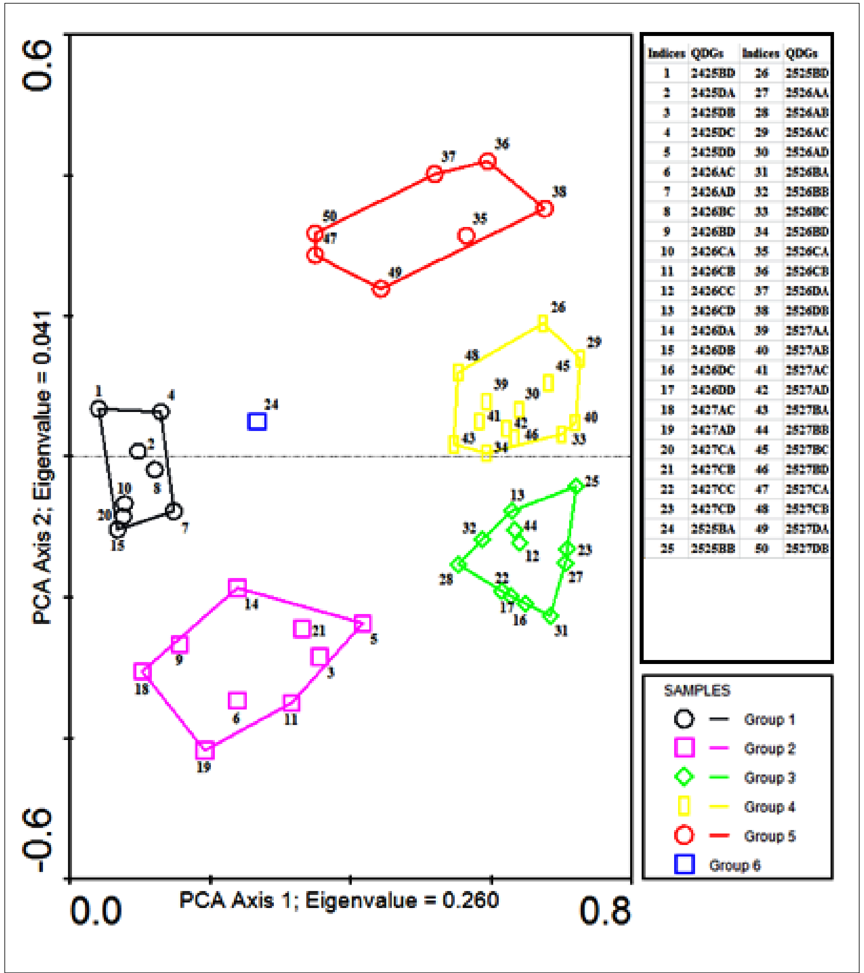

Figure 5.11: PCA ordination of unstandardized species data. The cumulative variance explained by the 1st and 2nd ordination axis amounts to 30.1 %.

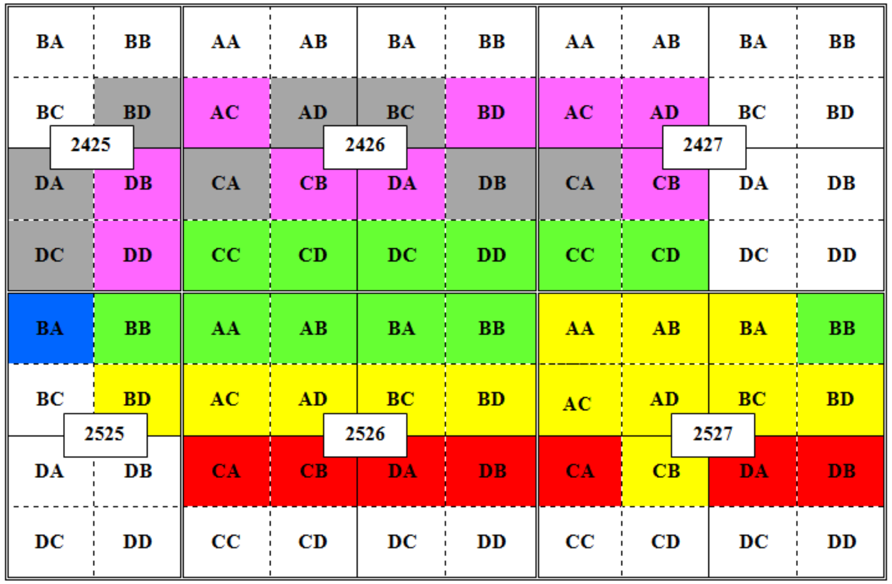

Figure 5.12: Floristic spatial pattern for unstandardized species data portrayed by the PCA groupings.

The PCA ordination of unstandardized species data results in a weak spatial clustering of floristic group 1 and 2 due to the low sampling status of the WCB flora in Botswana and the north of the study area beyond the Heritage Park (figure 5.12). Sample plot 24 (2525BA) appears to be an outlier in the unstandardized floristic data; the floristic affinity with other groups is not clear (figure 5.11). The floristic groupings show a horizontal arrangement from north to south across the WCB (figure 5.12).

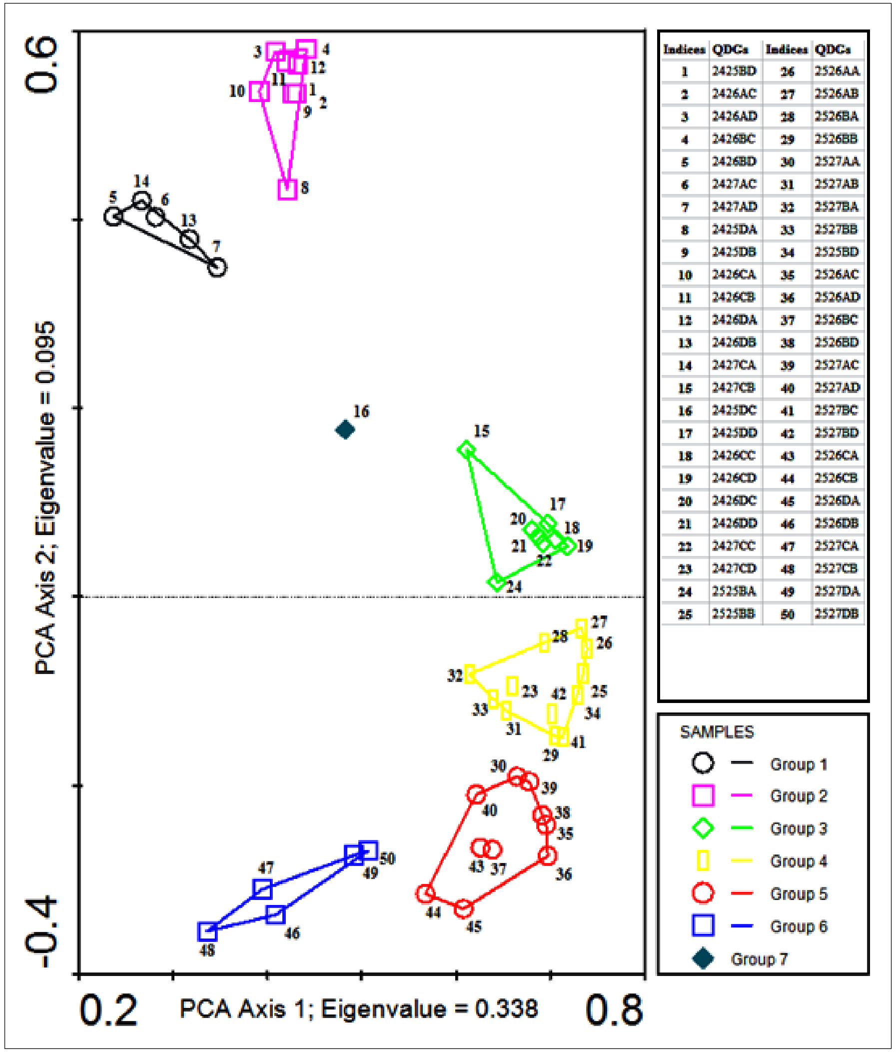

Figure 5.13: PCA ordination of standardized species data ('Centroid Grid' Profile). The cumulative variance explained by the 1st and 2nd ordination axis amounts to 43.3 %.

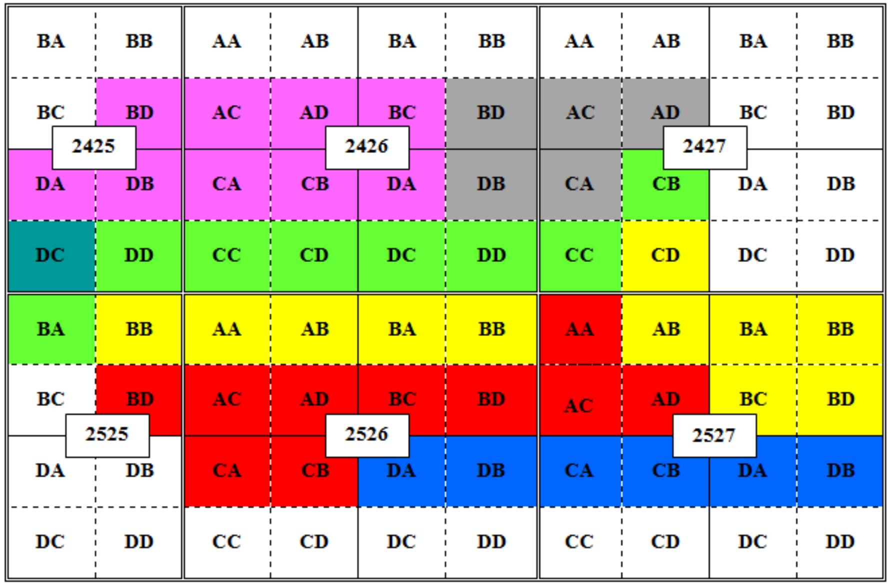

Figure 5.14: Floristic spatial pattern for standardized species data ('Centroid Grid' Profile) portrayed by the PCA groupings.

Standardization of species data with the 'Centroid Grid' Profile improved spatial clustering of floristic groups across the study area, particularly for group 1 and 2. Outlier 2525BA has formed a cluster with floristic group 3. Plot 16 (2425DC) became an outlier (figure 5.13), but figure 5.14 suggests an affinity with group 3. Furthermore, the former group 5 divided into two groups with the appearance of a sixth group; while group 4 formed two subgroups (figure 5.14). The spatial arrangement of floristic groups across the study area shifts from a horizontal orientation to a NW-SE directed diagonal.

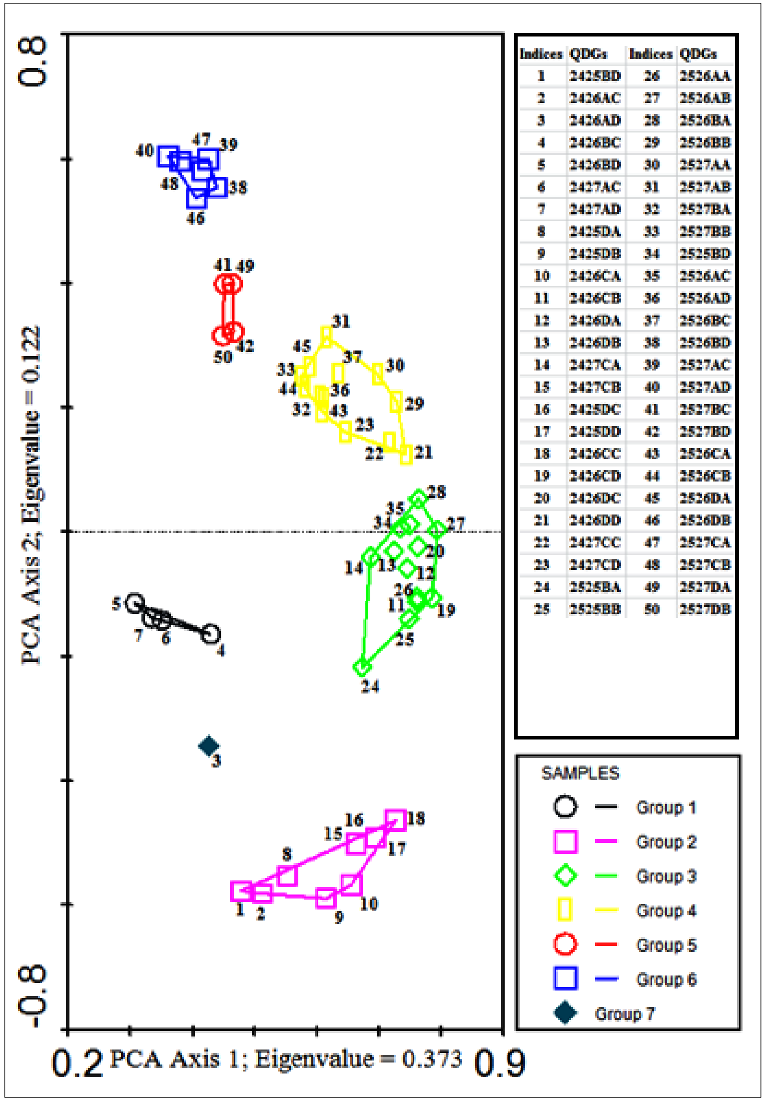

Figure 5.15: PCA ordination of standardized species data ('Integrated Grid' Profile). The cumulative variance explained by the 1st and 2nd ordination axis amounts to 49.5 %.

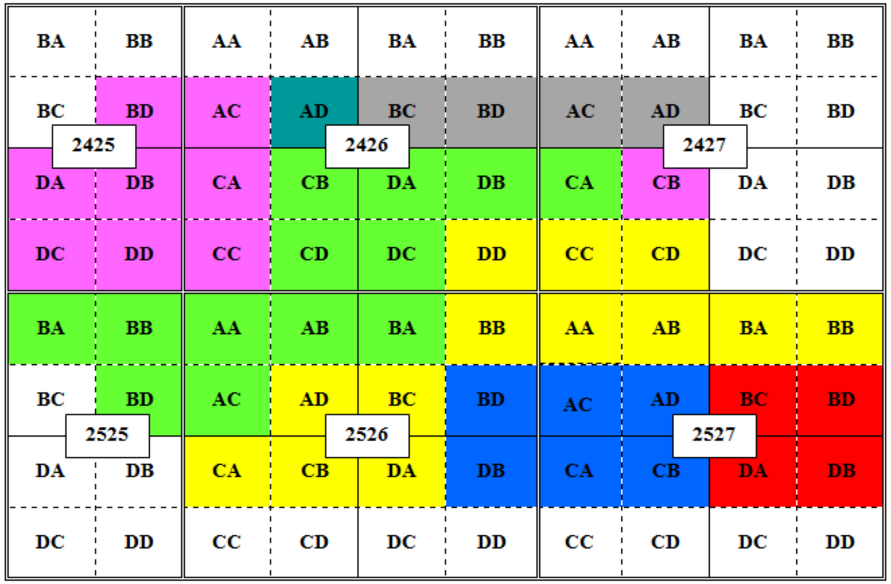

Figure 5.16: Floristic spatial pattern for standardized species data ('Integrated Grid' Profile) portrayed by the PCA groupings.

The indicated diagonal orientation of floristic groupings got more pronounced through the standardization of species data with the 'Integrated Grid' Profile (figure 5.16). Outlier 2425DC is now assembled with group 2; while sample plot 3 emerged to be an outlier, but a floristic affinity is assumed with group 1 (figure 5.15 and 5.16). Standardization improves the variance explained by the first and second ordination axis (figure 5.13 and 5.15). The PCA of the 'Integrated Grid' Profile shows the highest cumulative variance, and thus best explains the floristic similarities of the sample plots.

5.2.1.2 Genus-level analyses

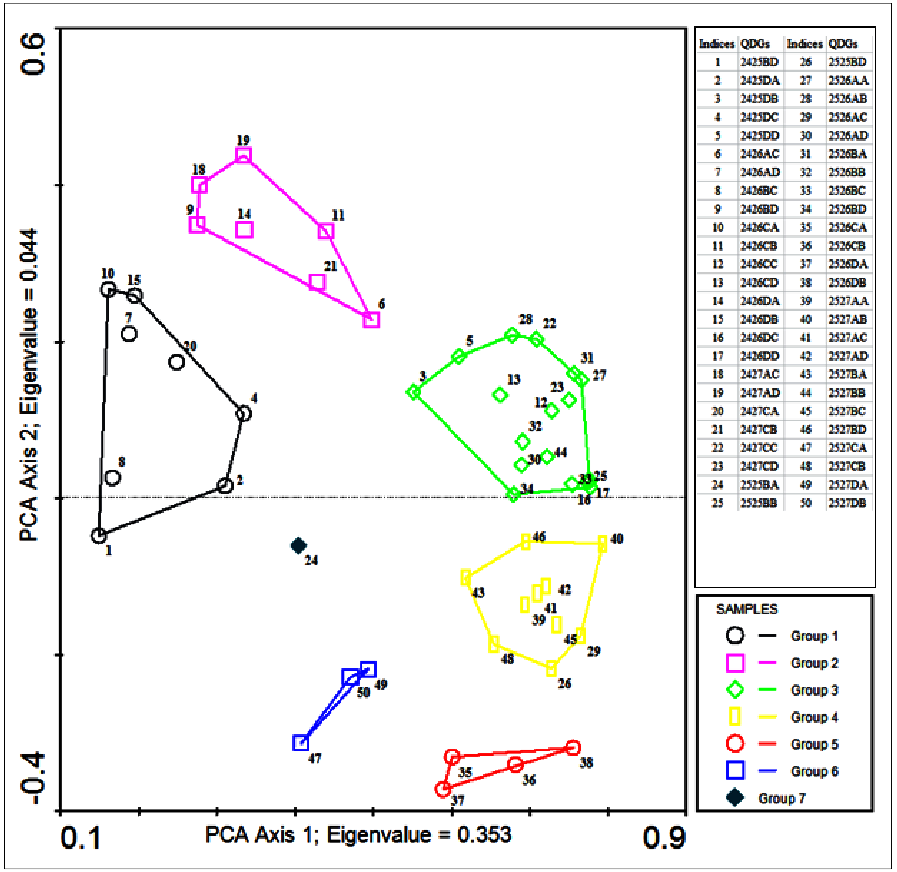

Figure 5.17: PCA ordination of unstandardized genus data. The cumulative variance explained by the 1st and 2nd ordination axis amounts to 39.7 %.

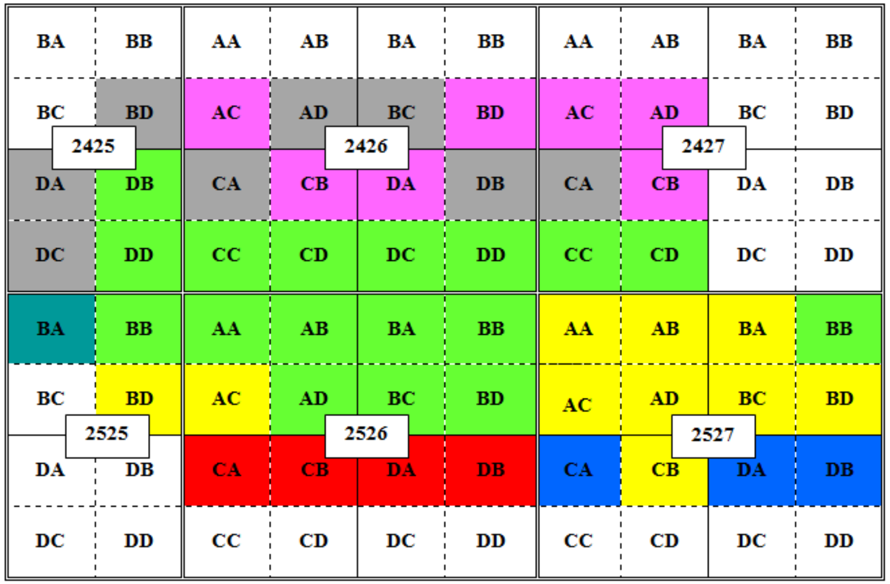

Figure 5.18: Floristic spatial pattern for unstandardized genus data portrayed by the PCA groupings.

The floristic groupings of the unstandardized genus data (figure 5.17) largely resemble those for the unstandardized species data (figure 5.11). However, group 3 emerges to be a more inclusive floristic group on genus level than on species level; while the former group 5 now clearly splits into the two groups 5 and 6 on genus level.

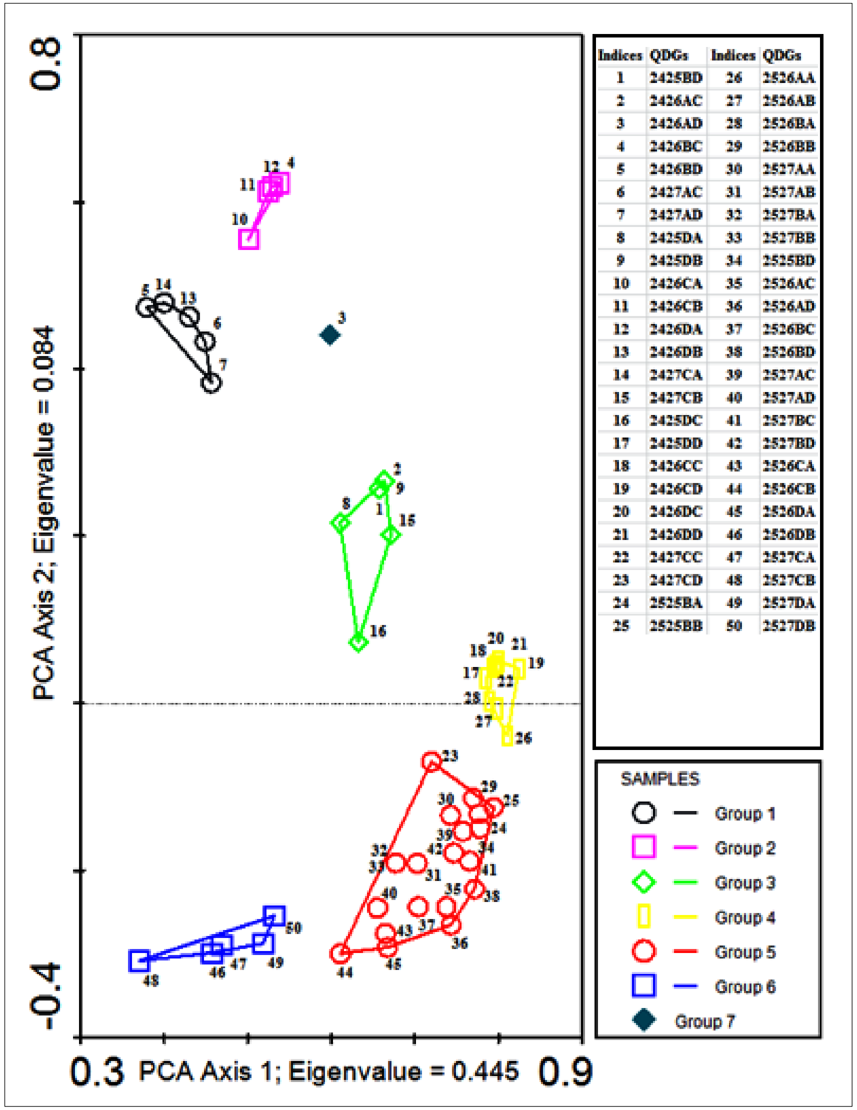

Figure 5.19: PCA ordination of standardized genus data ('Centroid Grid' Profile). The cumulative variance explained by the 1st and 2nd ordination axis amounts to 53.0 %.

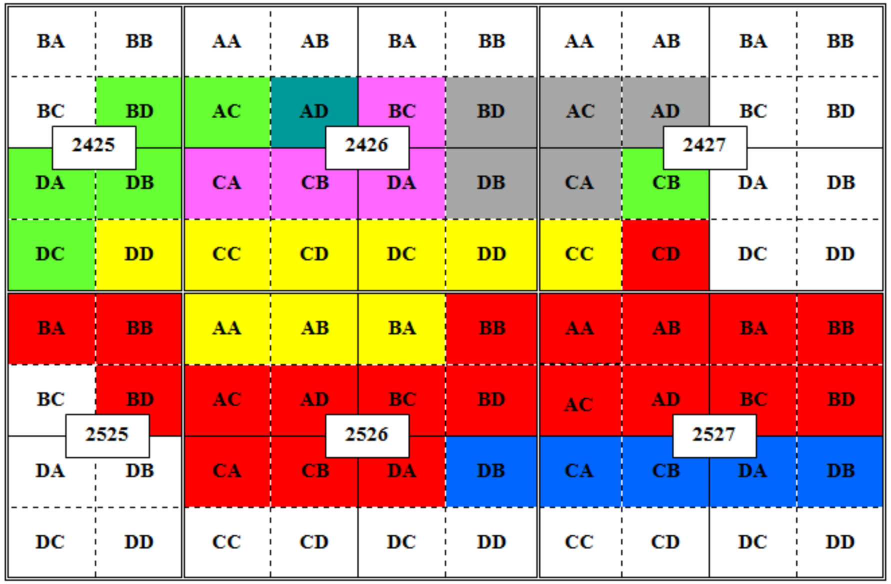

Figure 5.20: Floristic spatial pattern for standardized genus data ('Centroid Grid' Profile) portrayed by the PCA groupings.

The PCA ordination of the genus data standardized with the 'Centroid Grid' Profile shows a marked re-arrangement of floristic groups (figure 5.20). Here, group 5 emerged to be the more inclusive floristic group on genus level (figure 5.19). The spatial arrangement of floristic areas is vertical in the north and diagonal towards the south-east.

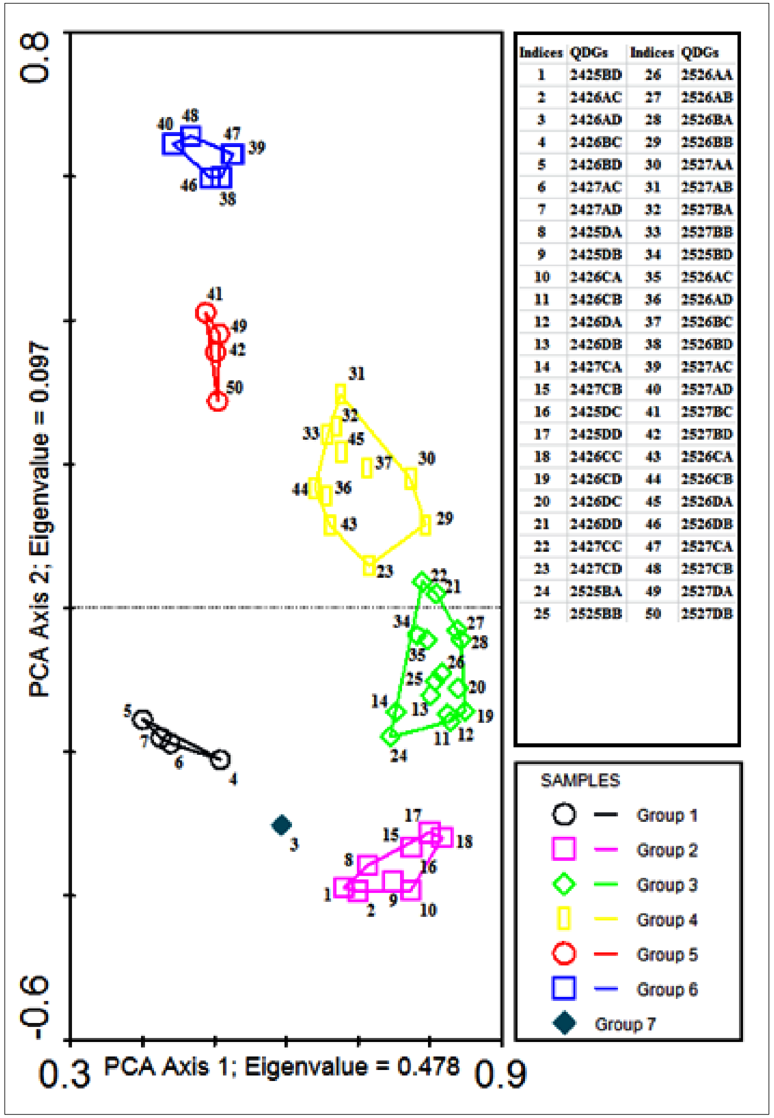

Figure 5.21: PCA ordination of standardized genus data ('Integrated Grid' Profile). The cumulative variance explained by the 1st and 2nd ordination axis amounts to 57.5 %.

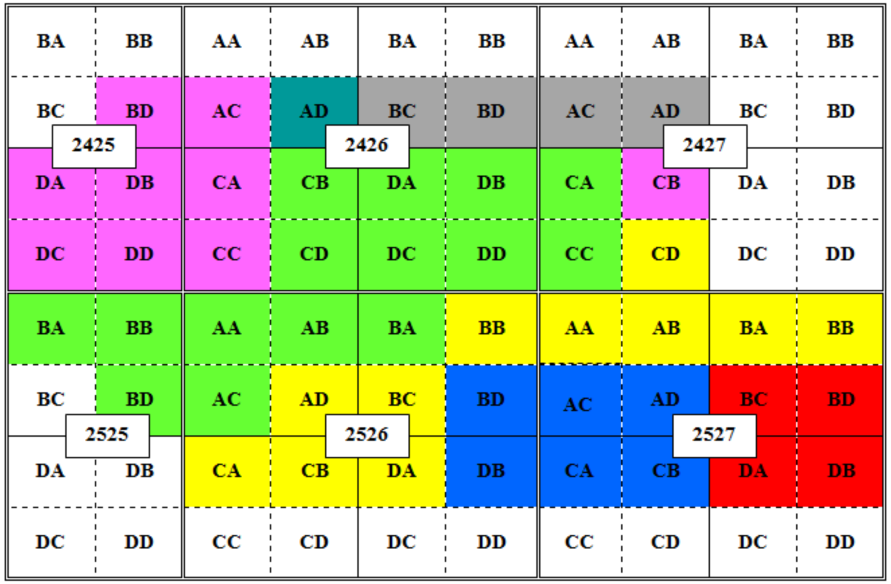

Figure 5.22: Floristic spatial pattern for standardized genus data ('Integrated Grid' Profile) portrayed by the PCA groupings.

On the other side, the PCA ordination of genus data standardized with the 'Integrated Grid' Profile (figure 5.21 and 5.22) principally resembles those of the species data standardized with the 'Integrated Grid' Profile (figure 5.15 and 5.16), with the difference that group 3 is more inclusive again on genus level.

5.2.1.3 Family-level analyses

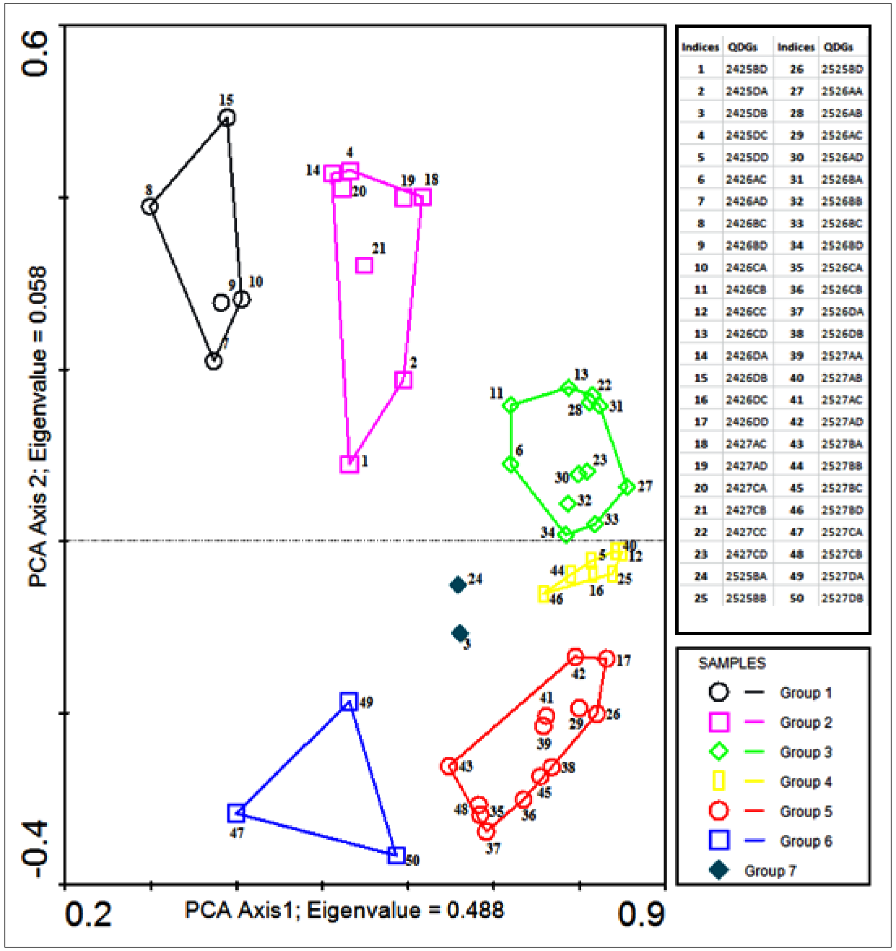

Figure 5.23: PCA ordination of unstandardized family data. The cumulative variance explained by the 1st and 2nd ordination axis amounts to 54.5 %.

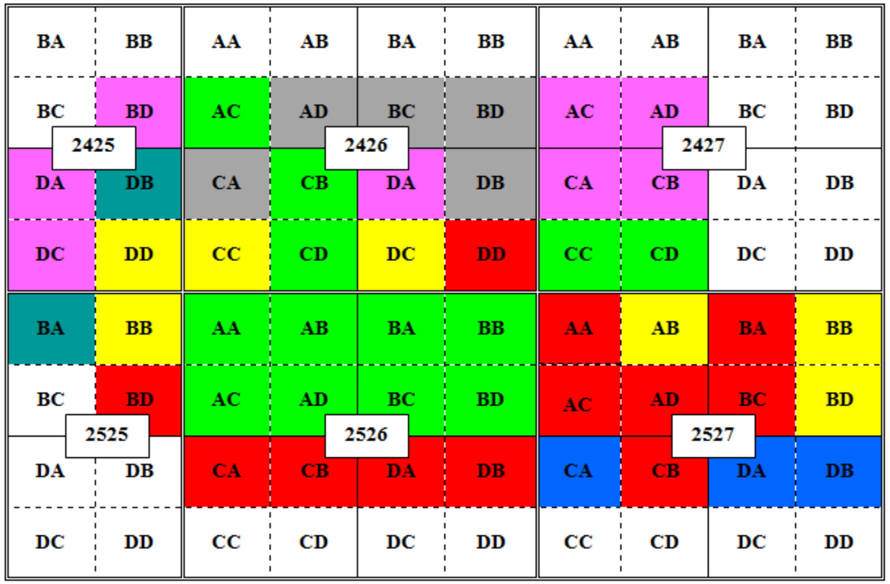

Figure 5.24: Floristic spatial pattern for unstandardized family data portrayed by the PCA groupings.

In contrast to the species and genus level the PCA ordination of the unstandardized family level yielded only a weak floristic grouping (figure 5.24). Thus, unstandardized data demonstrates a low floristic affinity on family level.

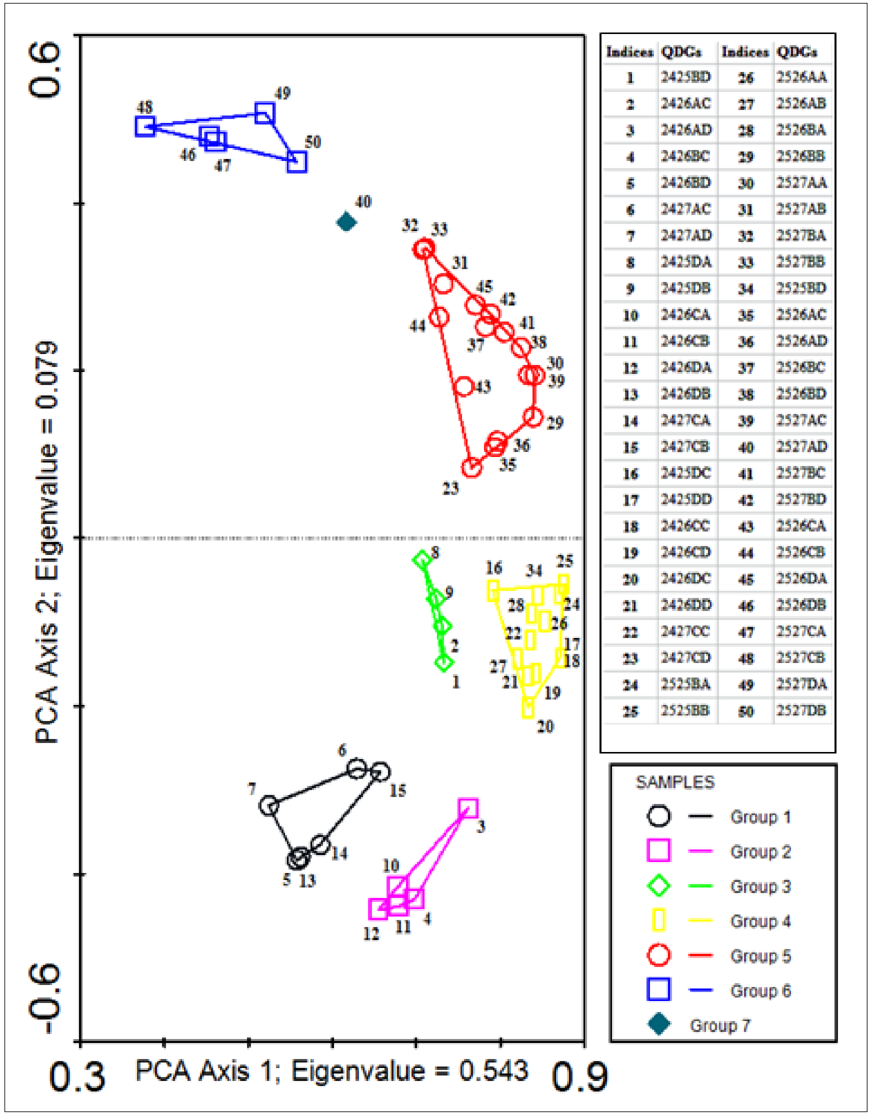

Figure 5.25: PCA ordination of standardized family data ('Centroid Grid' Profile). The cumulative variance explained by the 1st and 2nd ordination axis amounts to 62.2 %.

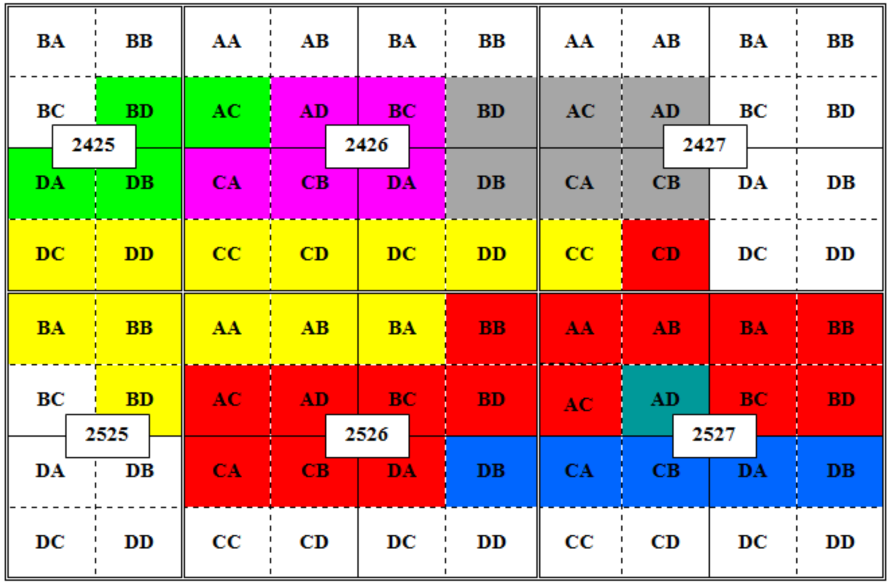

Figure 5.26: Floristic spatial pattern for standardized family data ('Centroid Grid' Profile) portrayed by the PCA groupings.

The floristic groupings of the family data standardized with the 'Centroid Grid' Profile (figure 5.26) resemble those of the genus data standardized with the 'Centroid Grid' Profile (figure 5.20).

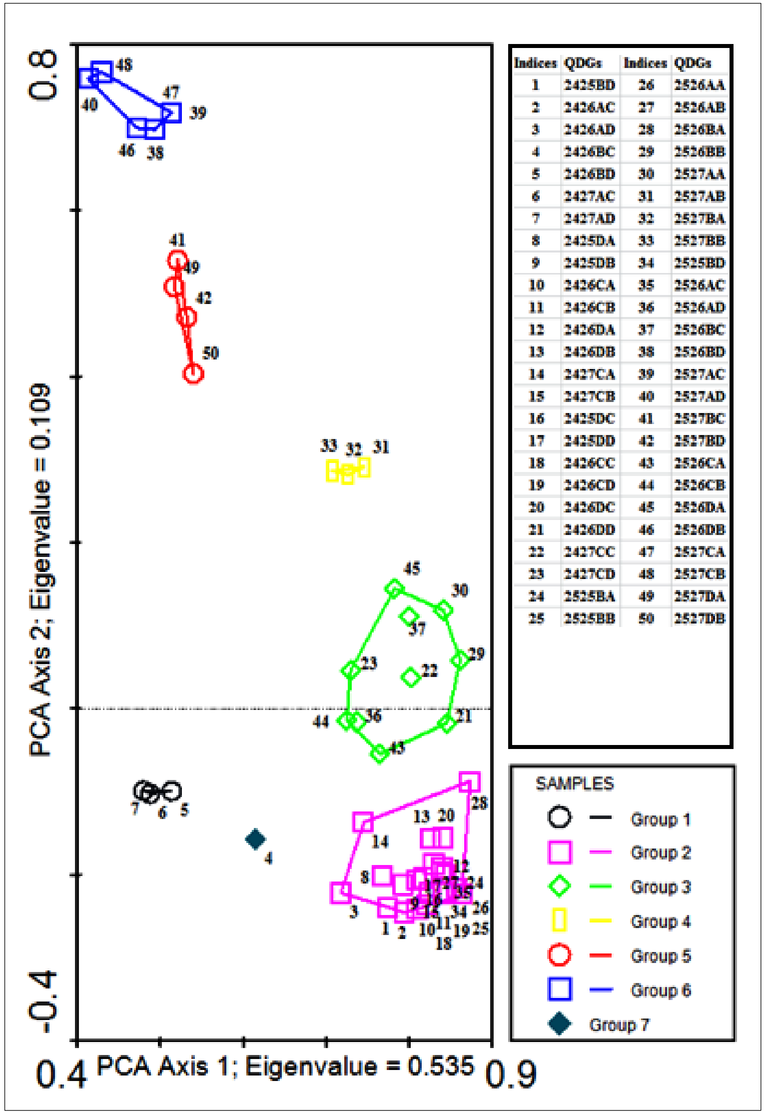

Figure 5.27: PCA ordination of standardized family data ('Integrated Grid' Profile). The cumulative variance explained by the 1st and 2nd ordination axis amounts to 64.4 %.

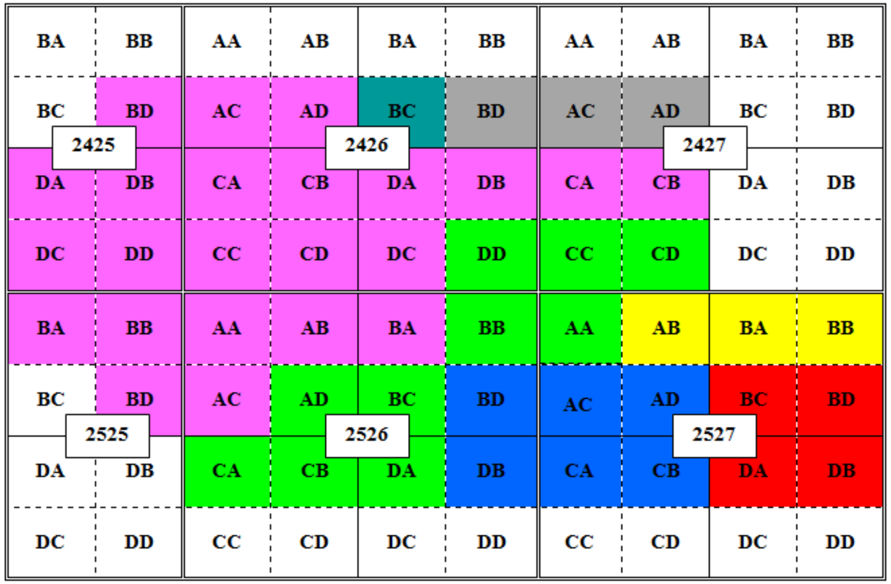

Figure 5.28: Floristic spatial pattern for standardized family data ('Integrated Grid' Profile) portrayed by the PCA groupings.

The PCA ordination of family data standardized with the 'Integrated Grid' Profile displays a similar pattern to the species and genus data standardized with the 'Integrated Grid' Profile (figures 5.15 and 5.21), except that group 2 now forms a large dominant floristic cluster diminishing floristic group 3 and 4.

Moreover, the analyses show that the cumulative variance explained by the ordination axes increases with increasing hierarchical level of plant taxa and by standardization with the 'Centroid Grid' and 'Integrated Grid' Profile.

5.2.2 Detrended Correspondence Analysis

DCA ordination graphs depicted an increase in beta-diversity for all taxonomic levels (species, genus and family) through standardization.

The ordination of unstandardized plant taxa resulted in clustering of the samples in the centre of the ordination graphs with little differentiation due to low beta-diversity (figure 5.29 to 5.31). This means that there is low floristic variation between the samples (low variance explained by the ordination axes), which also explains the weak formation of floristic groups in the PCA ordination. Floristic grouping becomes more diffuse with increasing taxonomic level.

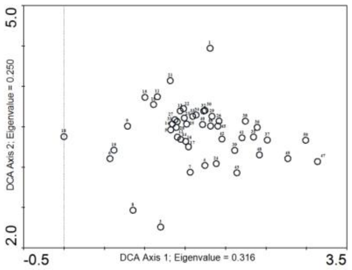

Figure 5.29: DCA ordination of unstandardized species data. Cumulative variance = 8.8 %.

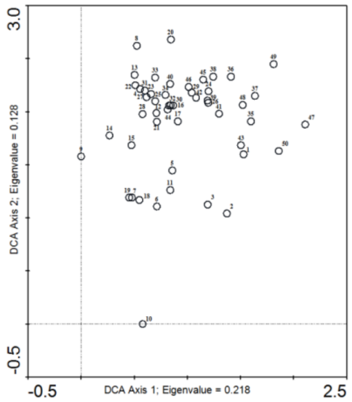

Figure 5.30: DCA ordination of unstandardized genus data. Cumulative variance = 11.4%.

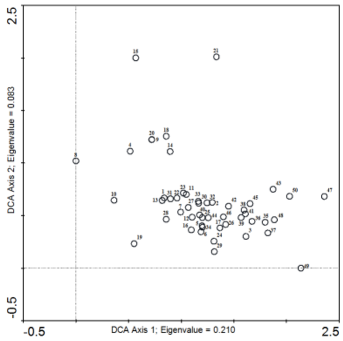

Figure 5.31: DCA ordination of unstandardized family data. Cumulative variance = 17.3%.

On the other side, the ordination of standardized plant taxa shows a stronger spatial differentiation, due to higher beta-diversity between the samples (figure 5.32 to 5.37). The variation between samples or groups of samples has increased (higher variance explained by the ordination axes), which also improved the clustering of samples into floristic groups in the PCA ordination. Floristic grouping becomes more distinct with increasing taxonomic level.

DCA ordination of plant taxa standardized with the 'Integrated Grid' Profile display the highest beta-diversity (highest variance explained by ordination axes). This in turn explains the strong clustering of plant taxa into floristic groups by PCA ordination.

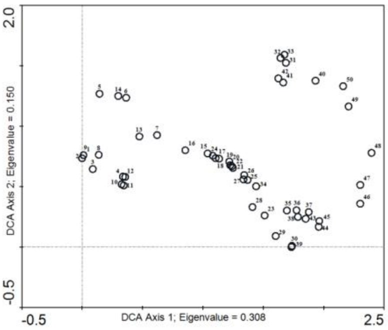

Figure 5.32: DCA ordination of standardized species data ('Centroid Grid' Profile). Cumulative variance = 19.7%.

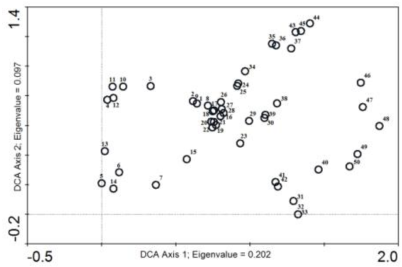

Figure 5.33: DCA ordination of standardized genus data ('Centroid Grid' Profile). Cumulative variance = 23.6%.

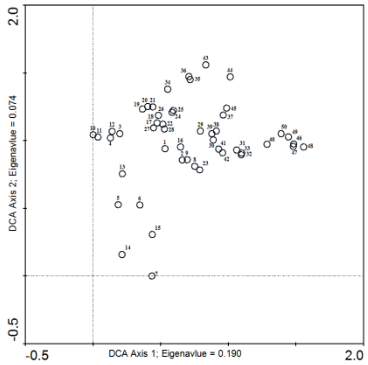

Figure 5.34: DCA ordination of standardized family data ('Centroid Grid' Profile). Cumulative variance = 30.4%.

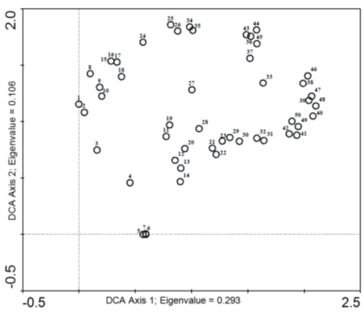

Figure 5.35: DCA ordination of standardized species data ('Integrated Grid' Profile). Cumulative variance = 27.6%.

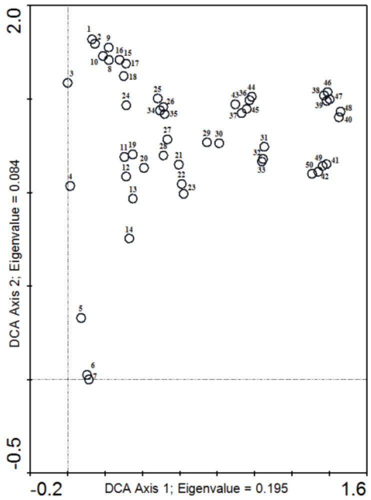

Figure 5.36: DCA ordination of standardized genus data ('Integrated Grid' Profile). Cumulative variance = 32.1%.

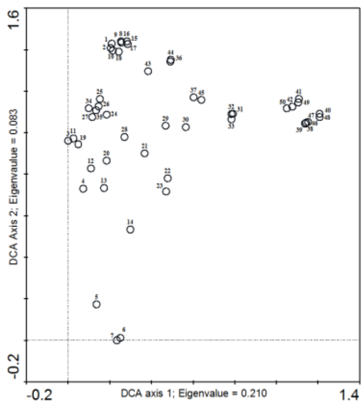

Figure 5.37: DCA ordination of standardized genus data ('Integrated Grid' Profile). Cumulative variance = 40.7%.

5.3 Spatial Analysis

5.3.1 Interpolation

The interpolation maps of plant taxa show a significant increase in the sampling status of underrepresented Quarter Degree Grids. Standardization predicts a higher phyto-diversity for plant species, genera and families in the northern extents of the study area than displayed by the present plant collections (figures 5.38 to 5.41). More significantly, a greater distribution range of plant taxa richness has been predicted for the endemic, Red Data and Protected Tree species (figures 5.42 to 5.47). Interpolation results will be discussed and put into context in chapter 6.

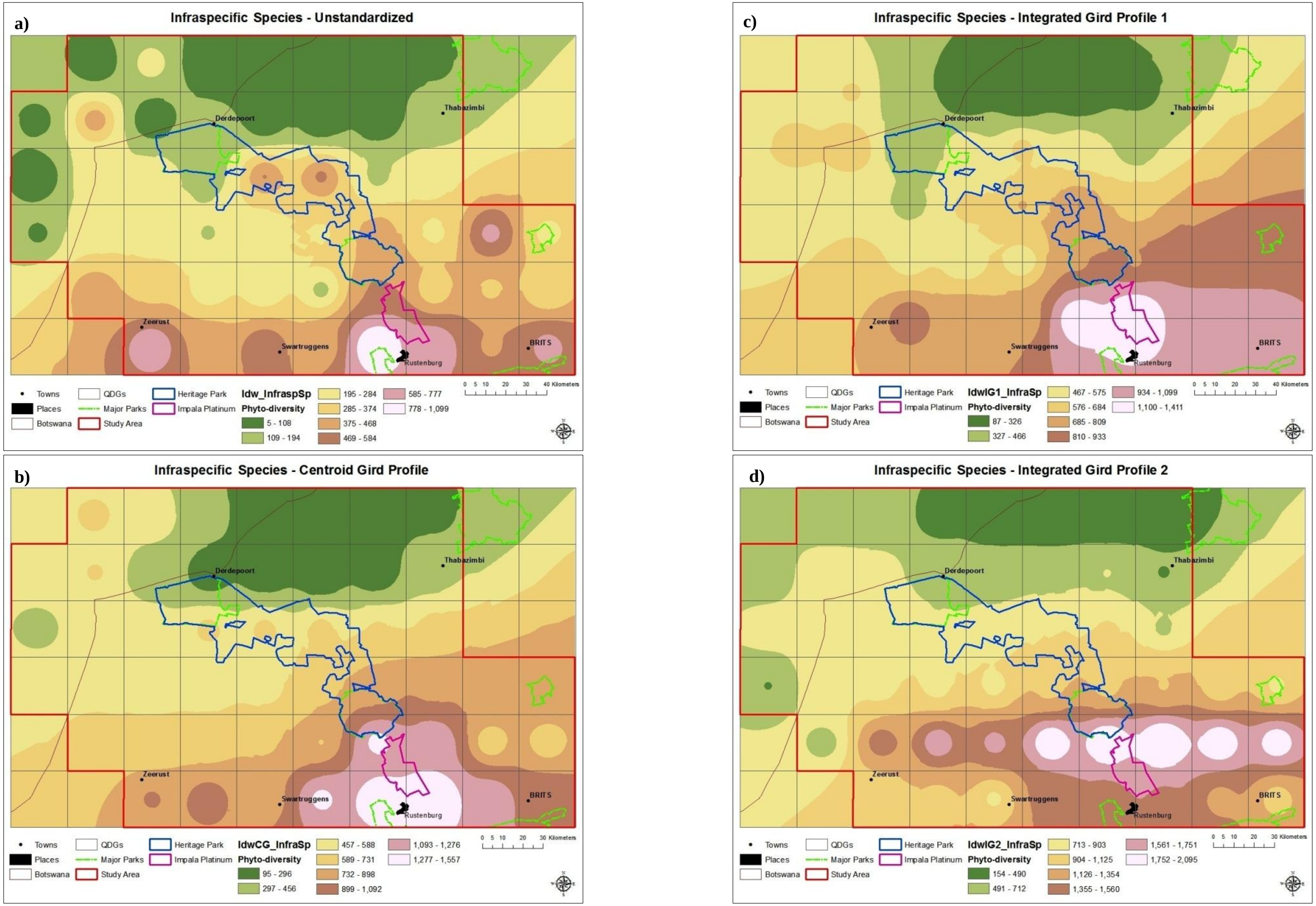

Figure 5.38: Interpolation maps for the richness of plant species on infraspecific taxonomic level in the western Central Bushveld.

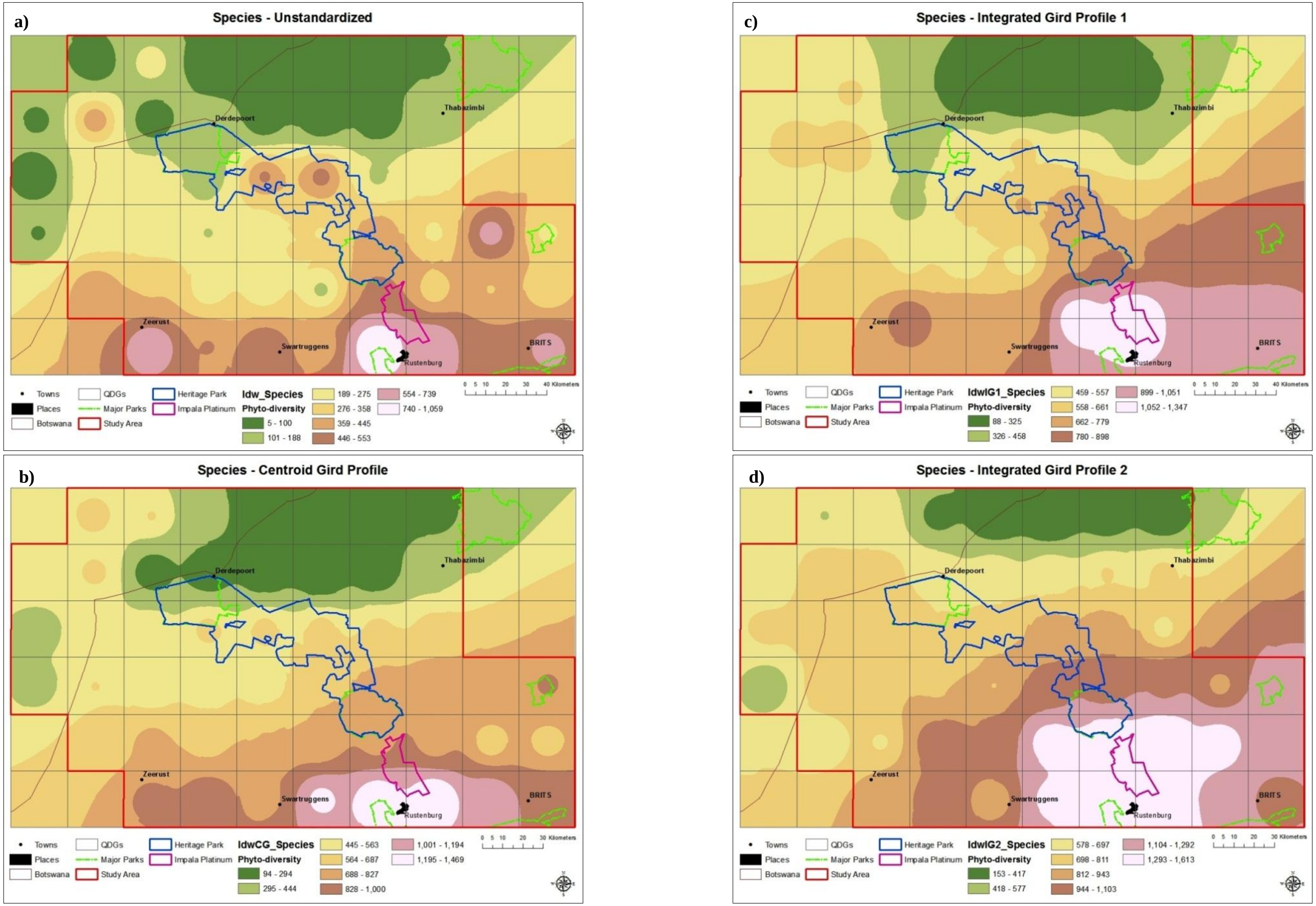

Figure 5.39: Interpolation maps for the richness of plant species in the western Central Bushveld.

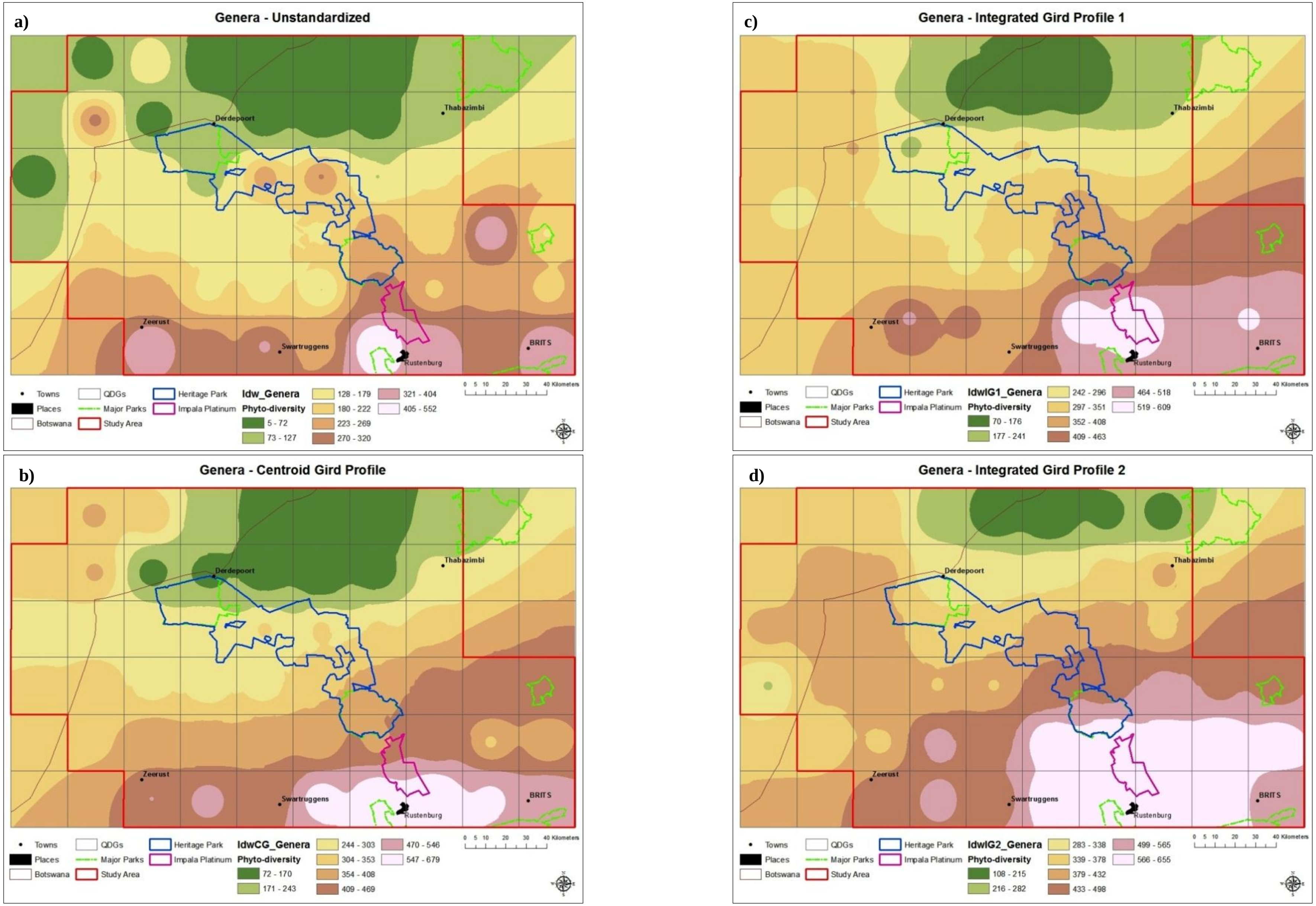

Figure 5.40: Interpolation maps for the richness of plant genera in the western Central Bushveld.

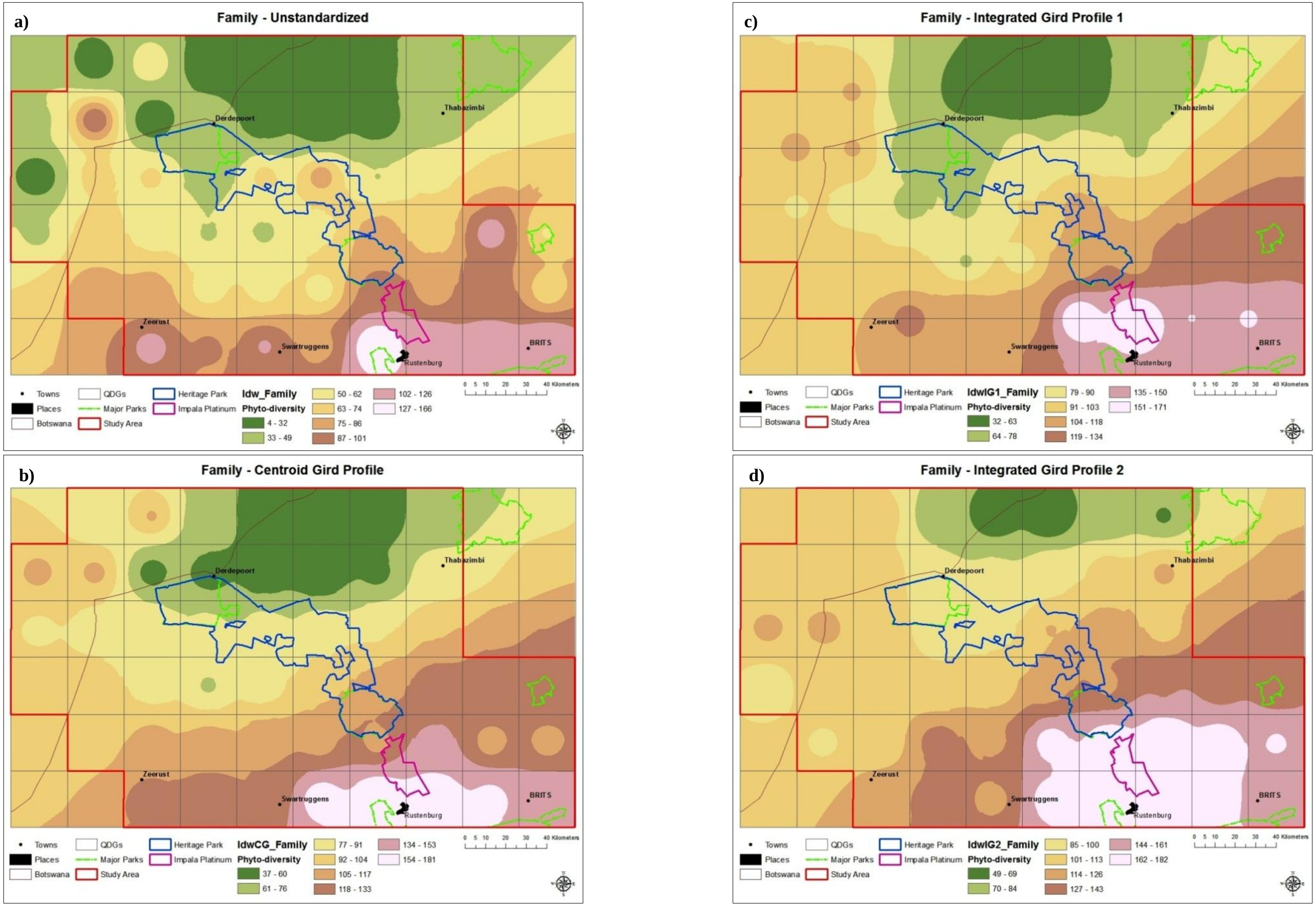

Figure 5.41: Interpolation maps for the richness of plant families in the western Central Bushveld.

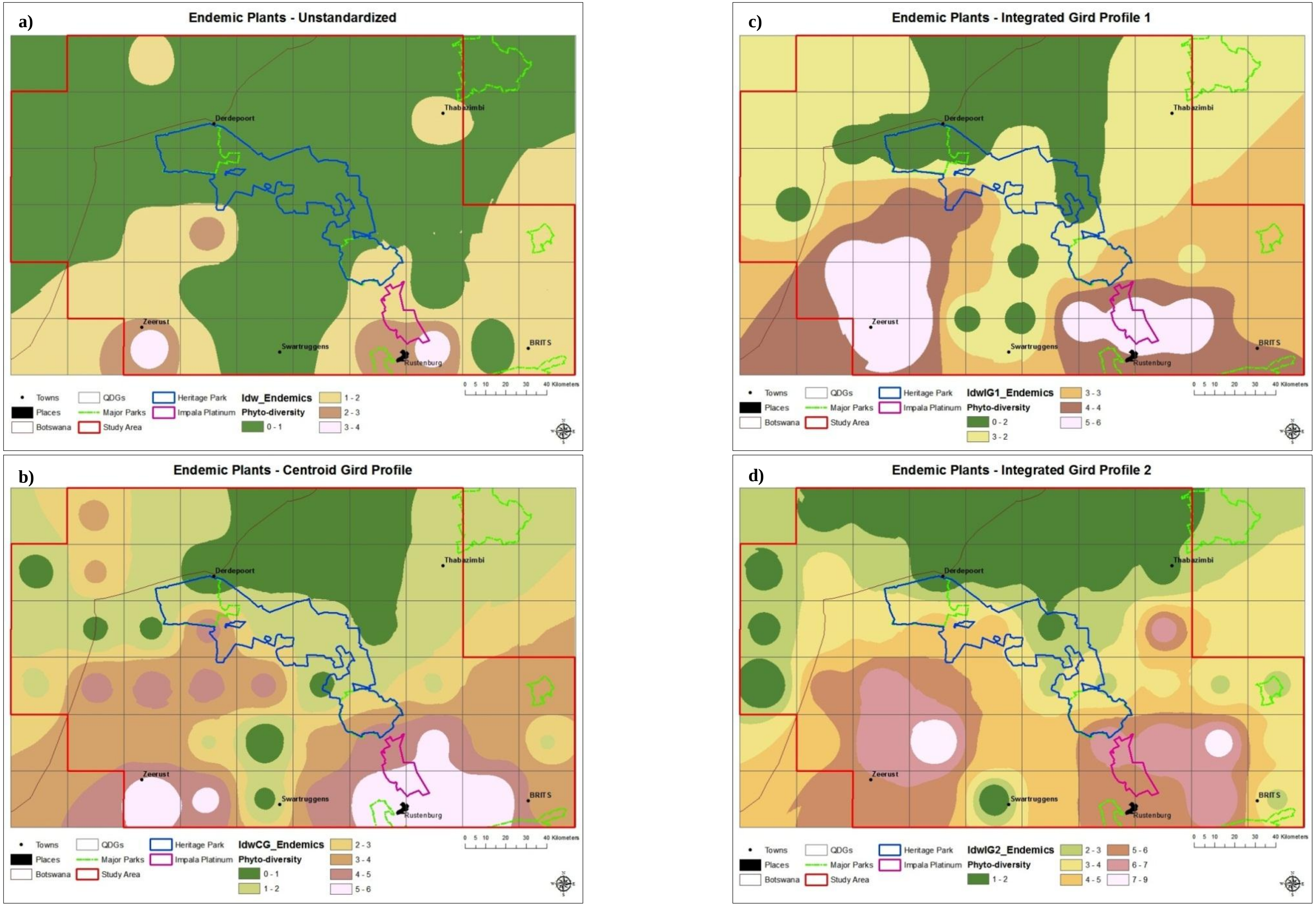

Figure 5.42: Interpolation maps for the richness of endemic plant species in the western Central Bushveld.

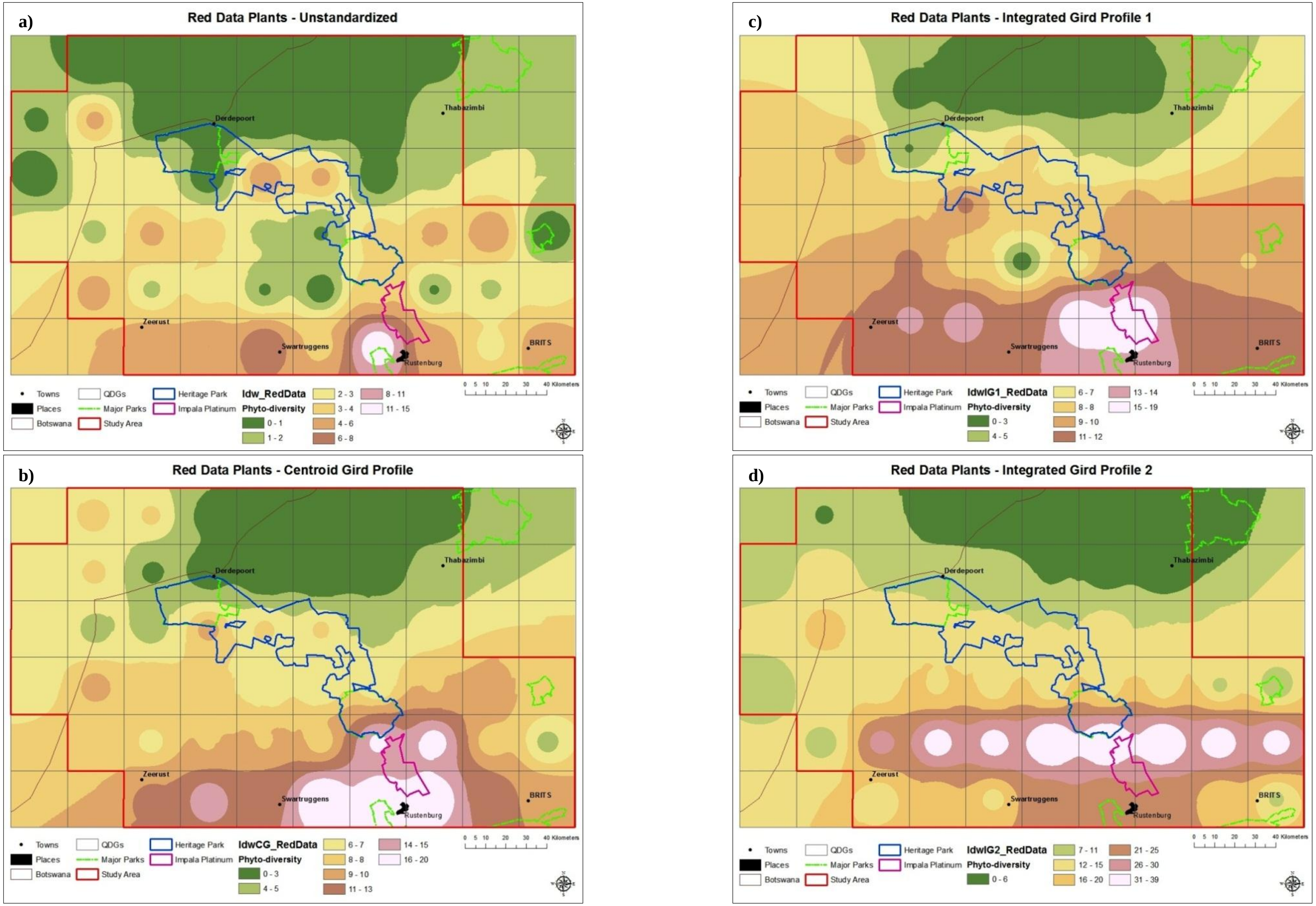

Figure 5.43: Interpolation maps for the richness of Red Data plant species in the western Central Bushveld.

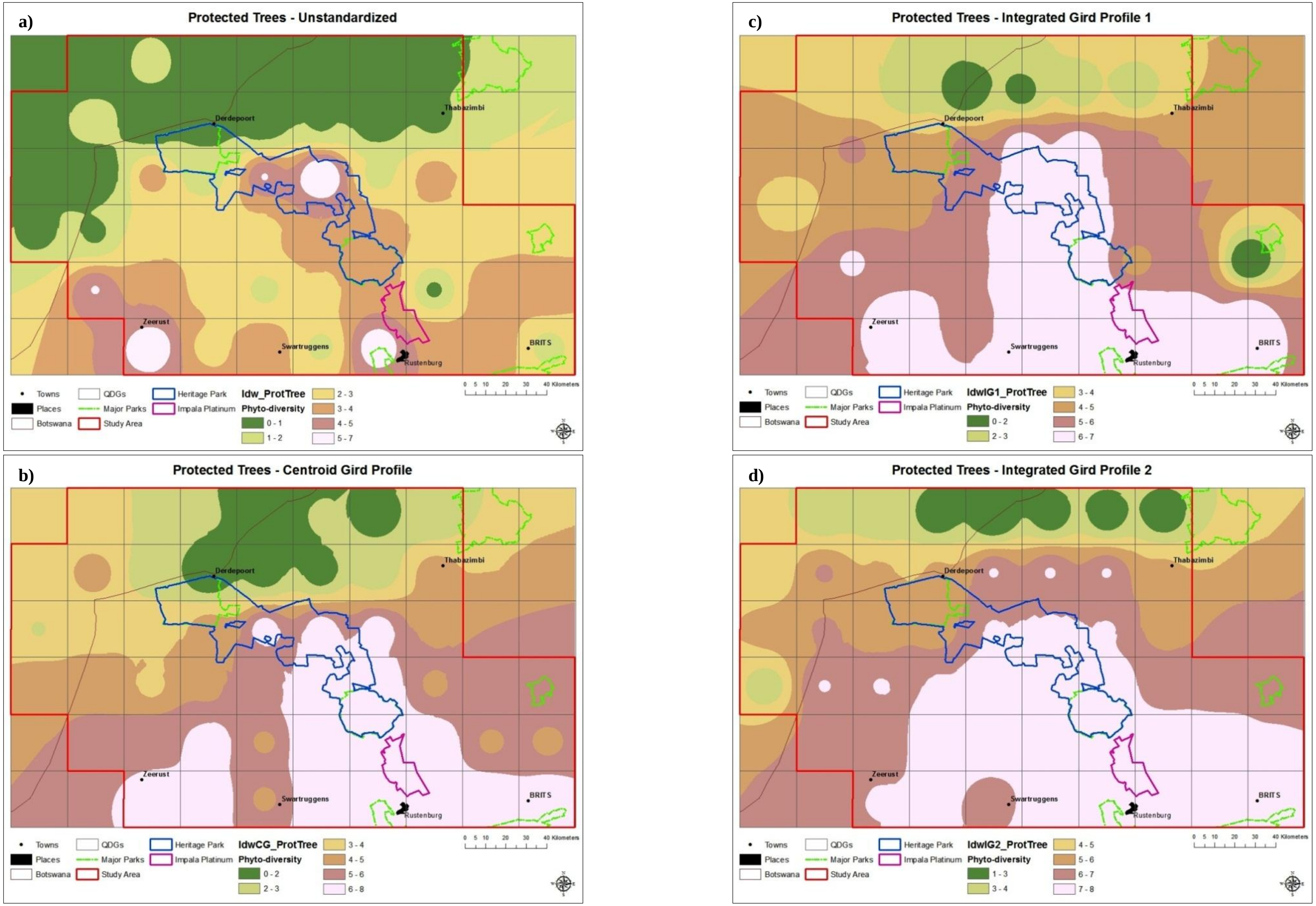

Figure 5.44: Interpolation maps for the richness of Protected Tree species in the western Central Bushveld.

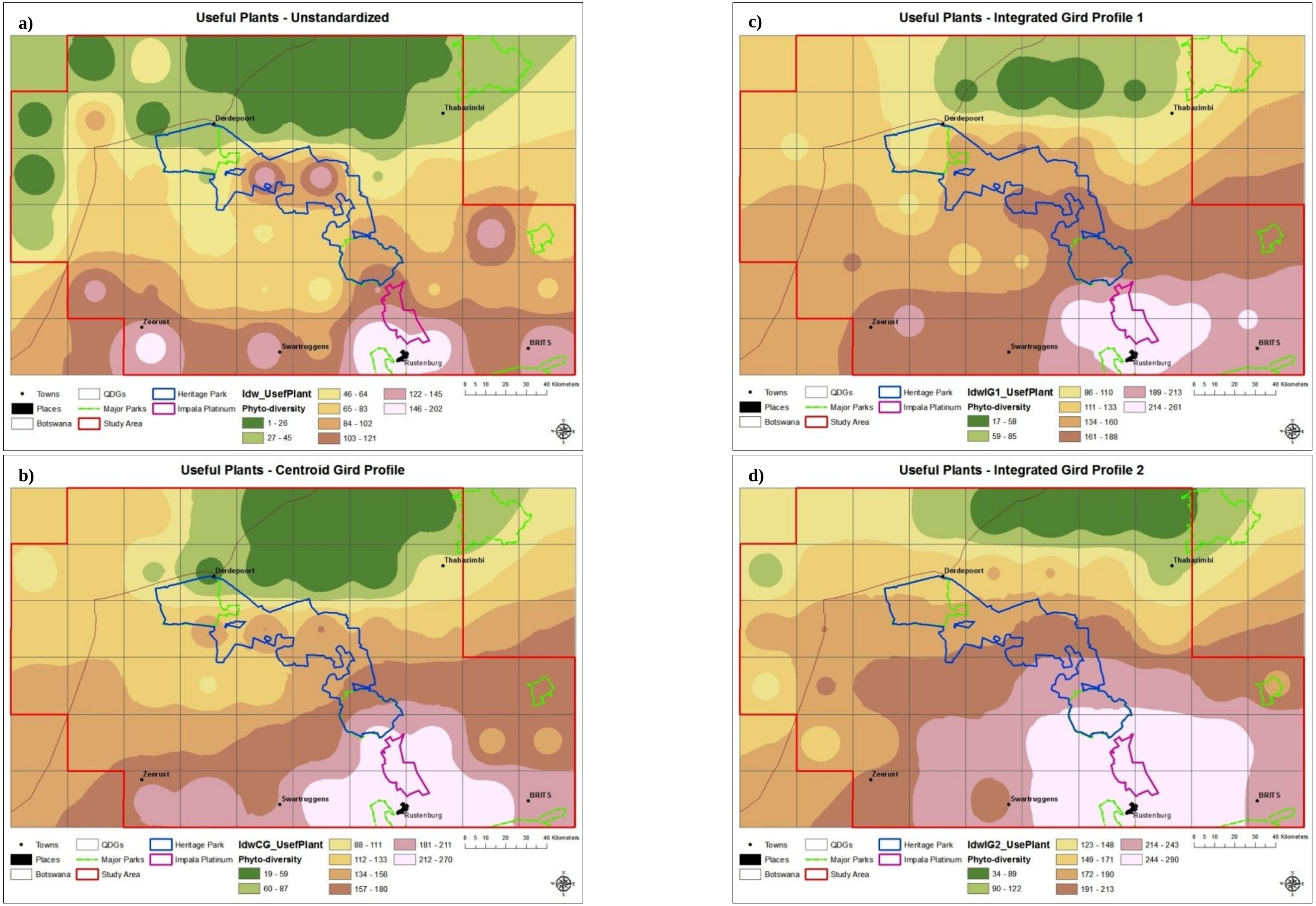

Figure 5.45: Interpolation maps for the richness of Useful Plant species in the western Central Bushveld.

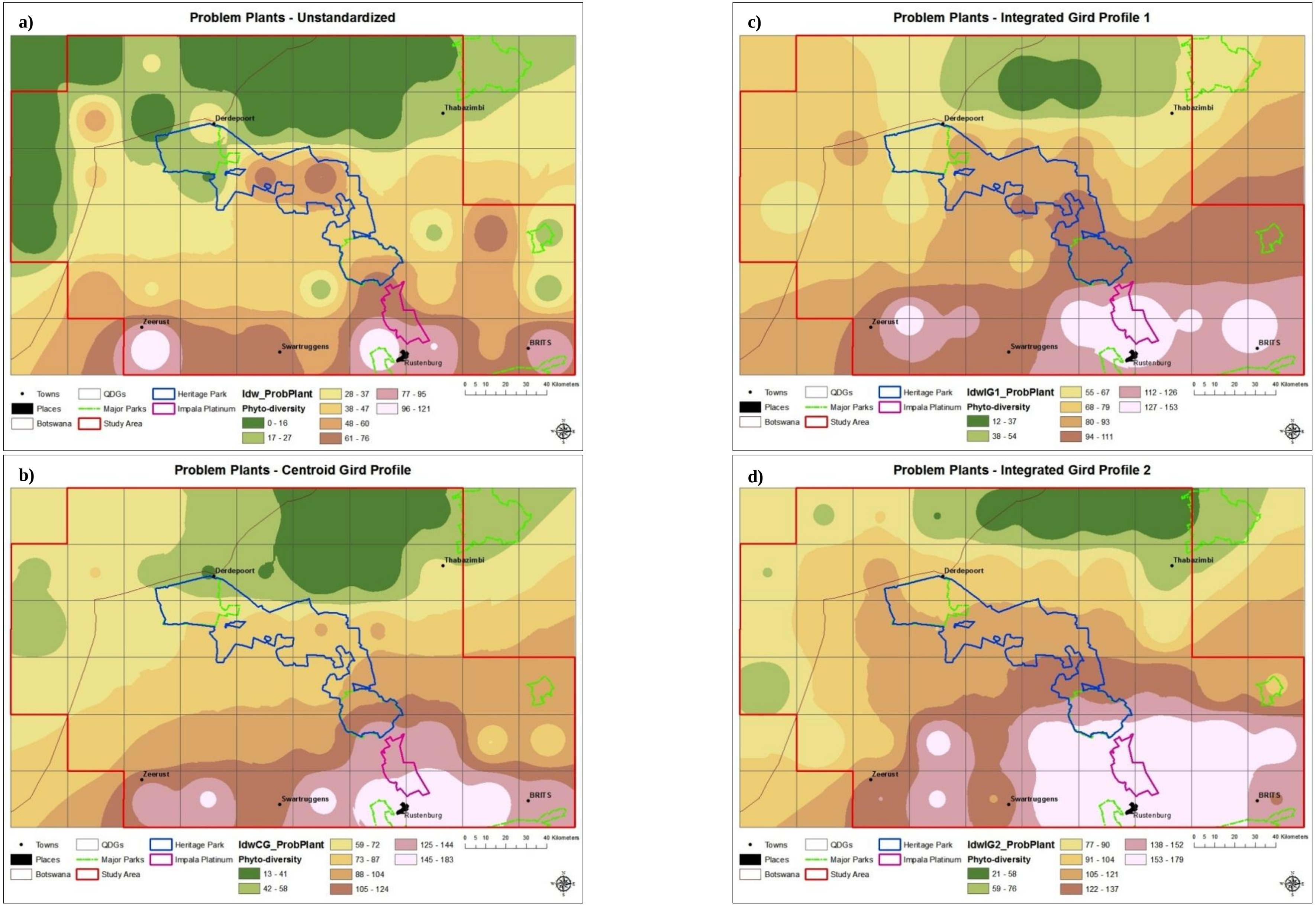

Figure 5.46: Interpolation maps for the richness of Problem Plant species in the western Central Bushveld.

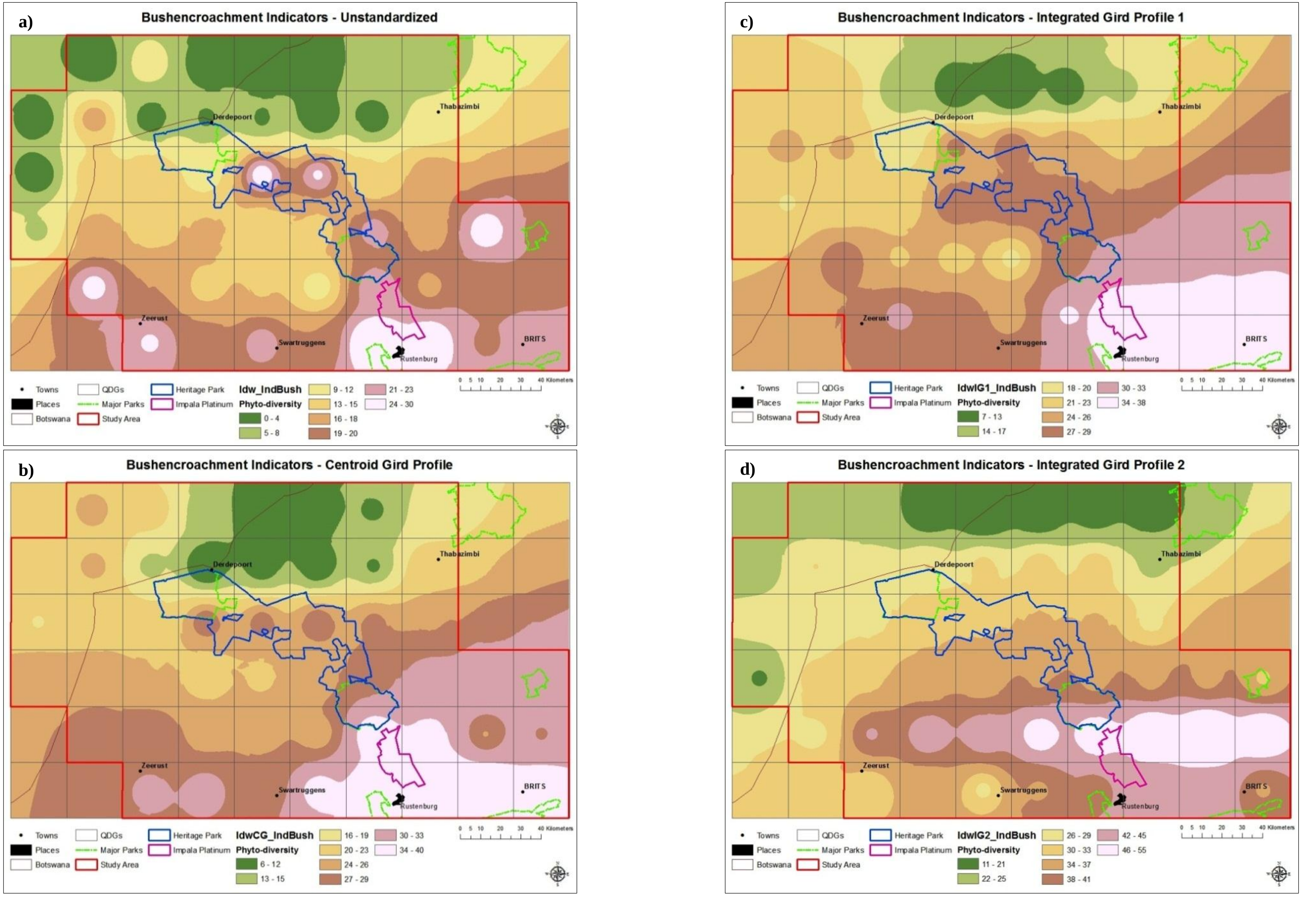

Figure 5.47: Interpolation maps for the richness of Bushencroachment Indicator species in the western Central Bushveld.

5.4 Correlation of the spatial distribution of plant species richness with environmental and anthropogenic factors.

The distribution of plant taxa richness in the study area has been found to be closely related to the climatic (figures 5.48 to 5.51; tables 5.2 to 5.9) and physical environmental (figures 5.52 to 5.54; tables 5.10 to 5.26) factors of the Central Bushveld Bioregion. Human-induced changes in the plant species richness patterns could be identified (figures 5.55 to 5.58; tables 5.27 to 5.40). The findings will be briefly outlined below and discussed in more detail in chapter 6.

Species richness roughly decreases with increasing annual minimum and maximum temperature on bioregional level (figures 5.48 and 5.49; tables 5.2 and 5.3). The increase in temperature is largely accompanied with declining precipitation and raised evaporation, resulting in a lower rainfall effectivity that limits species richness (figures 5.50 and 5.51; tables 5.10 and 5.11). Significant in this respect are evaporation levels above 2,001–2,200 mm (table 5.11). Looking closer at the annual maximum temperatures, species richness first increases with rising annual maximum temperatures from 0–25 ºC to 29.1–31 ºC but then declines again with a further temperature rise to 33.1– 35 ºC (table 5.3). The same climate related patterns have been observed for endemic (tables 5.4, 5.5, 5.12 and 5.13), Red Data (tables 5.6, 5.7, 5.14 and 5.15) and Protected Tree species (tables 5.8, 5.9, 5.16 and 5.17).

However, locally extraordinary species richness could be related to the volcanic rocks of the Bushveld Complex, such as dolerite, gabbro and norite (figure 5.53; table 5.21). Furthermore, the sedimentary rocks of the Transvaal Supergroup (e.g. shale, dolomite and quartzite) (figure 5.53; table 5.21), making up the hills and ridges encircling the Bushveld basin (Bankenveld) in the south and north (figure 5.52; table 5.18), could be associated with high species richness as well. A similar pattern could be observed for endemic (table 5.22) and Red Data (table 5.23) species.

Peaks in species richness are also found on nutrient-rich soils, such as the loamy to clayey red apedal and structured soils (figure 5.52; table 5.24). For example, the vertic and melanic clay soils that overlay the mafic and ultramafic rocks of the Bushveld Complex show high counts of plant species. The same applies to endemic and Red Data plants, which occur in greatest density on vertic, melanic, red structured soils and red-yellow soils with a high base status (tables 5.25 and 5.26). As opposed to this, the highest average plant species richness was recorded for soils of the Glenrosa and Mispah form with limited pedological development and nutrient status.

Furthermore, terrain morphology proved to play a big role in the distribution of phyto-diversity (figure 5.52; table 5.18) and rare plants (tables 5.19 and 5.20) in the study area. Hills and their associated lowlands and undulating plains, which display a high environmental heterogeneity, show the highest average species richness, in contrast to the plains of the Bushveld basin with a low variation in relief.

Analyses of the land-use and landcover mosaic revealed that the largest part of the plant diversity in the study area is still safeguarded in untransformed land (vacant land and conservation areas) (tables 5.27 and 5.28). Yet, land transformation has been recognized to be a real threat to the WCB phyto-diversity.

Table 5.28 illustrates that degraded land has lost about 50% of its plant species diversity in comparison to untransformed vegetation cover. Degradation is associated with built-up land, cultivation and mining (figures 5.55 and 5.56) accompanied by the invasion of problem plant and bush encroachment indicator species (tables 5.36 and 5.38). Although these areas of intense anthropogenic use rank among the species richest, it is those human activities that pose the greatest threat to plant diversity in the WCB.

For example, the large sections of vacant land in the centre of the study area including the Heritage Park is characterized by fertile soils with medium to high agricultural potential and considerable species richness (figure 5.57). This species rich area with maximum counts of plant species between 822 and 1,045 plant species is threatened by an expansion of agriculture if parts of it is set aside for conservation (table 5.41).

On the other hand, large sections in the southern study area are not suitable for arable farming (figure 5.58). However, several of these agricultural marginal areas have been identified to be used for crop cultivation, and thus the rich vegetation with plant diversity that locally may approach 784 species is threatened by habitat degradation (table 5.41).

5.4.1 Mean annual minimum and maximum temperature

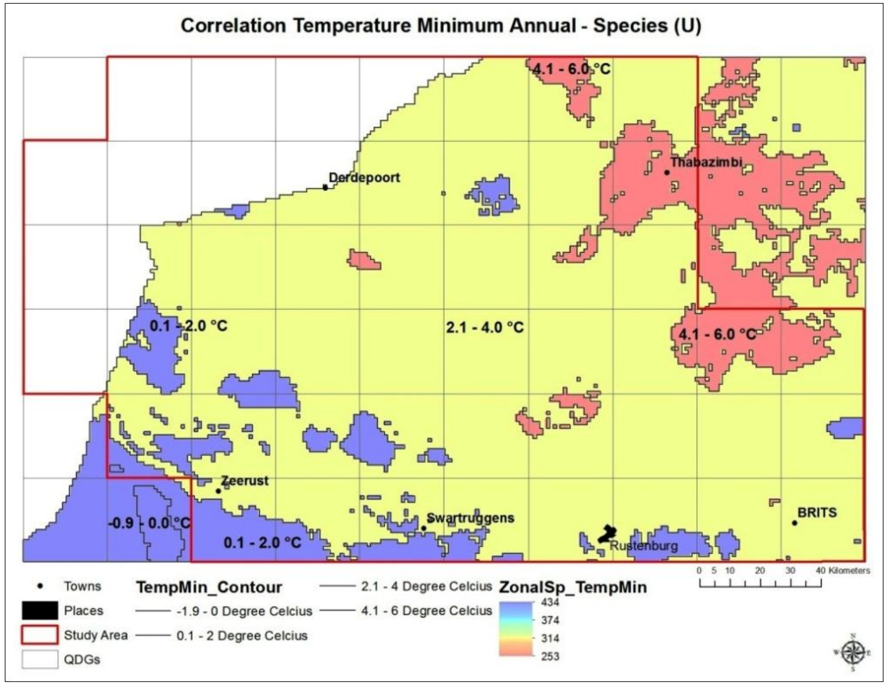

Figure 5.48: The mean number of plant species (unstandardized) occurring across the annual minimum temperature gradient.

Table 5.2: Zonal statistics for the correlation between annual minimum temperature and the richness of plant species (unstandardized).

ZonalStat_TempMinSp

SDE_SDE__2	AREA	MIN	MAX	MEAN
-1.9 - 0 Degree Celcius	0.022	360	502	434
0.1 - 2 Degree Celcius	0.338	19	952	390
2.1 - 4 Degree Celcius	2.312	7	1063	296
4.1 - 6 Degree Celcius	0.346	52	609	253

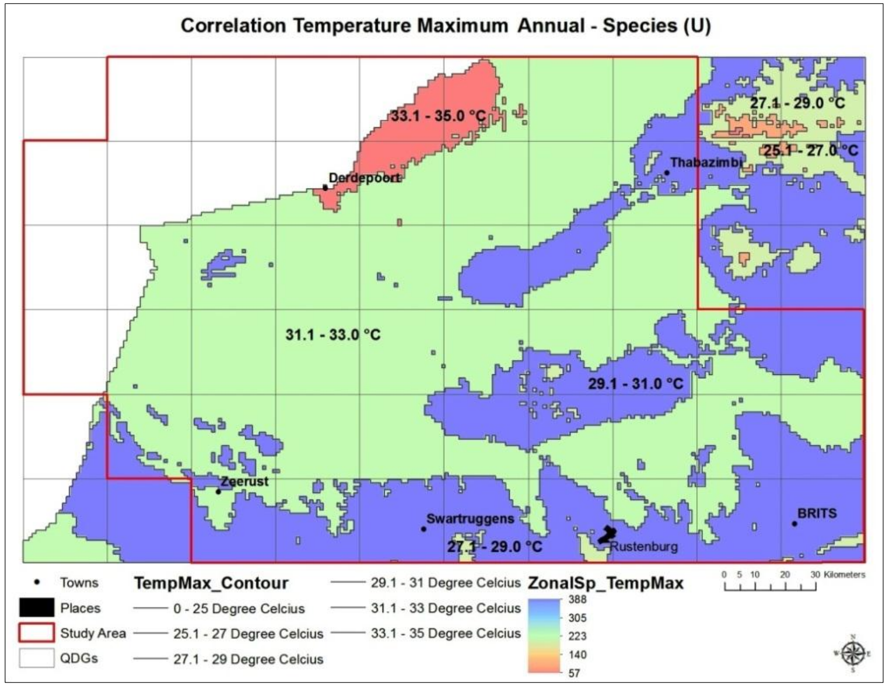

Figure 5.49: The mean number of plant species (unstandardized) occurring across the annual maximum temperature gradient.

Table 5.3: Zonal statistics for the correlation between annual maximum temperature and the richness of plant species (unstandardized).

ZonalStat_TempMaxSp

SDE_SDE__2	AREA	MIN	MAX	MEAN
0 - 25 Degree Celcius	0.001	150	163	156
25.1 - 27 Degree Celcius	0.018	124	311	181
27.1 - 29 Degree Celcius	0.144	121	1060	252
29.1 - 31 Degree Celcius	1.111	94	1063	388
31.1 - 33 Degree Celcius	1.659	19	854	264
33.1 - 35 Degree Celcius	0.086	7	218	57

Table 5.4: Zonal statistics for the correlation between annual minimum temperature and the richness of endemic plant species (unstandardized).

ZonalStat_TempMinEnd

SDE_SDE__2	AREA	MIN	MAX	MEAN
-1.9 - 0 Degree Celcius	0.022	2	2	2
0.1 - 2 Degree Celcius	0.338	0	4	1.5
2.1 - 4 Degree Celcius	2.312	0	4	0.9
4.1 - 6 Degree Celcius	0.346	0	2	0.9

Table 5.5: Zonal statistics for the correlation between annual minimum temperature and the richness of Red Data plant species (unstandardized).

ZonalStat_TempMinRD

SDE_SDE__2	AREA	MIN	MAX	MEAN
-1.9 - 0 Degree Celcius	0.022	4	5	4.5
0.1 - 2 Degree Celcius	0.338	0	13	4.1
2.1 - 4 Degree Celcius	2.312	0	15	2.8
4.1 - 6 Degree Celcius	0.346	0	6	2.2

Table 5.6: Zonal statistics for the correlation between annual minimum temperature and the richness of Protected Tree species (unstandardized).

ZonalStat_TempMinPT

SDE_SDE__2	AREA	MIN	MAX	MEAN
-1.9 - 0 Degree Celcius	0.022	4	5	4.1
0.1 - 2 Degree Celcius	0.338	1	6	3.5
2.1 - 4 Degree Celcius	2.312	0	7	2.8
4.1 - 6 Degree Celcius	0.346	1	4	2.2

Table 5.7: Zonal statistics for the correlation between annual maximum temperature and the richness of endemic plant species (unstandardized).

ZonalStat_TempMaxEnd

SDE_SDE__2	AREA	MIN	MAX	MEAN
0 - 25 Degree Celcius	0.001	1	1	0.7
25.1 - 27 Degree Celcius	0.018	0	1	0.7
27.1 - 29 Degree Celcius	0.144	0	3	0.9
29.1 - 31 Degree Celcius	1.111	0	4	1.3
31.1 - 33 Degree Celcius	1.659	0	4	0.8
33.1 - 35 Degree Celcius	0.086	0	1	0.1

Table 5.8: Zonal statistics for the correlation between annual maximum temperature and the richness of Red Data plant species (unstandardized).

ZonalStat_TempMaxRD

SDE_SDE__2	AREA	MIN	MAX	MEAN
0 - 25 Degree Celcius	0.001	1	2	1.5
25.1 - 27 Degree Celcius	0.018	1	3	1.7
27.1 - 29 Degree Celcius	0.144	0	15	2.4
29.1 - 31 Degree Celcius	1.111	0	15	3.8
31.1 - 33 Degree Celcius	1.659	0	11	2.6
33.1 - 35 Degree Celcius	0.086	0	2	0.3

Table 5.9: Zonal statistics for the correlation between annual maximum temperature and the richness of Protected Tree species (unstandardized).

ZonalStat_TempMaxPT

SDE_SDE__2	AREA	MIN	MAX	MEAN
0 - 25 Degree Celcius	0.001	1	2	1.5
25.1 - 27 Degree Celcius	0.018	1	3	1.8
27.1 - 29 Degree Celcius	0.144	1	6	2.2
29.1 - 31 Degree Celcius	1.111	1	7	3.3
31.1 - 33 Degree Celcius	1.659	0	6	2.7
33.1 - 35 Degree Celcius	0.086	0	2	0.4

5.4.2 Mean annual rainfall and evaporation

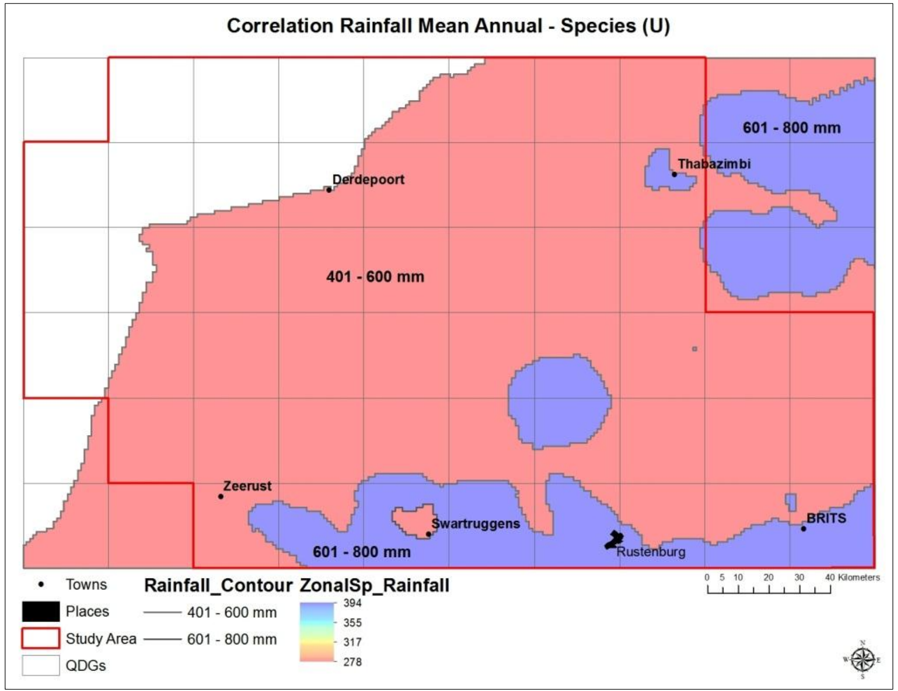

Figure 5.50: The mean number of plant species (unstandardized) occurring across the mean annual rainfall gradient.

Table 5.10: Zonal statistics for the correlation between mean annual rainfall and the richness of plant species (unstandardized).

ZonalStat_RainSp

SDE_SDE__2	AREA	MIN	MAX	MEAN
401 - 600 mm	2.393	6	844	278
601 - 800 mm	0.636	118	1063	394

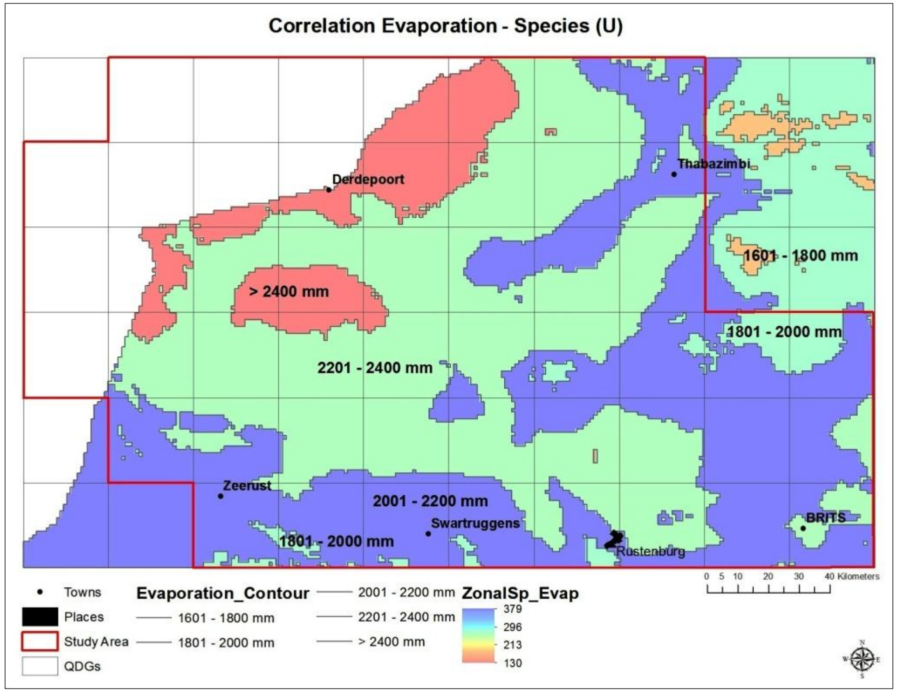

Figure 5.51: The mean number of plant species (unstandardized) occurring across the evaporation gradient.

Table 5.11: Zonal statistics for the correlation between evaporation and the richness of plant species (unstandardized).

ZonalStat_Evapsp

SDE_SDE__2	AREA	MIN	MAX	MEAN
1601 - 1800 mm	0.035	130	323	205
1801 - 2000 mm	0.367	121	993	285
2001 - 2200 mm	1.157	61	1063	379
2201 - 2400 mm	1.204	19	975	275
> 2400 mm	0.265	7	498	130

Table 5.12: Zonal statistics for the correlation between mean annual rainfall and the richness of endemic plant species (unstandardized).

ZonalStat_RainEnd

SDE_SDE__2	AREA	MIN	MAX	MEAN
401 - 600 mm	2.393	0	4	0.9
601 - 800 mm	0.636	0	4	1.2

Table 5.13: Zonal statistics for the correlation between mean annual rainfall and the richness of Red Data plant species (unstandardized).

ZonalStat_RainRD

SDE_SDE__2	AREA	MIN	MAX	MEAN
401 - 600 mm	2.393	0	11	2.6
601 - 800 mm	0.636	1	15	4.1

Table 5.14: Zonal statistics for the correlation between mean annual rainfall and the richness of Protected Tree species (unstandardized).

ZonalStat_RainPT

SDE_SDE__2	AREA	MIN	MAX	MEAN
401 - 600 mm	2.393	0	7	2.7
601 - 800 mm	0.636	1	6	3

Table 5.15: Zonal statistics for the correlation between evaporation and the richness of endemic plant species (unstandardized).

ZonalStat_EvapEnd

SDE_SDE__2	AREA	MIN	MAX	MEAN
> 2400 mm	0.265	0	3	0.4
1601 - 1800 mm	0.035	0	1	0.8
1801 - 2000 mm	0.367	0	4	1
2001 - 2200 mm	1.157	0	4	1.2
2201 - 2400 mm	1.204	0	4	0.9

Table 5.16: Zonal statistics for the correlation between evaporation and the richness of Red Data plant species (unstandardized).

ZonalStat_EvapRD

SDE_SDE__2	AREA	MIN	MAX	MEAN
> 2400 mm	0.265	0	5	1.2
1601 - 1800 mm	0.035	1	3	1.8
1801 - 2000 mm	0.367	0	14	2.4
2001 - 2200 mm	1.157	0	15	3.8
2201 - 2400 mm	1.204	0	13	2.7

Table 5.17: Zonal statistics for the correlation between evaporation and the richness of Protected Tree species (unstandardized).

ZonalStat_EvapPT

SDE_SDE__2	AREA	MIN	MAX	MEAN
> 2400 mm	0.265	0	4	1.2
1601 - 1800 mm	0.035	1	3	2
1801 - 2000 mm	0.367	1	6	2.5
2001 - 2200 mm	1.157	1	7	3.3
2201 - 2400 mm	1.204	0	6	2.8

5.4.3 Terrain morphology, geology and soil

5.4.3.1 Terrain morphology

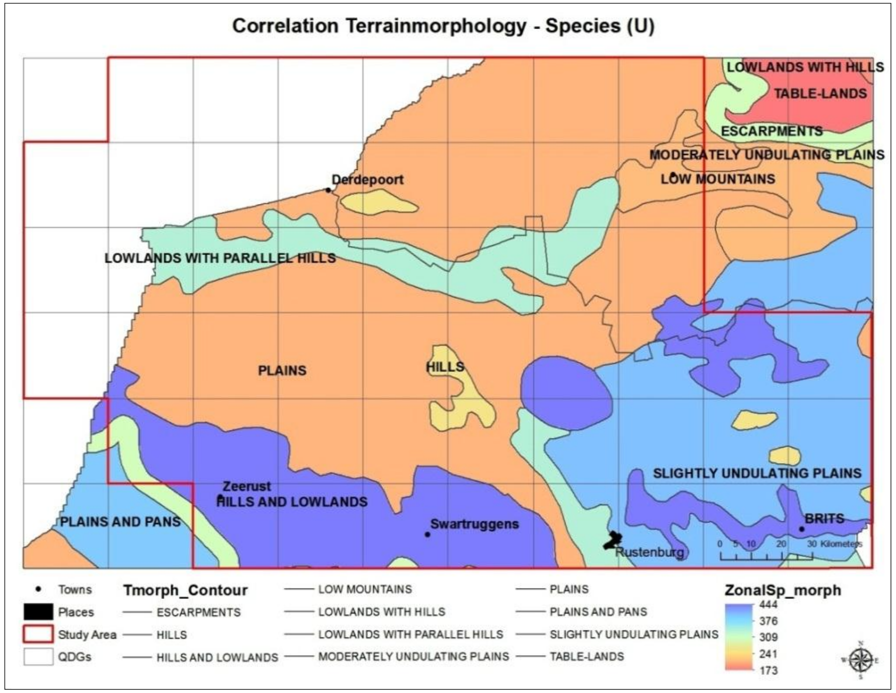

Figure 5.52: The mean number of plant species (unstandardized) occurring across the terrain morphology gradient in the western Central Bushveld.

Table 5.18: Zonal statistics for the relationship between terrain morphology and richness of plant species (unstandardized).

ZonalStat_morphSp

TERRMORPH	AREA	MIN	MAX	MEAN
HILLS AND LOWLANDS	0.503	227	854	444
SLIGHTLY UNDULATING PLAINS	0.549	236	892	404
PLAINS AND PANS	0.095	311	572	394
LOWLANDS WITH PARALLEL HILLS	0.244	31	1063	335
ESCARPMENTS	0.088	119	655	300
MODERATELY UNDULATING PLAINS	0.007	226	486	277
HILLS	0.044	68	399	255
LOW MOUNTAINS	0.138	106	305	212
PLAINS	1.276	7	1016	209

Table 5.19: Zonal statistics for the relationship between terrain morphology and the richness of endemic plant species (unstandardized).

ZonalStat_morphEnd

TERRMORPH	AREA	MIN	MAX	MEAN
PLAINS AND PANS	0.095	1	3	1.7
SLIGHTLY UNDULATING PLAINS	0.549	0	4	1.4
HILLS AND LOWLANDS	0.503	0	4	1.3
ESCARPMENTS	0.088	0	4	1.3
MODERATELY UNDULATING PLAINS	0.007	1	2	1
LOW MOUNTAINS	0.138	0	2	1
LOWLANDS WITH PARALLEL HILLS	0.244	0	3	0.8
PLAINS	1.276	0	3	0.6
HILLS	0.044	0	2	0.6

Table 5.20: Zonal statistics for the relationship between terrain morphology and richness of Red Data plant species (unstandardized).

ZonalStat_morphRD

TERRMORPH	AREA	MIN	MAX	MEAN
HILLS AND LOWLANDS	0.503	0	11	4.6
PLAINS AND PANS	0.095	4	5	4.3
LOWLANDS WITH PARALLEL HILLS	0.244	0	15	3.5
SLIGHTLY UNDULATING PLAINS	0.549	0	12	3.3
ESCARPMENTS	0.088	1	7	3
MODERATELY UNDULATING PLAINS	0.007	2	5	2.4
PLAINS	1.276	0	14	2.1
LOW MOUNTAINS	0.138	1	3	2
HILLS	0.044	0	3	1.8

5.4.3.2 Geology

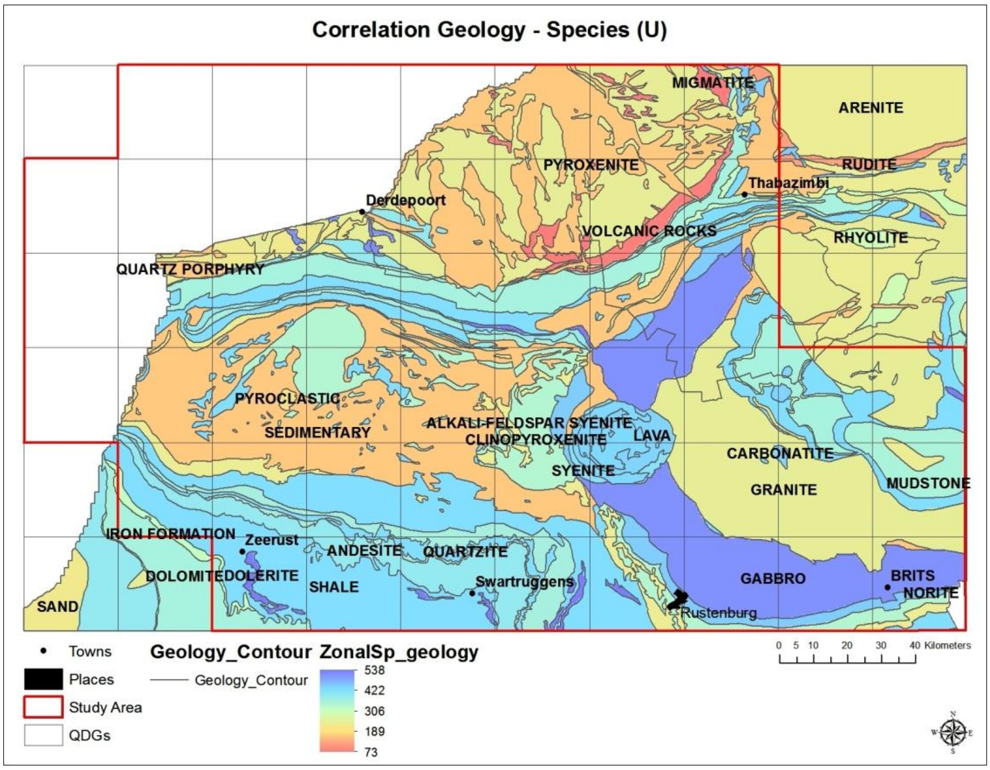

Figure 5.53: The mean number of plant species (unstandardized) occurring across the geological gradient in the western Central Bushveld.

5.21: Zonal statistics for the relationship between geology and the richness of plant species (unstandardized).

ZonalStat_geologySp

GEOLOGY	AREA	MIN	MAX	MEAN
DOLERITE	0.0147	289	1010	538
GABBRO	0.2277	108	783	449
NORITE	0.0609	89	879	402
LAVA	0.0216	325	455	396
CARBONATITE	0.0024	376	431	394
ALKALI-FELDSPAR SYENITE	0.0228	317	462	393
SHALE	0.4755	135	1063	388
SYENITE	0.0058	303	462	378
ANDESITE	0.1454	90	544	364
QUARTZITE	0.0757	102	527	344
DOLOMITE	0.2041	91	622	339
MUDSTONE	0.0492	283	461	335
CLINOPYROXENITE	0.1341	148	1055	326
IRON FORMATION	0.0256	133	660	306
RHYOLITE	0.0212	198	567	294
GRANITE	0.5705	16	561	256
ARENITE	0.2702	90	1061	252
SAND	0.0409	92	357	244
PYROCLASTIC	0.0019	221	236	228
QUARTZ PORPHYRY	0.0111	120	245	199
SEDIMENTARY	0.5872	7	509	199
RUDITE	0.0136	97	231	171
VOLCANIC ROCKS	0.0174	57	353	139
MIGMATITE	0.0169	42	275	109
PYROXENITE	0.0002	73	73	73

Table 5.22: Zonal statistics for the relationship between geology and the richness of endemic plant species (unstandardized).

ZonalStat_geolEnd

GEOLOGY	AREA	MIN	MAX	MEAN
DOLERITE	0.015	0	4	1.9
PYROCLASTIC	0.002	2	2	1.7
MUDSTONE	0.049	1	2	1.7
GABBRO	0.228	0	4	1.4
IRON FORMATION	0.026	0	4	1.3
NORITE	0.061	0	3	1.3
SHALE	0.476	0	4	1.2
ALKALI-FELDSPAR SYENITE	0.023	1	2	1.2
SYENITE	0.006	1	2	1.2
DOLOMITE	0.204	0	3	1.1
LAVA	0.022	1	2	1.1
CLINOPYROXENITE	0.134	0	3	1.1
RHYOLITE	0.021	1	2	1
ANDESITE	0.145	0	2	1
CARBONATITE	0.002	1	1	1
ARENITE	0.27	0	3	0.9
SAND	0.041	0	1	0.8
GRANITE	0.57	0	2	0.8
QUARTZITE	0.076	0	2	0.8
RUDITE	0.014	0	1	0.7
SEDIMENTARY	0.587	0	3	0.7
VOLCANIC ROCKS	0.017	0	1	0.6
QUARTZ PORPHYRY	0.011	0	1	0.4
MIGMATITE	0.017	0	1	0.4
PYROXENITE	0	0	0	0.3

Table 5.23: Zonal statistics for the relationship between geology and the richness of Red Data plant species (unstandardized).

ZonalStat_geolRedData

GEOLOGY	AREA	MIN	MAX	MEAN
DOLERITE	0.0147	1	14	5.7
SHALE	0.4755	0	15	4.2
PYROCLASTIC	0.0019	4	4	4.2
ANDESITE	0.1454	0	8	4.1
GABBRO	0.2277	0	10	3.9
NORITE	0.0609	0	12	3.8
QUARTZITE	0.0757	0	7	3.6
LAVA	0.0216	2	5	3.5
DOLOMITE	0.2041	0	6	3.5
ALKALI-FELDSPAR SYENITE	0.0228	2	4	3.4
CARBONATITE	0.0024	3	4	3.4
CLINOPYROXENITE	0.1341	0	15	3.2
SYENITE	0.0058	2	4	3.1
IRON FORMATION	0.0256	0	6	3.1
SAND	0.0409	0	4	2.7
MUDSTONE	0.0492	1	4	2.6
RHYOLITE	0.0212	1	5	2.4
ARENITE	0.2702	0	15	2.4
QUARTZ PORPHYRY	0.0111	0	3	2.2
GRANITE	0.5705	0	5	2
SEDIMENTARY	0.5872	0	5	2
RUDITE	0.0136	1	2	1.6
VOLCANIC ROCKS	0.0174	0	4	1.2
MIGMATITE	0.0169	0	3	0.9
PYROXENITE	0.0002	0	0	0.5

5.4.3.3 Soil type

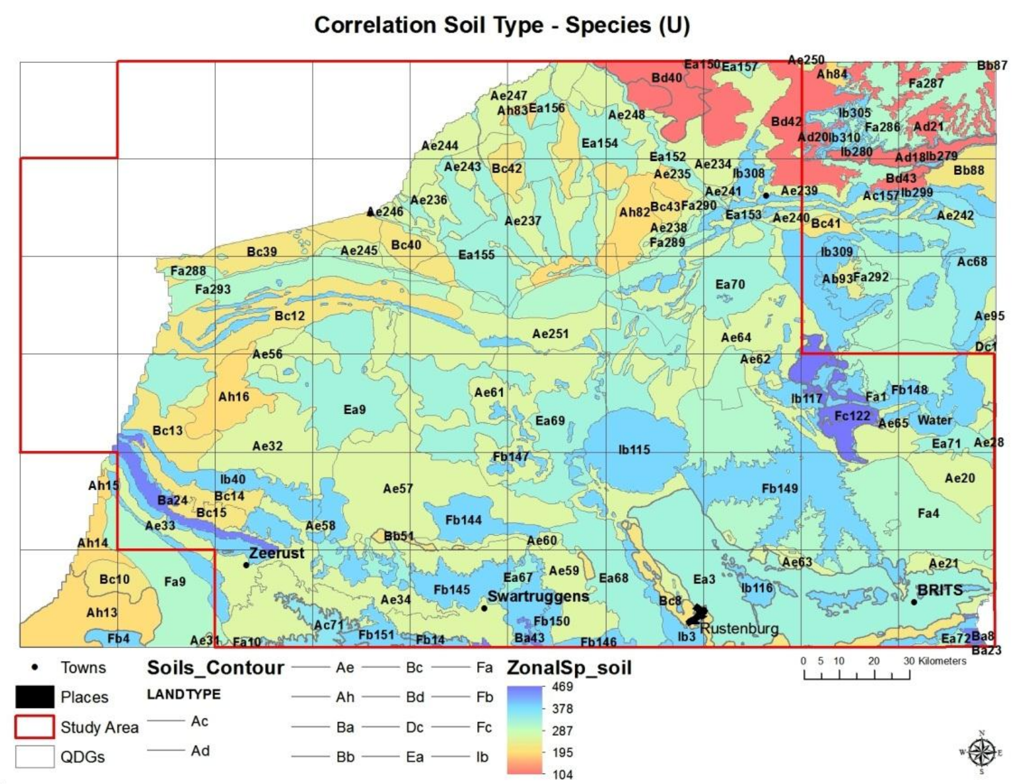

Figure 5.54: The mean number of plant species (unstandardized) occurring across the soil gradient in the western Central Bushveld.

Table 5.24: Zonal statistics for the relationship between soil type and the richness of plant species (unstandardized).

ZonalStat_soilsSp

Ltype	SOIL_DES	AREA	MIN	MAX	MEAN
Fc	Glenrosa and/or Mispah forms, lime generally present in the entire landscape	0.025	316	609	469
Ba	Plinthic catena: dystrophic and/or mesotrophic; red soils widespread, upland duplex and margalitic soils rare	0.019	231	571	400
Fb	Glenrosa and/or Mispah forms, lime rare/absent in upland soils but present in low-lying soils	0.27	147	784	360
Ib	Miscellaneous land classes, rocky areas with miscellaneous soils	0.241	100	1063	359
Ac	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	0.051	210	679	343
Ea	One or more of: vertic, melanic, red structured diagnostic horizons, undifferentiated	0.581	12	1055	325
Fa	Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in the entire landscape	0.449	75	574	315
Dc	Prisma-/pedocutanic diagnostic horizons. One or more of: vertic, melanic, red structured diagnostic horizons	0.001	302	319	313
Water	No Data	0.003	164	541	312
Ae	Red-yellow apedal, freely drained soils; red, high base status, > 300 mm deep (no dunes)	0.874	8	990	284
Ab	Red-yellow apedal, freely drained soils; red, dystrophic and/or mesotrophic	0.005	246	306	276
Bb	Plinthic catena: dystrophic and/or mesotrophic; red soils not widespread, upland duplex and margalitic soils rare	0.02	175	497	262
Bc	Plinthic catena: eutrophic; red soils widespread, upland duplex and margalitic soils rare	0.223	23	1045	260
Ah	Red-yellow apedal, freely drained soils; red and yellow, high base status, usually < 15% clay	0.117	27	426	249
Ad	Red-yellow apedal, freely drained soils; yellow, dystrophic and/or mesotrophic	0.044	122	231	179
Bd	Plinthic catena: eutrophic; red soils not widespread, upland duplex and margalitic soils rare	0.093	52	228	104

Table 5.25: Zonal statistics for the relationship between soil type and the richness of endemic plant species (unstandardized).

ZonalStat_soilsEnd

Ltype	SOIL_DES	AREA	MIN	MAX	MEAN
Dc	Prisma-/pedocutanic diagnostic horizons. One or more of: vertic, melanic, red structured diagnostic horizons	0.001	1	2	1.6
Ba	Plinthic catena: dystrophic and/or mesotrophic; red soils widespread, upland duplex and margalitic soils rare	0.019	0	2	1.5
Ac	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	0.051	1	4	1.3
Water	No Data	0.003	0	2	1.3
Ib	Miscellaneous land classes, rocky areas with miscellaneous soils	0.241	0	4	1.3
Ea	One or more of: vertic, melanic, red structured diagnostic horizons, undifferentiated	0.581	0	4	1.1
Fa	Glenrosa and/or Mispah forms, lime rare or absent in the entire landscape	0.449	0	3	1.1
Ah	Red-yellow apedal, freely drained soils; red and yellow, high base status, usually < 15% clay	0.117	0	2	1
Fc	Glenrosa and/or Mispah forms, lime generally present in the entire landscape	0.025	1	1	1
Ae	Red-yellow apedal, freely drained soils; red, high base status, > 300 mm deep (no dunes)	0.874	0	4	0.9
Fb	Glenrosa and/or Mispah forms, lime rare or absent in upland soils but generally present in low-lying soils	0.27	0	2	0.9
Bb	Plinthic catena: dystrophic and/or mesotrophic; red soils not widespread, upland duplex and margalitic soils rare	0.02	0	1	0.9
Ab	Red-yellow apedal, freely drained soils; red, dystrophic and/or mesotrophic	0.005	1	1	0.9
Bc	Plinthic catena: eutrophic; red soils widespread, upland duplex and margalitic soils rare	0.223	0	3	0.8
Ad	Red-yellow apedal, freely drained soils; yellow, dystrophic and/or mesotrophic	0.044	0	1	0.7
Bd	Plinthic catena: eutrophic; red soils not widespread, upland duplex and margalitic soils rare	0.093	0	1	0.3

Table 5.26: Zonal statistics for the relationship between soil type and the richness of Red Data plant species (unstandardized).

ZonalStat_soilsRD

Ltype	SOIL_DES	AREA	MIN	MAX	MEAN
Fc	Glenrosa and/or Mispah forms, lime generally present in the entire landscape	0.025	3	6	4.5
Ba	Plinthic catena: dystrophic and/or mesotrophic; red soils widespread, upland duplex and margalitic soils rare	0.019	3	6	4.3
Ib	Miscellaneous land classes, rocky areas with miscellaneous soils	0.241	0	15	3.4
Fb	Glenrosa and/or Mispah forms, lime rare or absent in upland soils but present in low-lying soils	0.27	0	10	3.3
Ea	One or more of: vertic, melanic, red structured diagnostic horizons, undifferentiated	0.581	0	15	3.1
Ac	Red-yellow apedal, freely drained soils; red and yellow, dystrophic and/or mesotrophic	0.051	2	6	3
Ah	Red-yellow apedal, freely drained soils; red and yellow, high base status, usually < 15% clay	0.117	0	5	2.9
Fa	Glenrosa and/or Mispah forms, lime rare or absent in the entire landscape	0.449	0	6	2.9
Ae	Red-yellow apedal, freely drained soils; red, high base status, > 300 mm deep (no dunes)	0.874	0	14	2.8
Bc	Plinthic catena: eutrophic; red soils widespread, upland duplex and margalitic soils rare	0.223	0	15	2.7
Ab	Red-yellow apedal, freely drained soils; red, dystrophic and/or mesotrophic	0.005	2	3	2.4
Ba	Plinthic catena: dystrophic and/or mesotrophic; red soils not widespread, upland duplex and margalitic soils rare	0.02	2	6	2.4
Water	No Data	0.003	0	5	2.1
Dc	Prisma-/pedocutanic diagnostic horizons. One or more of: vertic, melanic, red structured diagnostic horizons	0.001	1	2	1.6
Ad	Red-yellow apedal, freely drained soils; yellow, dystrophic and/or mesotrophic	0.044	1	2	1.6
Bb	Plinthic catena: eutrophic; red soils not widespread, upland duplex and margalitic soils rare	0.093	0	2	0.9

5.4.3.4 Landuse and landcover

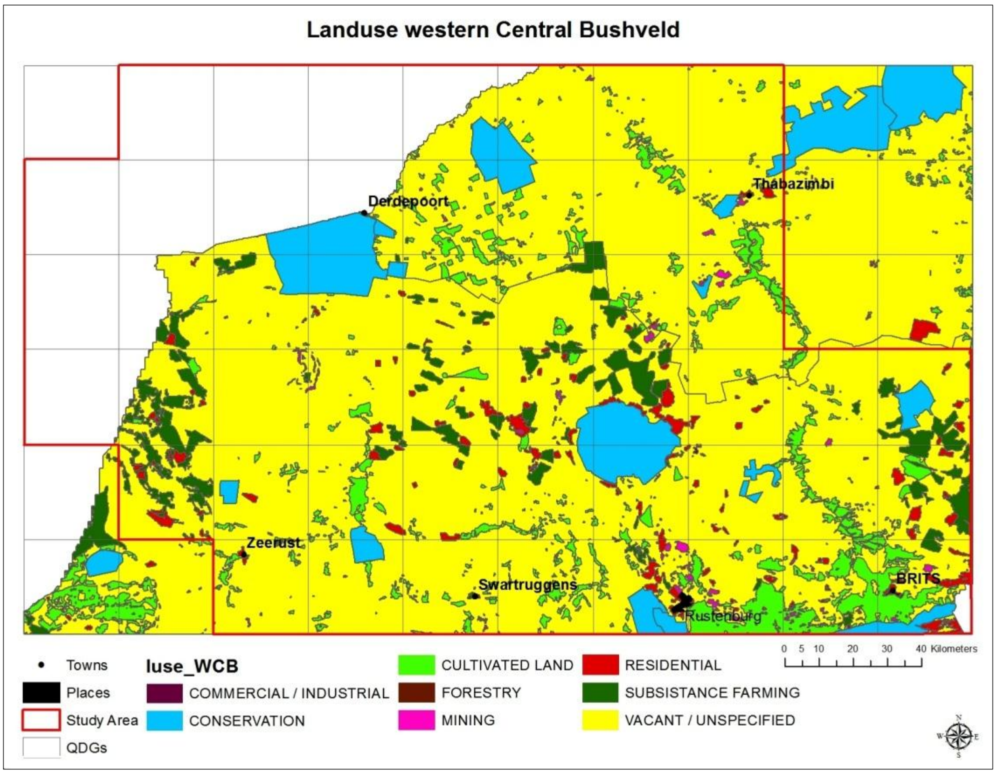

Figure 5.55: Landuse pattern in the western Central Bushveld Bioregion.

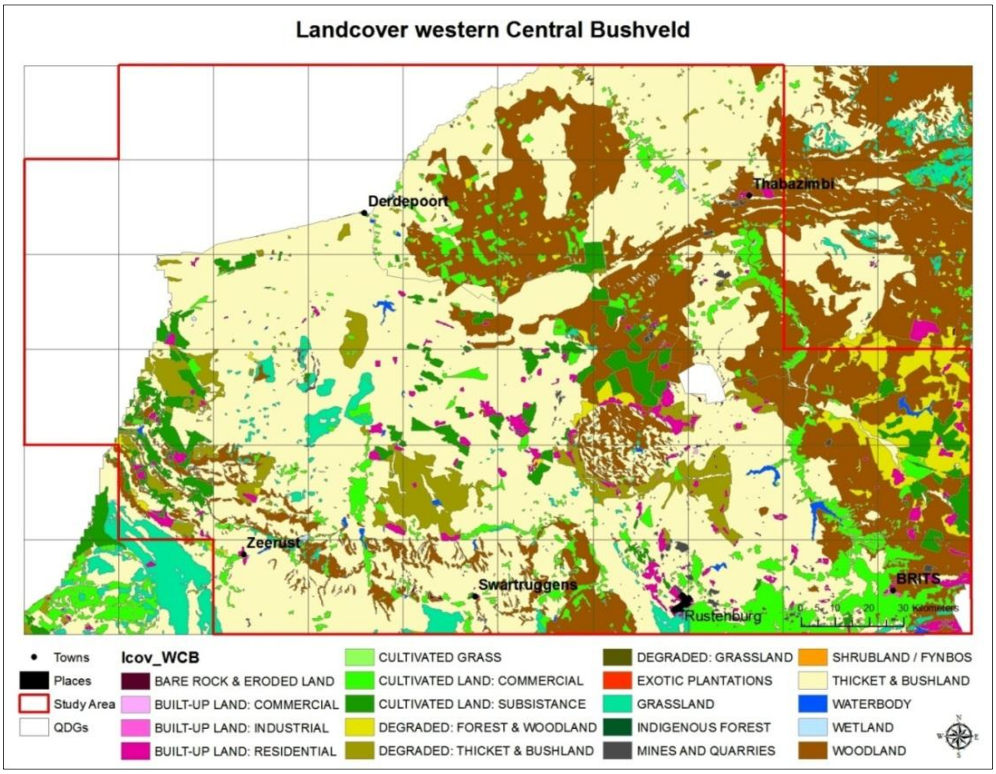

Figure 5.56: Landcover of the western Central Bushveld Bioregion.

Table 5.27: Zonal statistics for the correlation between landuse and the richness of plant species (unstandardized).

ZonalStat_luseSp

LAND_USE	AREA	MIN	MAX	MEAN
COMMERCIAL / INDUSTRIAL	0.001	113	748	540
MINING	0.01	13	801	421
FORESTRY	0.001	192	585	418
RESIDENTIAL	0.053	108	1045	403
CULTIVATED LAND	0.2	20	1061	378
SUBSISTANCE FARMING	0.121	94	898	314
VACANT / UNSPECIFIED	2.396	7	1063	297
CONSERVATION	0.235	29	1060	257

Table 5.28: Zonal statistics for the correlation between landcover and the richness of plant species (unstandardized).

ZonalStat_lcovSp

LANDCOV	AREA	MIN	MAX	MEAN
BUILT-UP LAND: INDUSTRIAL	0.00083	450	705	551
BUILT-UP LAND: COMMERCIAL	0.00036	113	748	517
EXOTIC PLANTATIONS	0.00058	192	585	427
MINES AND QUARRIES	0.01037	13	801	415
BUILT-UP LAND: RESIDENTIAL	0.05371	108	1045	406
DEGRADED: UNIMPROVED GRASSLAND	0.00011	223	503	405
CULTIVATED GRASS	0.0004	139	557	390
SHRUBLAND / FYNBOS	0.00004	389	389	389
CULTIVATED LAND: COMMERCIAL	0.20301	20	1061	378
BARE ROCK AND ERODED LAND	0.00144	260	523	370
GRASSLAND	0.10577	137	1055	362
WATERBODY	0.01001	113	623	345
WETLAND	0.00205	88	817	338
DEGRADED: FOREST AND WOODLAND	0.07592	27	572	334
CULTIVATED LAND: SUBSISTANCE	0.12075	94	898	314
THICKET AND BUSHLAND	1.52728	7	1063	293
DEGRADED: THICKET AND BUSHLAND	0.12057	13	617	286
WOODLAND	0.77502	19	917	281
INDIGENOUS FOREST	0.00014	64	431	157

Table 5.29: Zonal statistics for the correlation between landuse and the richness of endemic plant species (unstandardized).

ZonalStat_luseEnd

LAND_USE	AREA	MIN	MAX	MEAN
COMMERCIAL / INDUSTRIAL	0.001	0	3	1.8
MINING	0.01	0	4	1.5
RESIDENTIAL	0.053	0	4	1.4
CULTIVATED LAND	0.2	0	4	1.2
FORESTRY	0.001	0	3	1.1
SUBSISTANCE FARMING	0.121	0	3	1
VACANT / UNSPECIFIED	2.396	0	4	1
CONSERVATION	0.235	0	3	0.8

Table 5.30: Zonal statistics for the correlation between landcover and the richness of endemic plant species (unstandardized).

ZonalStat_lcovEnd

LANDCOV	AREA	MIN	MAX	MEAN
DEGRADED: UNIMPROVED GRASSLAND	0.00011	2	2	2.1
BUILT-UP LAND: INDUSTRIAL	0.00083	1	3	1.9
BUILT-UP LAND: COMMERCIAL	0.00036	0	3	1.7
CULTIVATED GRASS	0.0004	0	2	1.7
MINES AND QUARRIES	0.01037	0	4	1.5
GRASSLAND	0.10577	0	3	1.5
DEGRADED: FOREST AND WOODLAND	0.07592	0	2	1.4
BUILT-UP LAND: RESIDENTIAL	0.05371	0	4	1.4
WETLAND	0.00205	0	2	1.3
CULTIVATED LAND: COMMERCIAL	0.20301	0	4	1.2
EXOTIC PLANTATIONS	0.00058	0	3	1.2
WATERBODY	0.01001	0	3	1.1
CULTIVATED LAND: SUBSISTANCE	0.12075	0	3	1
SHRUBLAND / FYNBOS	0.00004	1	1	1
WOODLAND	0.77502	0	3	0.9
BARE ROCK AND ERODED LAND	0.00144	0	2	0.9
THICKET AND BUSHLAND	1.52728	0	4	0.9
DEGRADED: THICKET AND BUSHLAND	0.12057	0	2	0.7
INDIGENOUS FOREST	0.00014	1	1	0.7

Table 5.31: Zonal statistics for the correlation between landuse and the richness of Red Data plant species (unstandardized).

ZonalStat_luseRD

LAND_USE	AREA	MIN	MAX	MEAN
COMMERCIAL / INDUSTRIAL	0.001	1	9	5.3
FORESTRY	0.001	2	7	4.6
MINING	0.01	0	10	4.1
RESIDENTIAL	0.053	1	15	3.9
CULTIVATED LAND	0.2	0	15	3.6
SUBSISTANCE FARMING	0.121	0	12	3
VACANT / UNSPECIFIED	2.396	0	15	2.9
CONSERVATION	0.235	0	15	2.4

Table 5.32: Zonal statistics for the correlation between landcover and the richness of Red Data plant species (unstandardized).

ZonalStat_lcovRD

LANDCOV	AREA	MIN	MAX	MEAN
BUILT-UP LAND: COMMERCIAL	0.00036	1	9	5.5
BUILT-UP LAND: INDUSTRIAL	0.00083	4	8	5.3
EXOTIC PLANTATIONS	0.00058	2	7	4.7
DEGRADED: UNIMPROVED GRASSLAND	0.00011	4	5	4.4
BARE ROCK AND ERODED LAND	0.00144	2	8	4.2
GRASSLAND	0.10577	0	15	4.1
MINES AND QUARRIES	0.01037	0	10	4
BUILT-UP LAND: RESIDENTIAL	0.05371	1	15	4
WETLAND	0.00205	1	10	3.7
SHRUBLAND / FYNBOS	0.00004	4	4	3.6
CULTIVATED LAND: COMMERCIAL	0.20301	0	15	3.6
CULTIVATED GRASS	0.0004	0	5	3.5
CULTIVATED LAND: SUBSISTANCE	0.12075	0	12	3
THICKET AND BUSHLAND	1.52728	0	15	2.9
WATERBODY	0.01001	0	6	2.7
DEGRADED: THICKET AND BUSHLAND	0.12057	0	7	2.6
WOODLAND	0.77502	0	12	2.5
DEGRADED: FOREST AND WOODLAND	0.07592	0	6	2.4
INDIGENOUS FOREST	0.00014	0	5	1.6

Table 5.33: Zonal statistics for the correlation between landuse and the richness of Protected Tree species (unstandardized).

ZonalStat_lusePT

LAND_USE	AREA	MIN	MAX	MEAN
RESIDENTIAL	0.053	0	6	3.4
MINING	0.01	0	5	3.3
COMMERCIAL / INDUSTRIAL	0.001	1	5	3.3
FORESTRY	0.001	2	5	3.2
SUBSISTANCE FARMING	0.121	0	5	3.2
CULTIVATED LAND	0.2	0	6	3.1
VACANT / UNSPECIFIED	2.396	0	7	2.8
CONSERVATION	0.235	0	6	2.3

Table 5.34: Zonal statistics for the correlation between landcover and the richness of Protected Tree species (unstandardized).

ZonalStat_lcovPT

LANDCOV	AREA	MIN	MAX	MEAN
DEGRADED: UNIMPROVED GRASSLAND	0.00011	3	5	4
BUILT-UP LAND: COMMERCIAL	0.00036	1	5	3.5
GRASSLAND	0.10577	1	6	3.4
BUILT-UP LAND: RESIDENTIAL	0.05371	0	6	3.4
SHRUBLAND / FYNBOS	0.00004	3	3	3.3
BARE ROCK AND ERODED LAND	0.00144	2	4	3.3
MINES AND QUARRIES	0.01037	0	5	3.2
BUILT-UP LAND: INDUSTRIAL	0.00083	2	5	3.2
DEGRADED: FOREST AND WOODLAND	0.07592	0	5	3.2
CULTIVATED LAND: SUBSISTANCE	0.12075	0	5	3.2
EXOTIC PLANTATIONS	0.00058	2	5	3.1
CULTIVATED LAND: COMMERCIAL	0.20301	0	6	3.1
WATERBODY	0.01001	0	5	3
CULTIVATED GRASS	0.0004	1	4	2.9
WETLAND	0.00205	1	5	2.9
THICKET AND BUSHLAND	1.52728	0	7	2.8
DEGRADED: THICKET AND BUSHLAND	0.12057	0	6	2.6
WOODLAND	0.77502	0	7	2.6
INDIGENOUS FOREST	0.00014	1	3	1.6

Table 5.35: Zonal statistics for the correlation between landuse and the richness of Problem Plant species (unstandardized).

ZonalStat_luse PP

LAND_USE	AREA	MIN	MAX	MEAN
COMMERCIAL / INDUSTRIAL	0.001	18	95	74
MINING	0.01	2	104	58
FORESTRY	0.001	26	83	57
CULTIVATED LAND	0.2	2	121	53
RESIDENTIAL	0.053	20	119	52
VACANT / UNSPECIFIED	2.396	1	121	41
SUBSISTANCE FARMING	0.121	11	105	40
CONSERVATION	0.235	5	121	35

Table 5.36: Zonal statistics for the correlation between landcover and the richness of Problem Plant species (unstandardized).

ZonalStat_lcovPP

LANDCOV	AREA	MIN	MAX	MEAN
BUILT-UP LAND: INDUSTRIAL	0.00083	64	95	78
BUILT-UP LAND: COMMERCIAL	0.00036	18	93	65
DEGRADED: UNIMPROVED GRASSLAND	0.00011	32	79	62
CULTIVATED GRASS	0.0004	25	82	59
EXOTIC PLANTATIONS	0.00058	26	85	58
MINES AND QUARRIES	0.01037	2	104	58
BUILT-UP LAND: RESIDENTIAL	0.05371	20	119	53
CULTIVATED LAND: COMMERCIAL	0.20301	2	121	53
GRASSLAND	0.10577	20	120	51
SHRUBLAND / FYNBOS	0.00004	51	51	51
WETLAND	0.00205	15	98	48
WATERBODY	0.01001	20	87	47
BARE ROCK AND ERODED LAND	0.00144	24	73	46
THICKET AND BUSHLAND	1.52728	1	121	42
CULTIVATED LAND: SUBSISTANCE	0.12075	11	105	40
DEGRADED: THICKET AND BUSHLAND	0.12057	2	78	40
DEGRADED: FOREST AND WOODLAND	0.07592	2	74	37
WOODLAND	0.77502	1	107	37
INDIGENOUS FOREST	0.00014	9	59	22

Table 5.37: Zonal statistics for the correlation between landuse and the richness of Bushencroachment Indicator species (unstandardized).

ZonalStat_luseIB

LAND_USE	AREA	MIN	MAX	MEAN
COMMERCIAL / INDUSTRIAL	0.001	7	26	22
RESIDENTIAL	0.053	6	30	19
MINING	0.01	1	26	19
FORESTRY	0.001	12	22	18
CULTIVATED LAND	0.2	1	30	18
SUBSISTANCE FARMING	0.121	4	27	18
VACANT / UNSPECIFIED	2.396	1	30	15
CONSERVATION	0.235	2	30	13

Table 5.38: Zonal statistics for the correlation between landcover and the richness of Bushencroachment Indicators species (unstandardized).

ZonalStat_lcovIB

LANDCOV	AREA	MIN	MAX	MEAN
BUILT-UP LAND: INDUSTRIAL	0.00083	21	25	22
BUILT-UP LAND: COMMERCIAL	0.00036	7	26	21
BUILT-UP LAND: RESIDENTIAL	0.05371	6	30	19
DEGRADED: FOREST AND WOODLAND	0.07592	1	25	19
DEGRADED: UNIMPROVED GRASSLAND	0.00011	15	21	19
BARE ROCK AND ERODED LAND	0.00144	16	21	19
MINES AND QUARRIES	0.01037	1	26	19
EXOTIC PLANTATIONS	0.00058	12	23	18
CULTIVATED GRASS	0.0004	8	22	18
WATERBODY	0.01001	5	25	18
GRASSLAND	0.10577	8	30	18
CULTIVATED LAND: COMMERCIAL	0.20301	1	30	18
CULTIVATED LAND: SUBSISTANCE	0.12075	4	27	18
SHRUBLAND / FYNBOS	0.00004	17	17	17
DEGRADED: THICKET AND BUSHLAND	0.12057	1	25	16
WETLAND	0.00205	6	26	16
WOODLAND	0.77502	1	28	15
THICKET AND BUSHLAND	1.52728	1	30	15
INDIGENOUS FOREST	0.00014	4	19	8

Table 5.39: Zonal statistics for the correlation between landuse and the richness of Useful Plant species (unstandardized).

ZonalStat_luseUP

LAND_USE	AREA	MIN	MAX	MEAN
COMMERCIAL / INDUSTRIAL	0.001	32	160	126
MINING	0.01	4	166	102
FORESTRY	0.001	48	131	100
RESIDENTIAL	0.053	29	200	99
CULTIVATED LAND	0.2	3	203	95
SUBSISTANCE FARMING	0.121	27	179	85
VACANT / UNSPECIFIED	2.396	1	203	77
CONSERVATION	0.235	8	203	64

Table 5.40: Zonal statistics for the correlation between landcover and the richness of Useful Plant species (unstandardized).

ZonalStat_lcovUP

LANDCOV	AREA	MIN	MAX	MEAN
BUILT-UP LAND: INDUSTRIAL	0.00083	114	155	130
BUILT-UP LAND: COMMERCIAL	0.00036	32	160	117
DEGRADED: UNIMPROVED GRASSLAND	0.00011	66	126	105
EXOTIC PLANTATIONS	0.00058	48	135	102
MINES AND QUARRIES	0.01037	4	166	100
BUILT-UP LAND: RESIDENTIAL	0.05371	29	200	100
CULTIVATED GRASS	0.0004	28	132	97
SHRUBLAND / FYNBOS	0.00004	96	96	96
CULTIVATED LAND: COMMERCIAL	0.20301	3	203	95
GRASSLAND	0.10577	33	202	94
BARE ROCK AND ERODED LAND	0.00144	68	129	93
WATERBODY	0.01001	33	151	89
WETLAND	0.00205	22	167	86
CULTIVATED LAND: SUBSISTANCE	0.12075	27	179	85
DEGRADED: FOREST AND WOODLAND	0.07592	3	129	84
DEGRADED: THICKET AND BUSHLAND	0.12057	4	137	78
THICKET AND BUSHLAND	1.52728	1	203	76
WOODLAND	0.77502	1	181	70
INDIGENOUS FOREST	0.00014	15	107	38

5.4.3.5 Soil potential and landuse

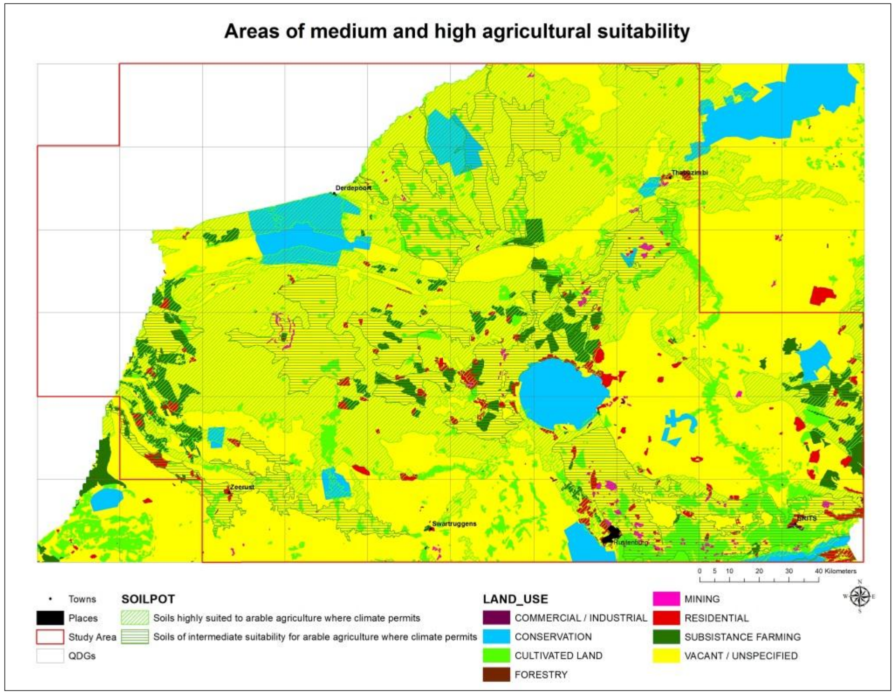

Figure 5.57: Land-use pattern and arable areas in the western Central Bushveld.

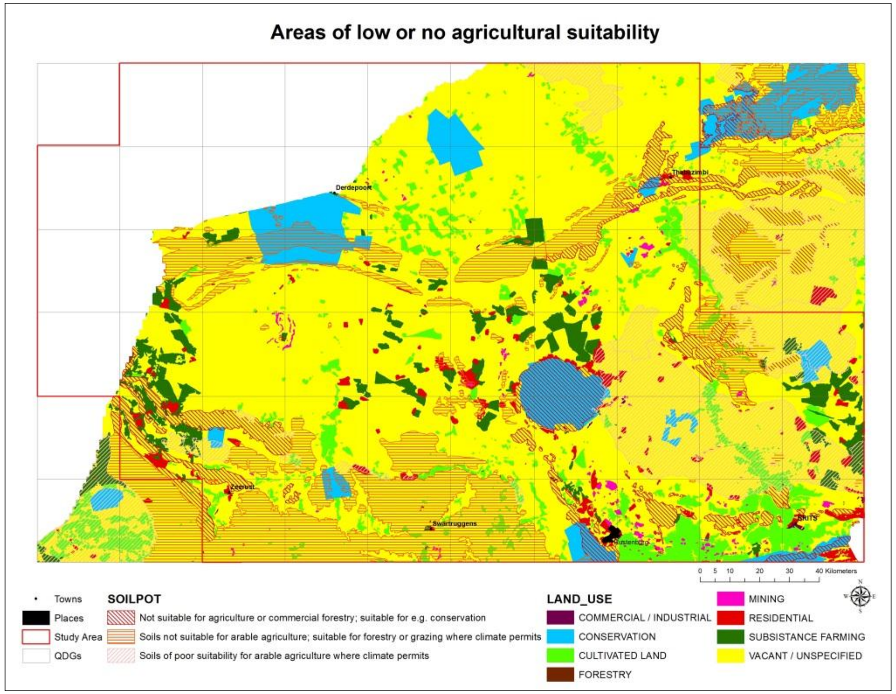

Figure 5.58: Land-use pattern and areas unsuitable for arable agriculture in the western Central Bushveld.

Table 5.41: Zonal statistics for the correlation between soil potential and richness of plant species (unstandardized).

ZonalSt_soilpotential

SOILPOT	AREA	MIN	MAX	MEAN
Not suitable for agriculture or commercial forestry; suitable for conservation, recreation or water catchments	0.241	100	1063	359
Soils not suitable for arable agriculture; suitable for forestry or grazing where climate permits	0.512	75	784	358
Soils of poor suitability for arable agriculture where climate permits	0.525	52	589	332
Soils of intermediate suitability for arable agriculture where climate permits	0.574	12	822	317
Soils highly suited to arable agriculture where climate permits	1.073	8	1045	233

5.5 Summary

Plant biodiversity of the western Central Bushveld (WCB) Bioregion has been underestimated for a long time and thus neglected in conservation planning. The under-valuation of the mostly remote and rural characterized study area is the reason that low floristic information is available for many Quarter Degree Grids.

Furthermore, it has led to a large-scale transformation and degradation of natural vegetation by increasing trends of agriculture, industrial development and urbanization. Especially cultivation for commercial and subsistence farming was identified as a leading threat in areas of high species richness. Cultivation makes up the largest portion of the land-use in the WCB. Additionally, large areas of still untransformed land has been recognized to be of medium to high agricultural suitability, which are thus expected to be progressively put to use as regional populations grow. Land transformation has proved to result into a 50% loss of species richness compared to untransformed land.

However, the analysis of land-use has also shown that the largest part of the WCB still consists of untransformed land where the highest numbers of plant species have been recorded. Thus, the remaining pristine bushveld areas need to be considered in conservation planning within the Central Bushveld Bioregion.

To increase the protection of plant diversity in the study area and to identify gaps in the conservation network, the flora of the WCB has been systematically assessed. This started with the assessment of the floristic diversity of the bioregion. It showed that the WCB cannot be considered as a floristic depauperate region, but as a region that holds an important representation of the Flora of Southern Africa.

The study area contains several unique vegetation types and plant taxa that are mainly found in the Central Bushveld Bioregion. Several of the encountered endemic species are restricted to the Central Bushveld region. Furthermore, numerous socially and economically important plant species have been identified, many of which require conservation attention as they are contained in the Red Data and/or Protected Tree List.

Looking at the genus and family diversity, the WCB displays typical characteristics of the Savanna Biome, especially in regard to the dominant families, the Asteraceae (daisy family), the Cyperaceae (the sedge family), the Fabaceae (leguminose family) and the Poaceae (grass family).

The next step in the conservation assessment involved the identification of spatial patterns of plant taxa richness in the WCB using ordination and spatial interpolation. Principal Component Analysis resulted in a significant spatial arrangement of plant taxa groups which becomes more pronounced through standardization. This could be related to an increase in beta-diversity. Detrended Correspondence Analysis proved that standardization increases the variation between the sample plots and thus results in a stronger spatial differentiation, especially at more inclusive taxonomic levels.

Eventually, the increase in variation can be attributed to the improved sampling status of under-represented Quarter Degree Grids as shown by the plant taxa interpolation maps. A higher richness of plant taxa is predicted for many parts of the WCB than presently documented, particularly for endemic, Red Data and Protected Tree species.

The distribution patterns of plant taxa richness in the study area could be associated with climatic and physical environmental factors. Here, increased annual minimum and maximum temperatures accompanied with lowered precipitation and raised evaporation levels play a significant role in the distribution of species richness. However, local species richness is largely determined by the terrain morphology and associated geological and soil formations.