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Palaeoenvironments of the Middle Stone Age at Sibudu Cave, KwaZulu-Natal, South Africa: An analysis of archaeological charcoal

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FIGURES

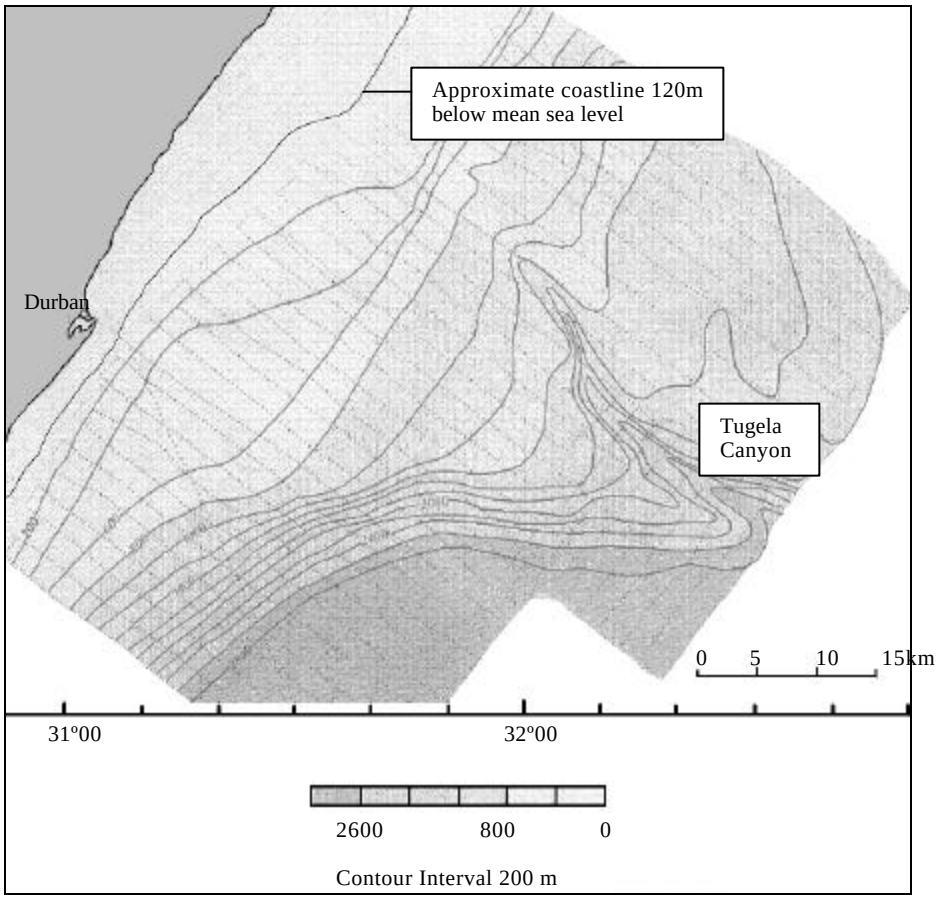


Figure 2.1. Bathymetric Map of Tugela Canyon (after Zhiv 1975) with projected sea-level at 120 m below mean sea level

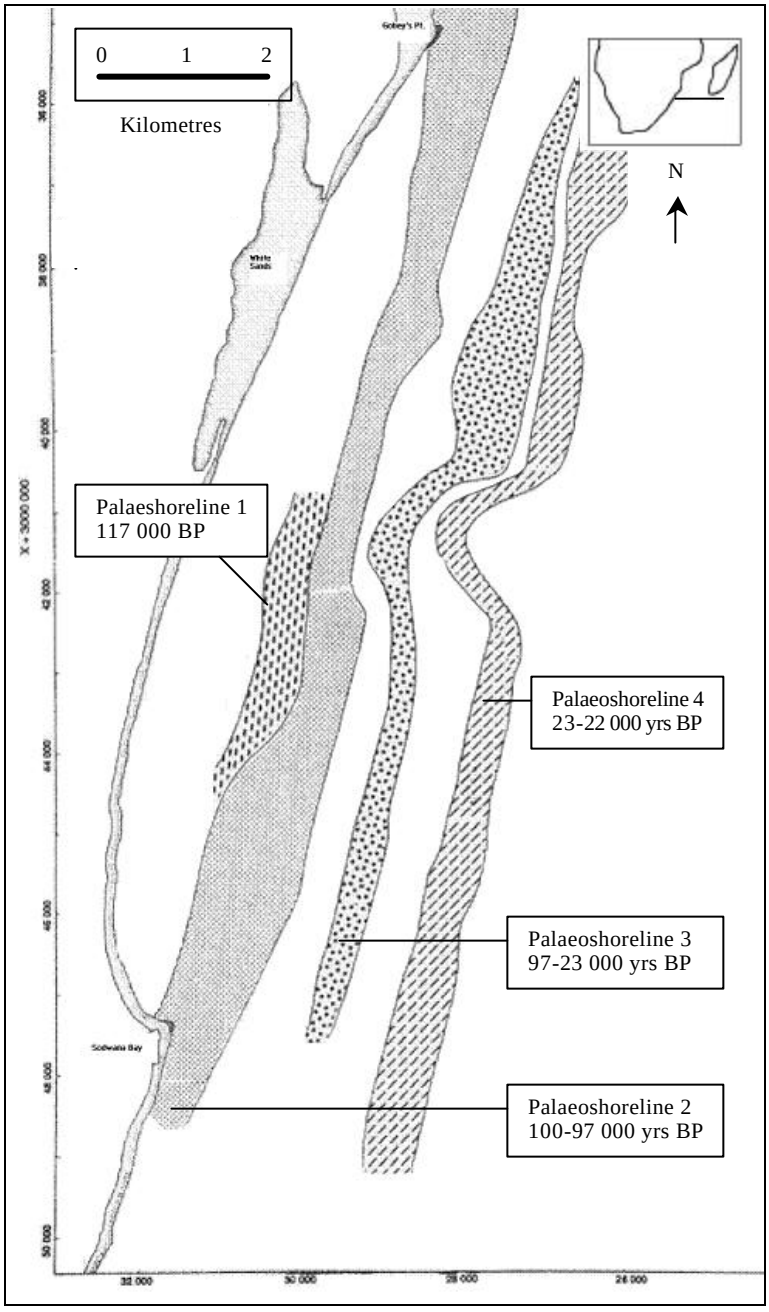


Figure 2.2. Offshore Palaeoshorelines 1-4 (after Ramsay 1996)

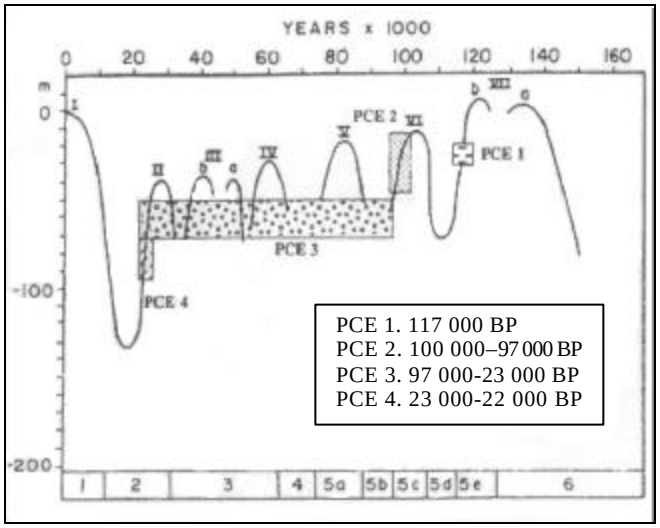


Figure 2.3. Plot of sea-level curve (after Williams *et al.* 1981) and the inferred age and depth relationships of Palaeocoastlines 1-4, on the Sodwana Bay shelf (after Ramsay 1996)

Maputaland Group (Botha 1997)	Age and Lithologies
Sibayi Formation	Post Mid-Holocene composite accretionary coastal dune cordon
Kwambonambi Formation	Late Pleistocene and Holocene inland dunes and interdune diatomite and peat
Kosi Bay Formation	Late Pleistocene **lignite** and dune sand, surficially weathered reddish brown
Isipingo Formation	Late Pleistocene eolianite and beach deposit
Port Durnford Formation	Middle-Late Pleistocene marine or estuarine mudstone and clayey sand deposited on coastal dunes and in lakes

Figure 2.4. Current interpretation of the Kosi Bay and Port Durford Formations (adapted from Maud & Botha 2000)

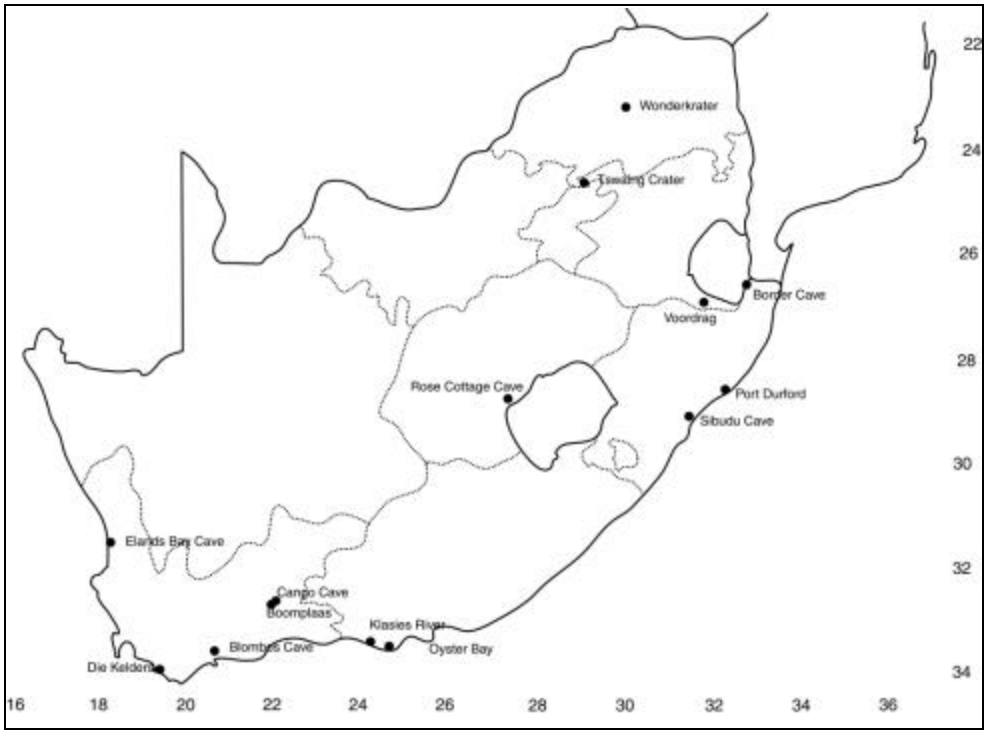


Figure 2.5. Map showing locations of sites with palaeoenvironmental data

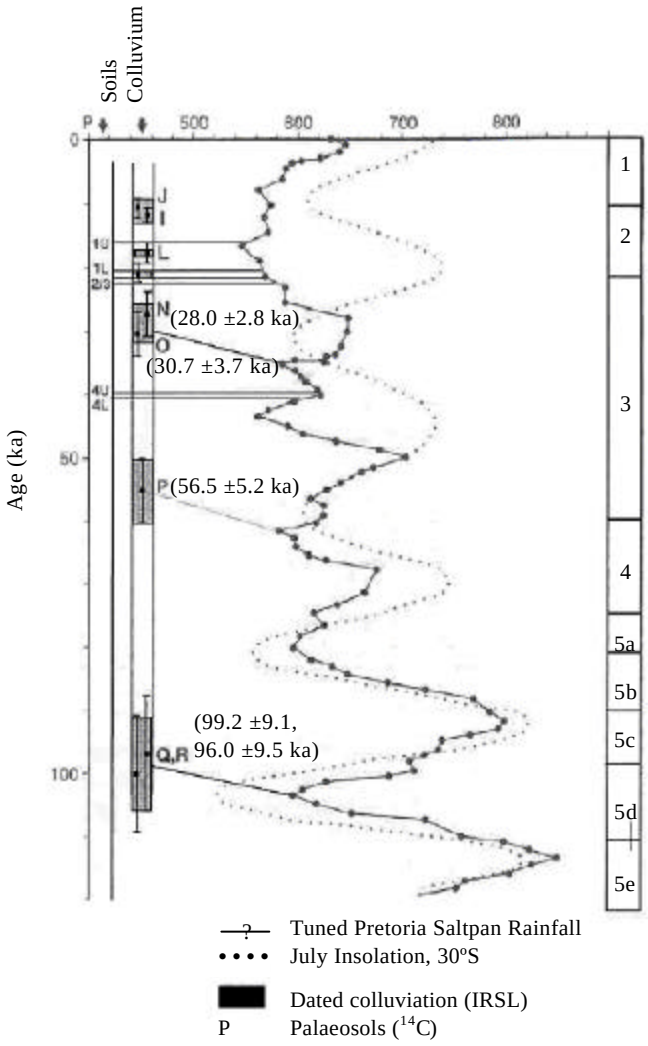


Figure 2.6. Tswaing Crater (Partridge *et al.* 1997) proxy rainfall record aligned with Voordrag colluvium and palaeosol formations (adapted from Clarke *et al.* 2003)

^{14}C (ka)	Tswaing zone	Wonderkrater Zone
2-1	Z15	W9
7-2	Z14	W6b-W8
7.2	Z13	W6b
10.3		W5-W6a
14-10.3		W4
25-20		W4
31?	Z12	W3?
>32.5?	Z11	
<40?	Z10	W2?
>40	Z9	W1b + c?
	Z8	W1a?

Figure 2.7. "Tentative" correlation between pollen zones at Tswaing Crater and Wonderkrater (redrawn from Scott 1999)

Earlier Upper Pleistocene Units Klein (1978)	Excavation Units Deacon (1989)
EUP Unit 3 40 000-21 000 years ago	OLP-GWA/GGU (oldest to youngest)
EUP Unit 2 >40 000 years ago	BOL
EUP Unit 1 >40 000 years ago	LOH-OCH (oldest-youngest)

Figure 2.8. Correlation of Boomplaas stratigraphic units to Klein's (1978) Earlier Upper Pleistocene Units

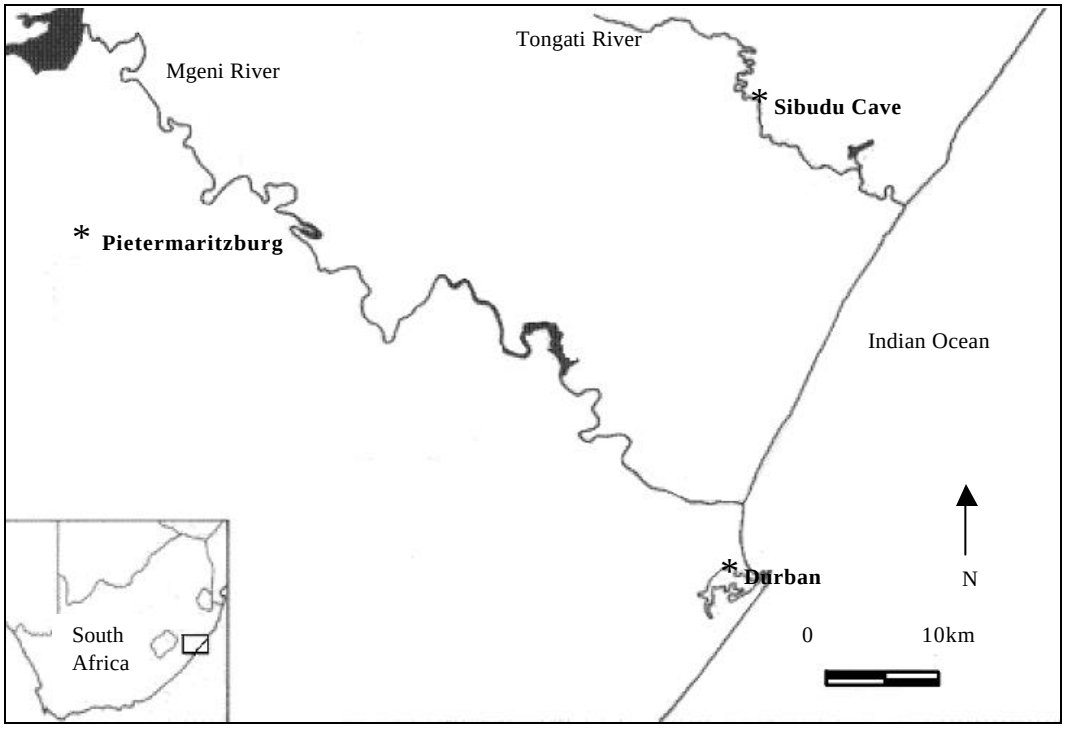


Figure 3.1. Location of Sibudu Cave (redrawn from Wadley & Jacobs 2004)

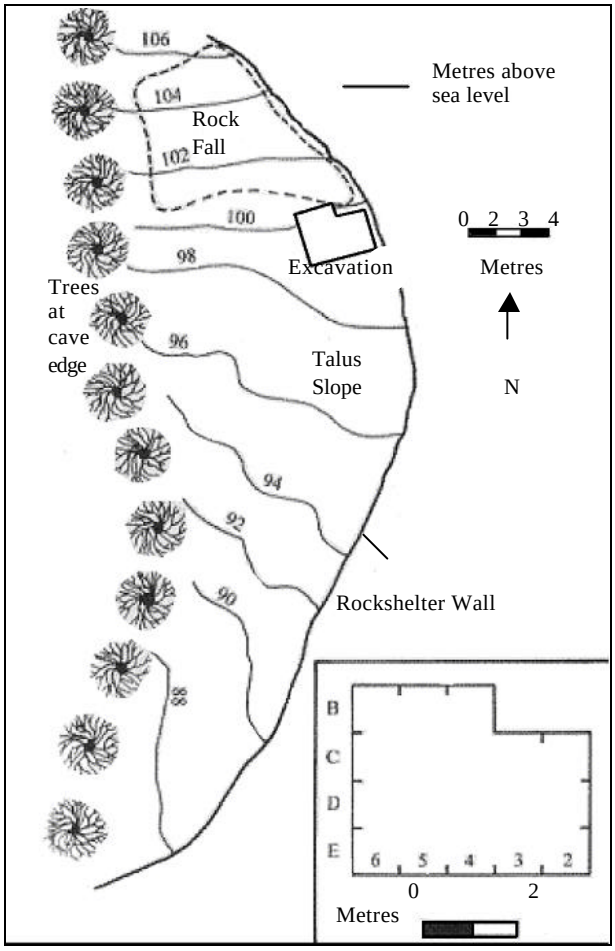


Figure 3.2. Plan of Sibudu Cave and excavation (after Wadley & Jacobs 2004)

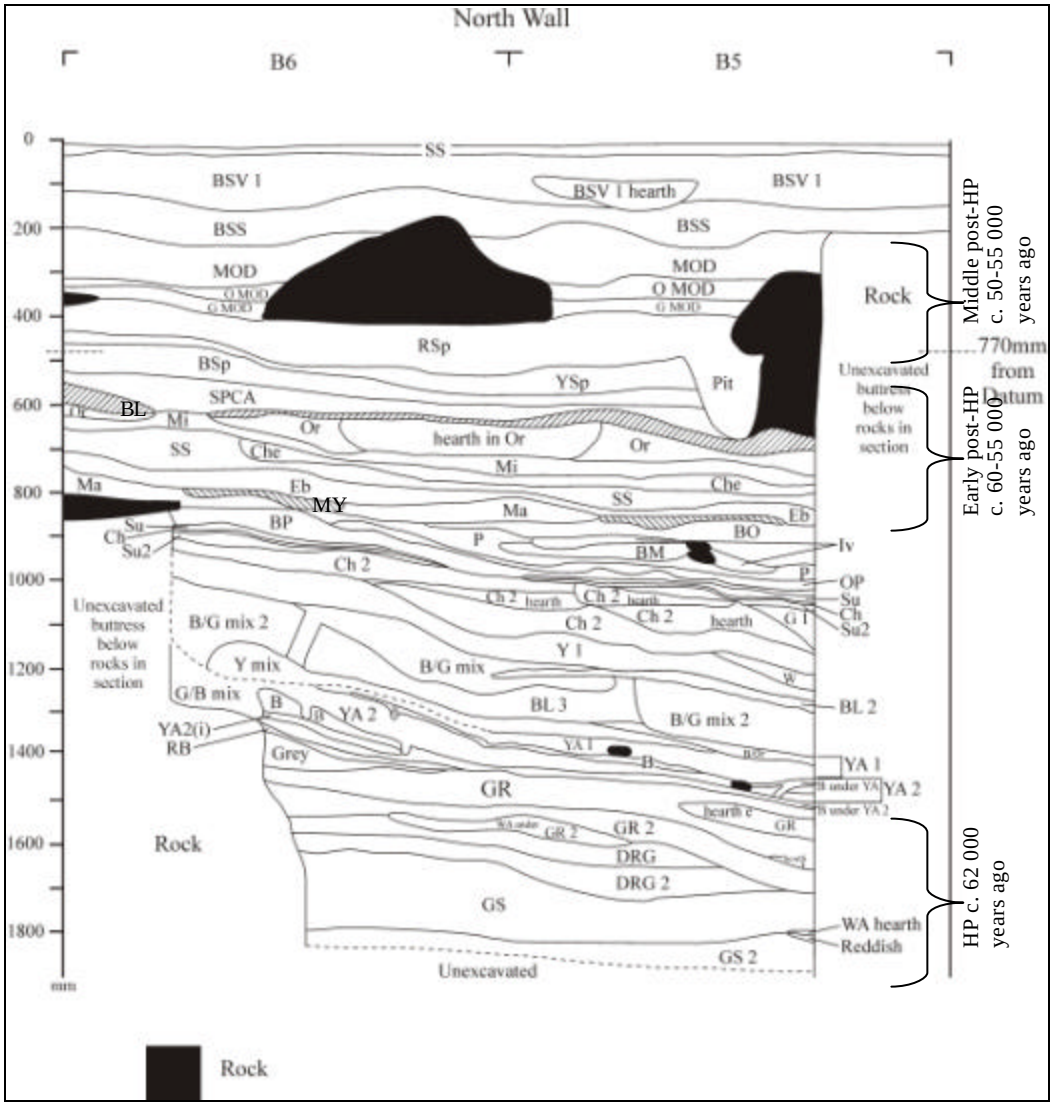


Figure 3.3. a) B5 and B6 North wall Stratigraphy

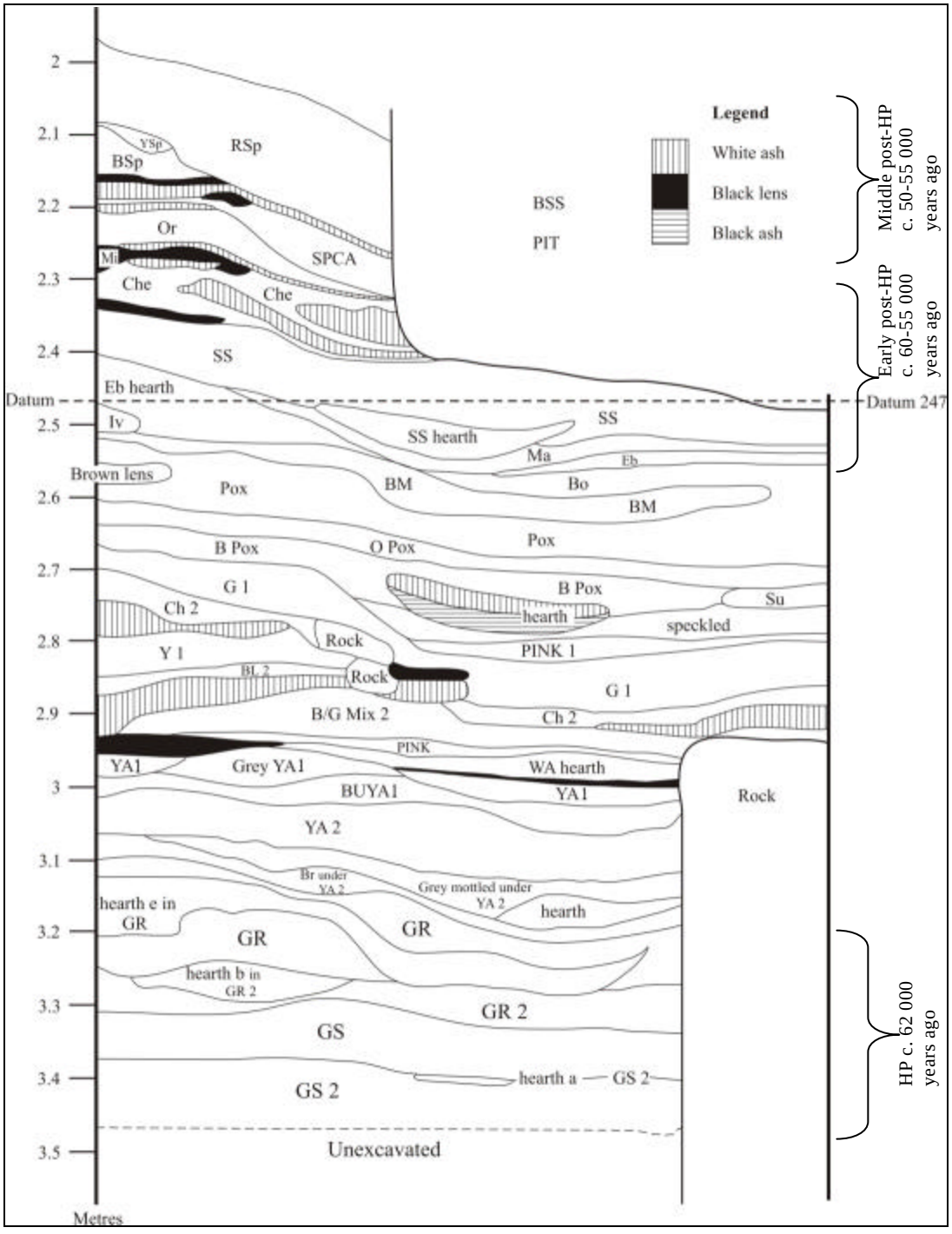


Figure 3.3. b) B5 East wall Stratigraphy

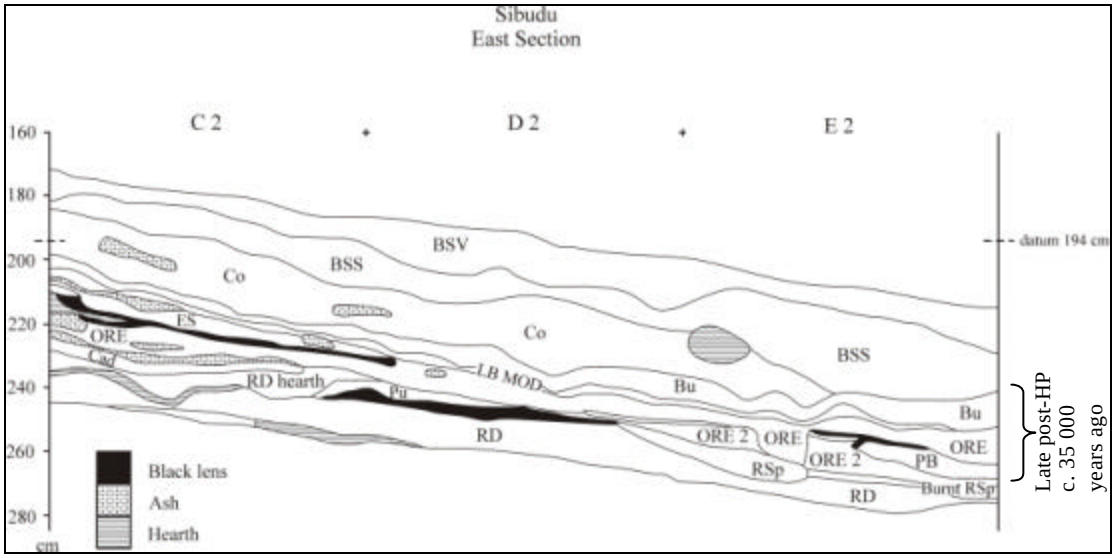


Figure 3.4. Stratigraphy of East Section Wall showing layer Bu (after Wadley 2001)

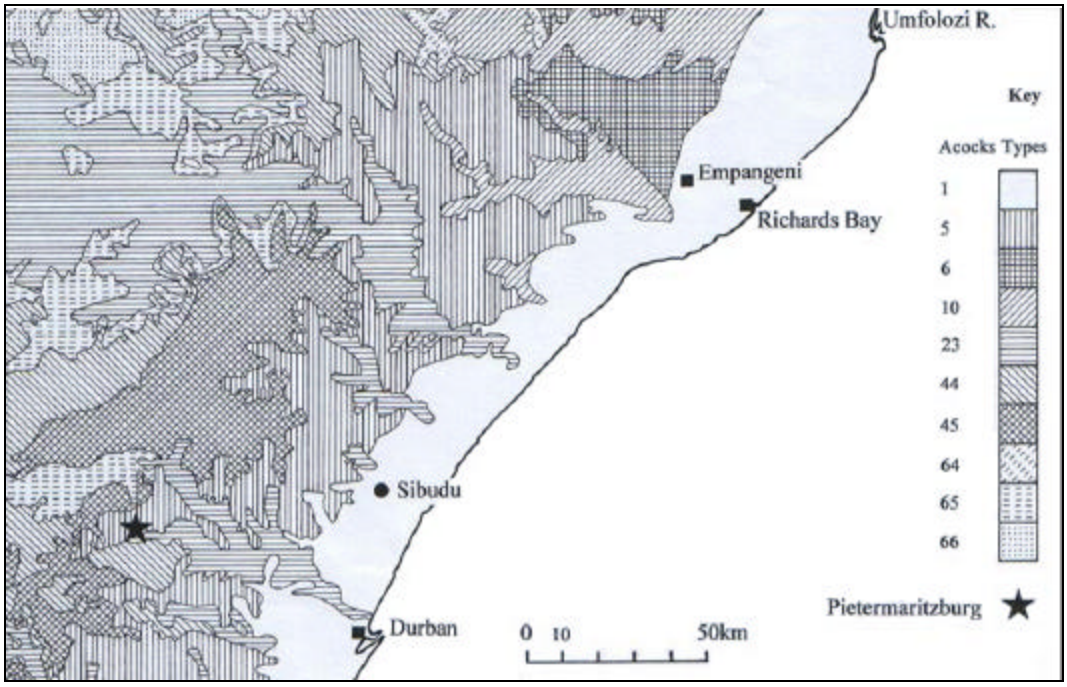


Figure 3.5. Map from Acocks (1988) showing Veld Types (1 = Coastal Forest Thornveld, 5 = 'Ngongoni Veld, 6 = Zululand Thornveld, 10 = Lowveld, 23 = Valley Bushveld, 44 = Temperate Forest and Scrub, 45 = Transitional Forest and Scrub, 64 = Northern Tall Grassveld, 65 = Southern Tall Grassveld, 66 = Natal Sour Sandveld) in Savanna Biome (after Wadley 2004)

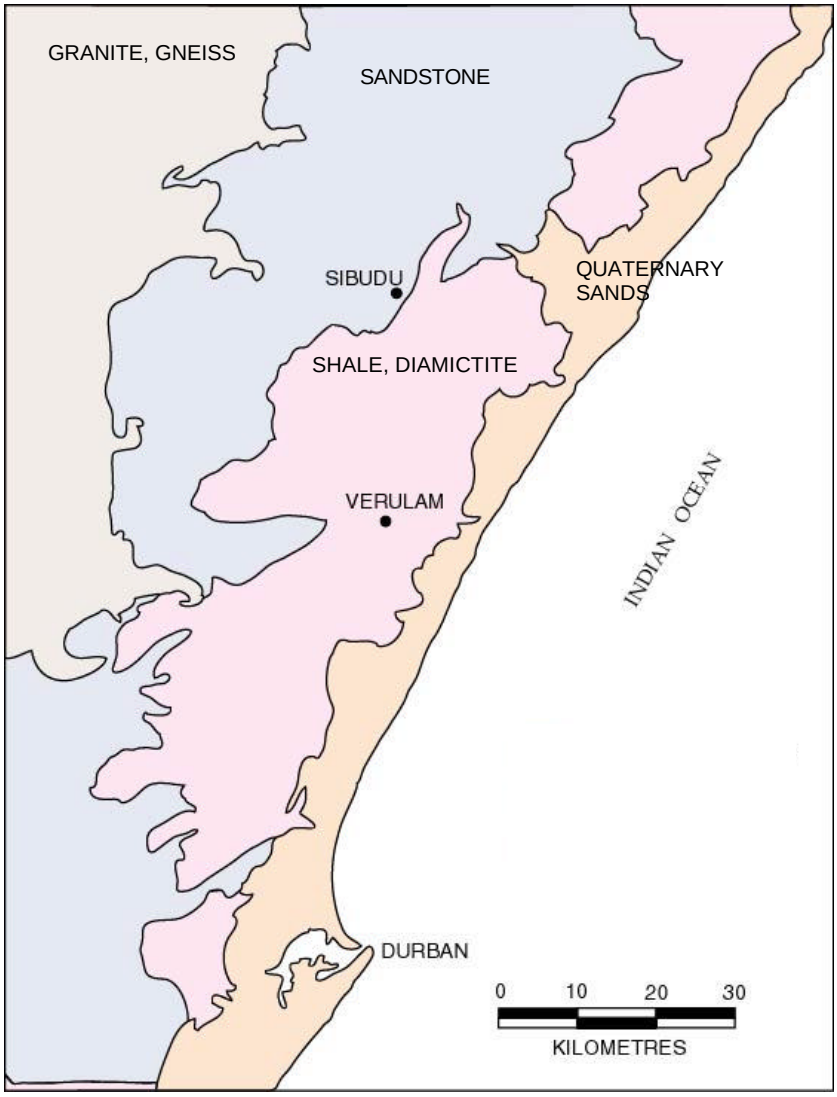


Figure 3.6. Map of Local Geology (supplied by G. Cochrane)



Figure 3.7. Dolerite Dyke formation dipping into Tongati River (supplied by G. Cochrane)

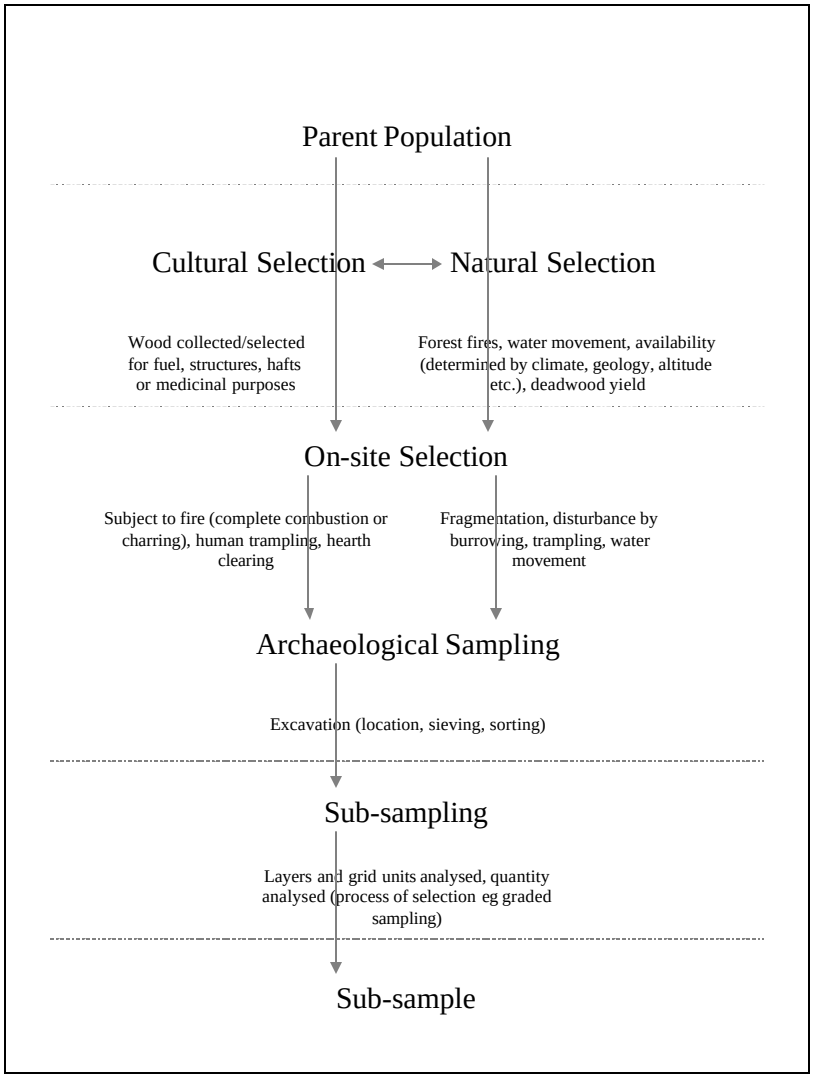


Figure 4.1. Flow chart showing stages of sampling

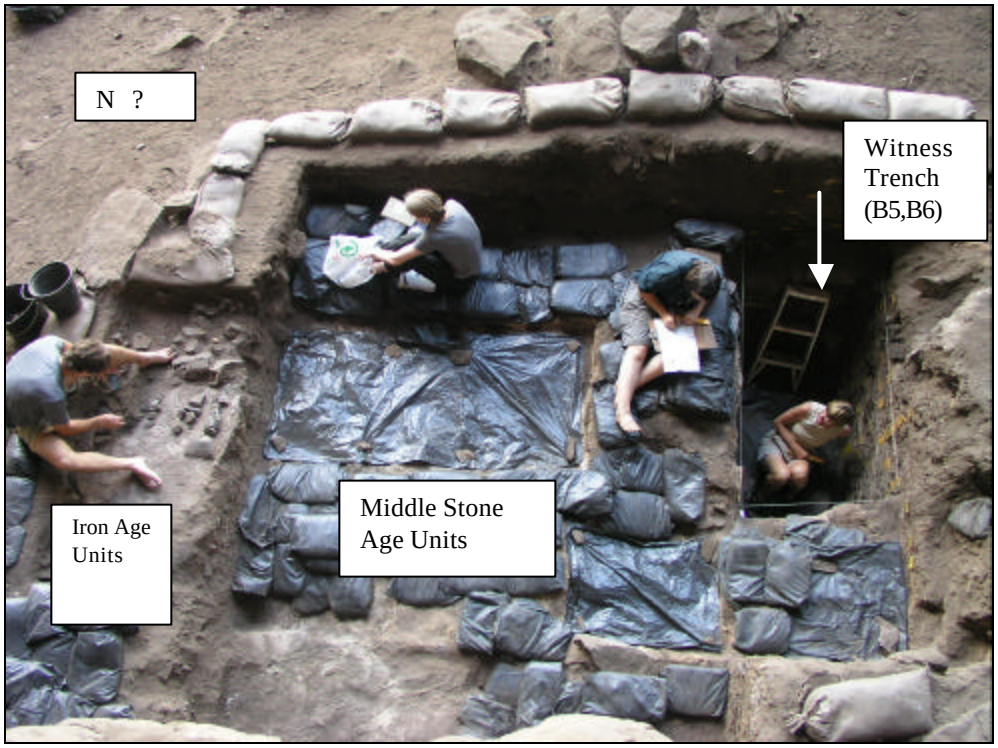


Figure 5.1 Photograph of Sibudu Cave Excavation (supplied by C. Scott)

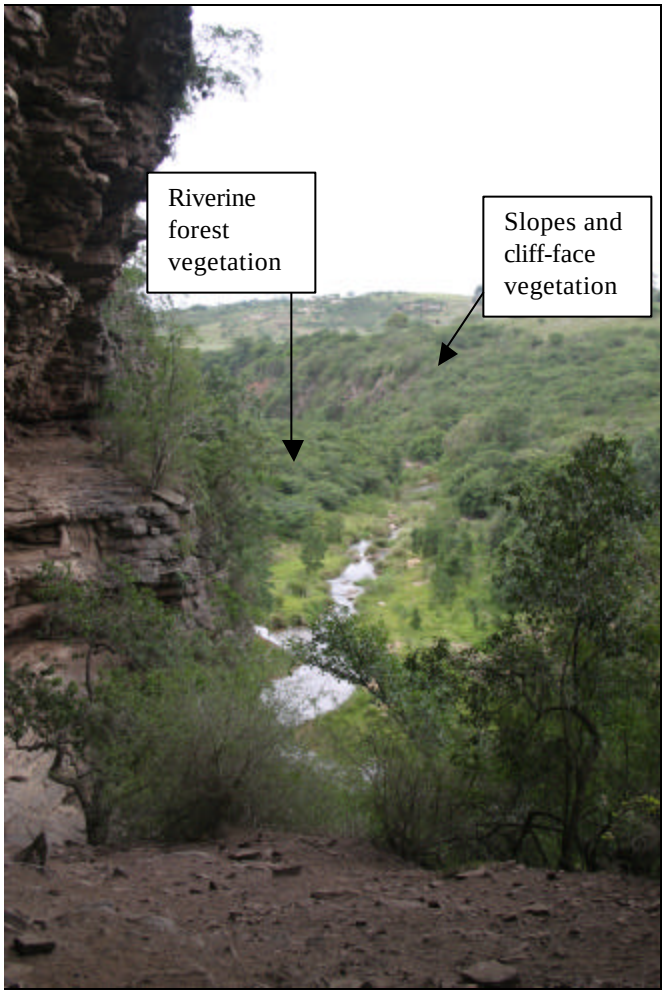


Figure 5.2. View of the Tongati River and vegetation from Sibudu Cave (supplied by L Wadley)

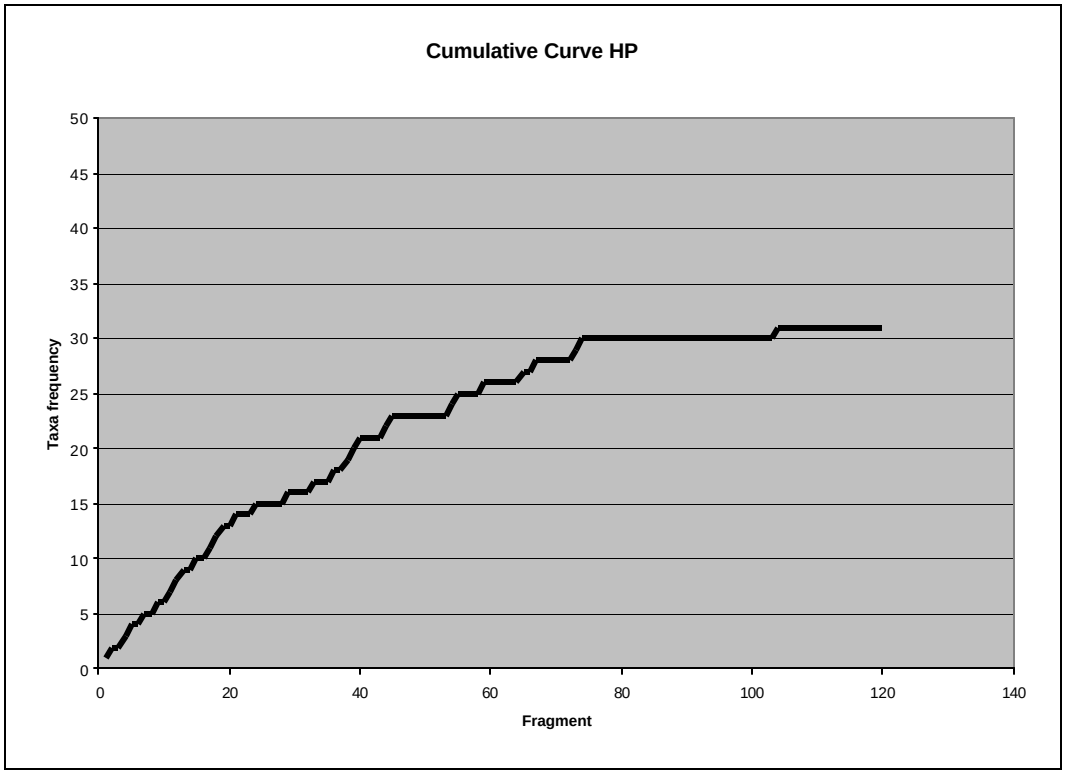


Figure 5.3. Cumulative curve Howiesons Poort layers

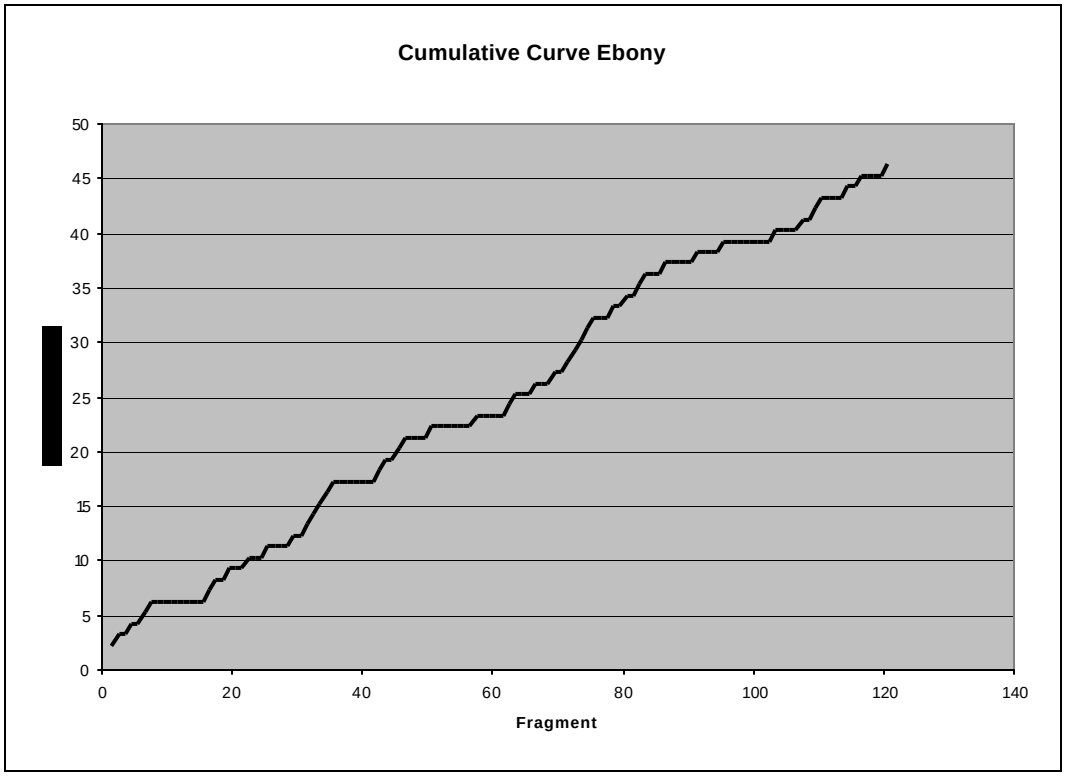


Figure 5.4. Cumulative Curve Layer Eb.

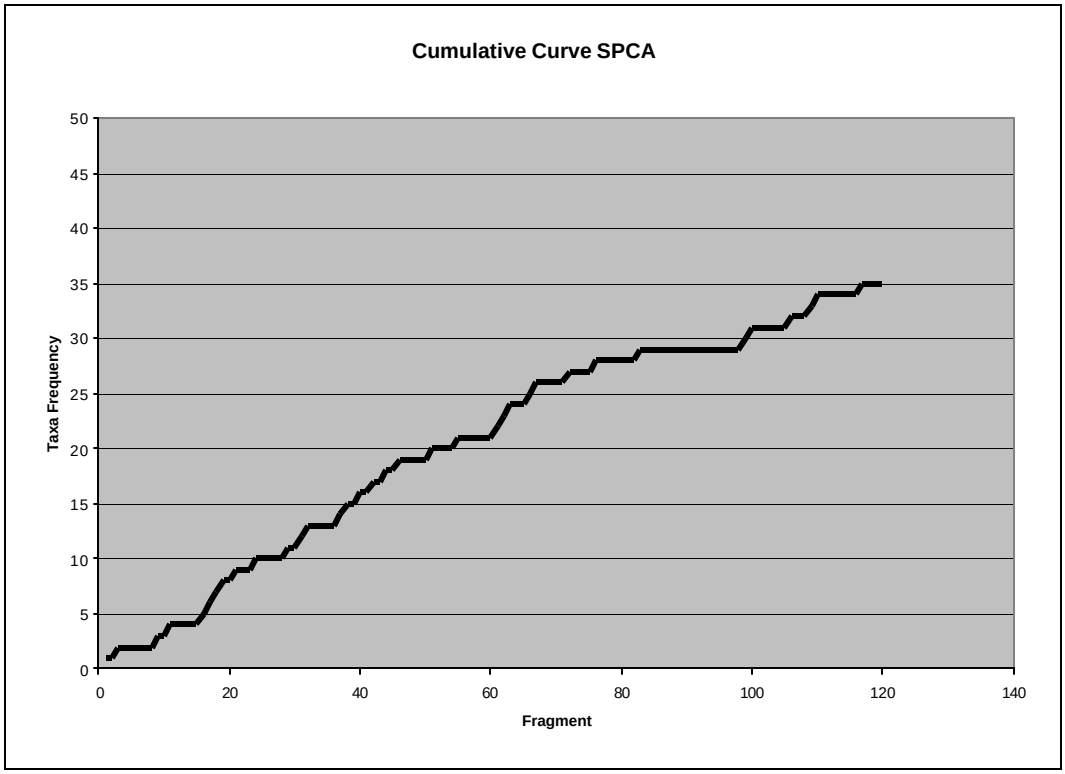


Figure 5.5. Cumulative Curve Layer SPCA

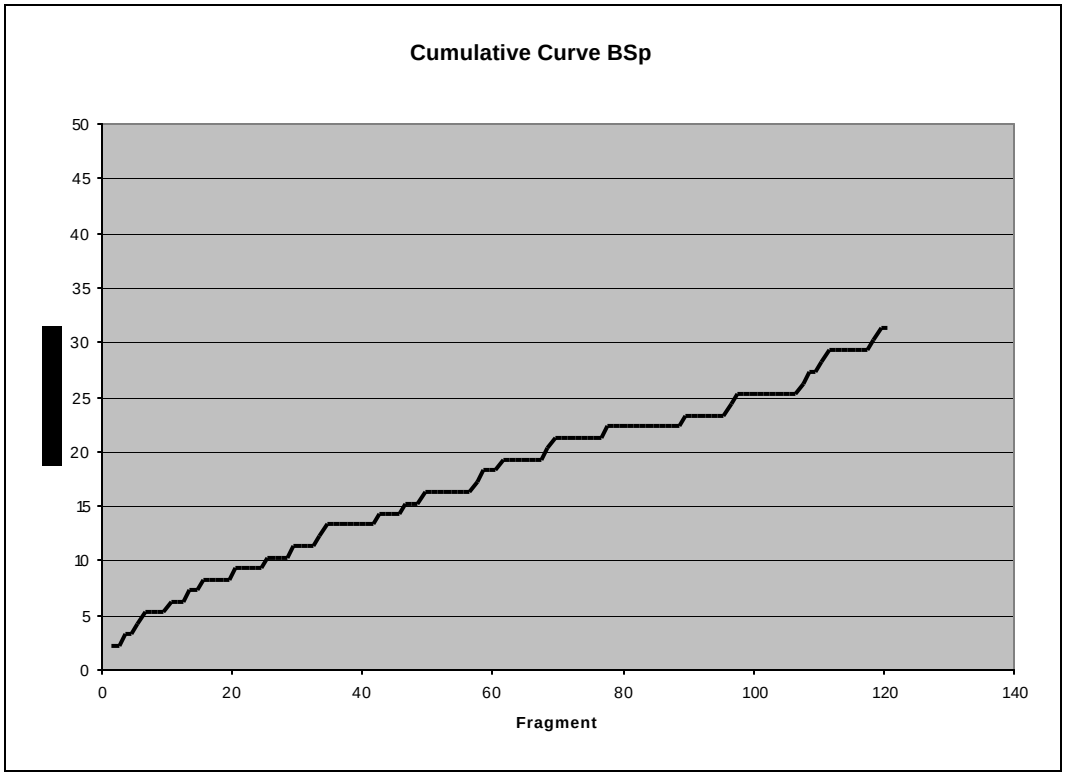


Figure 5.6. Cumulative Curve Layer BSp

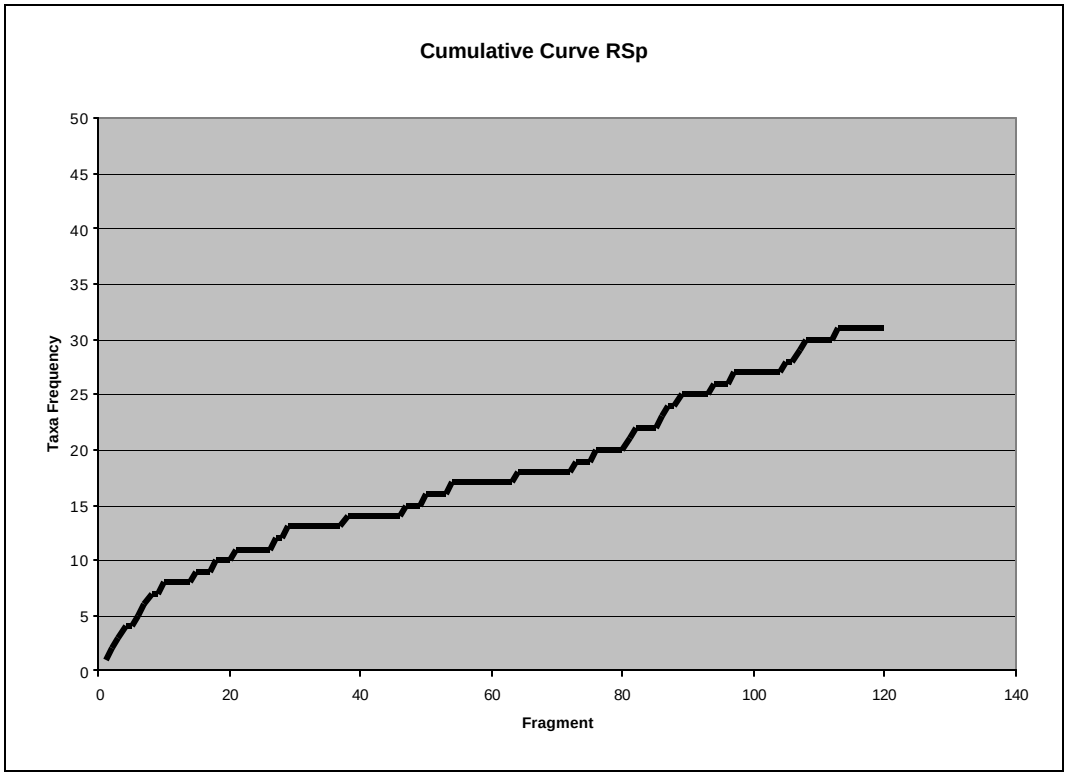


Figure 5.7. Cumulative Curve Layer RSp

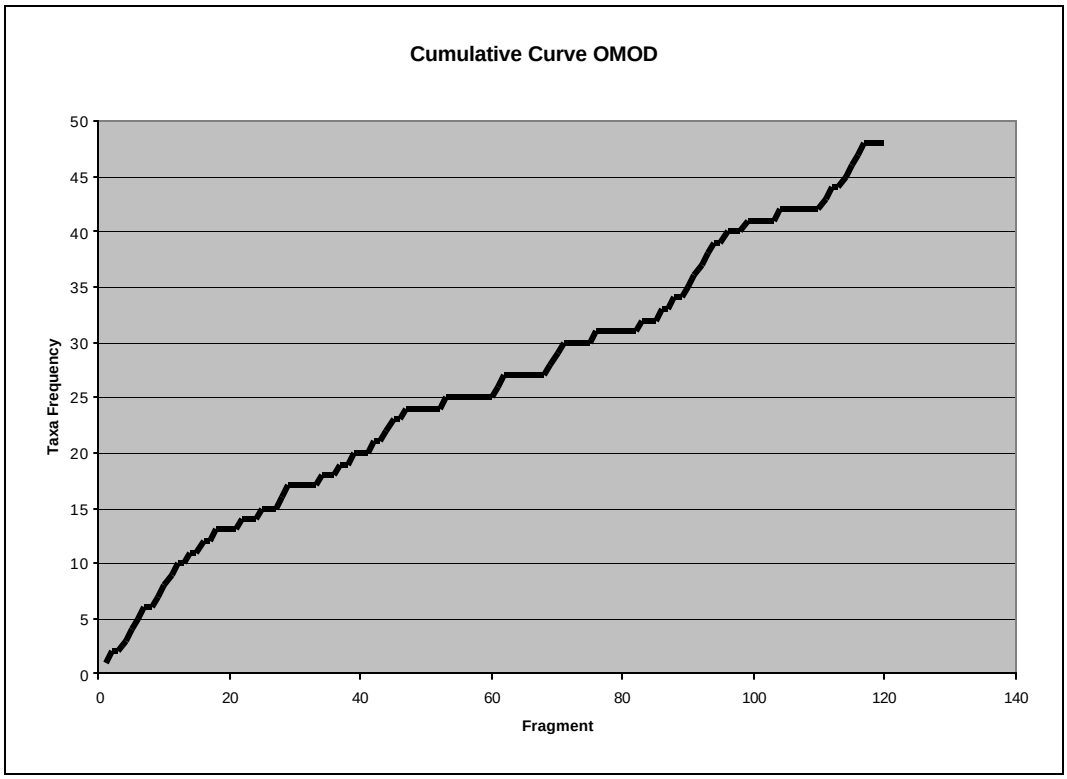


Figure 5.8. Cumulative Curve Layer OMOD

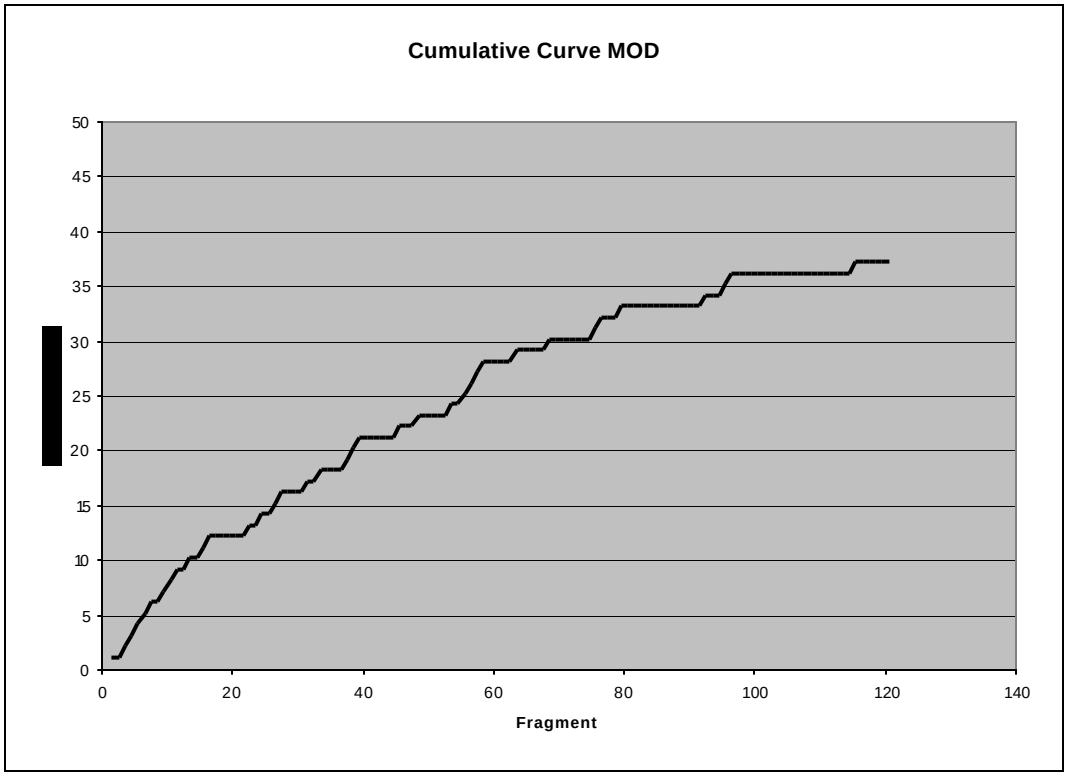


Figure 5.9. Cumulative Curve Layer MOD

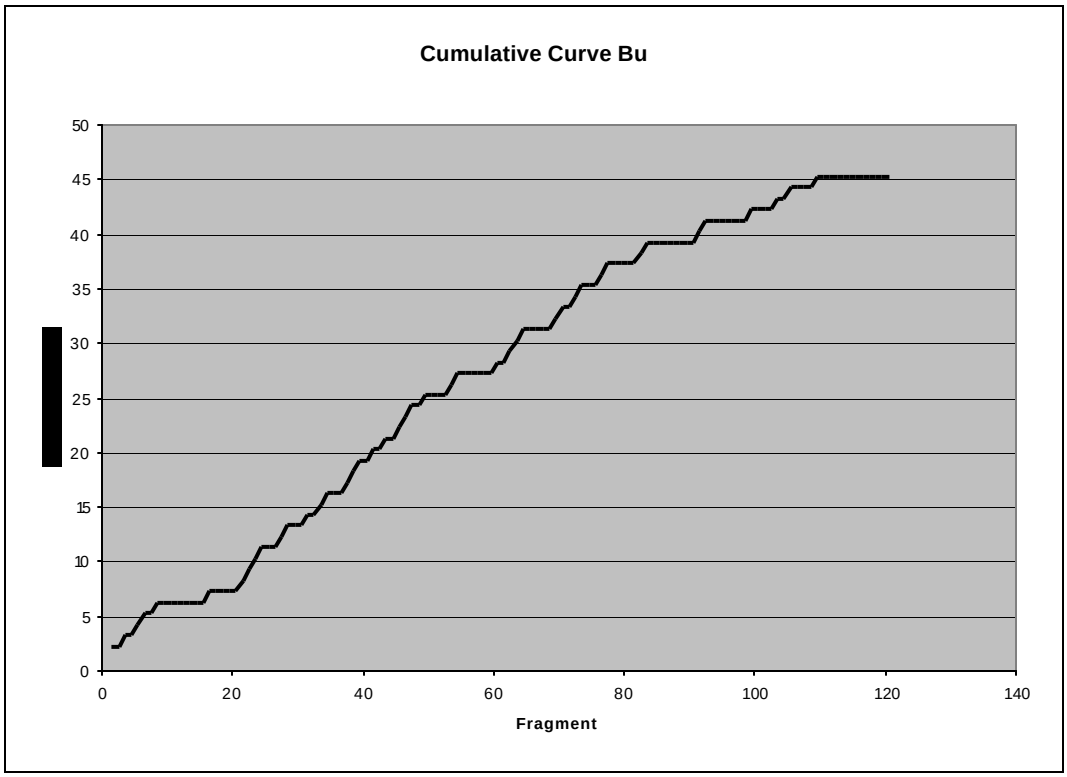


Figure 5.10. Cumulative Curve Layer Bu

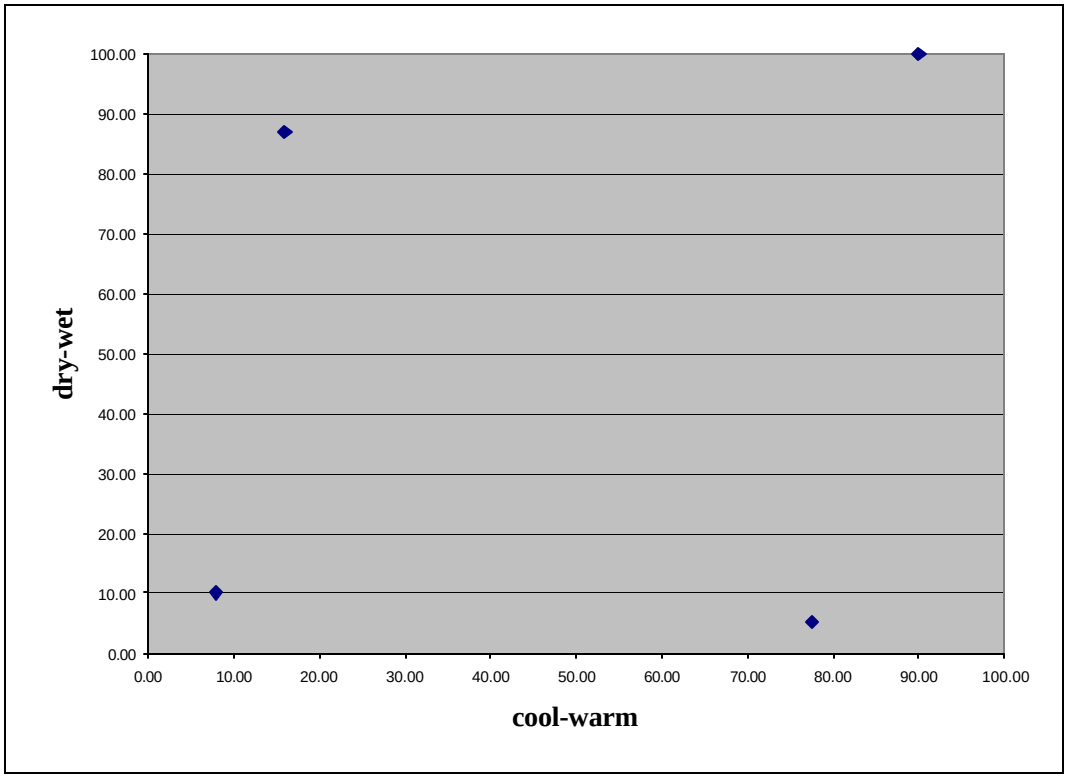
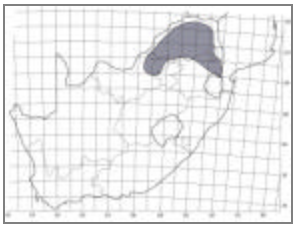
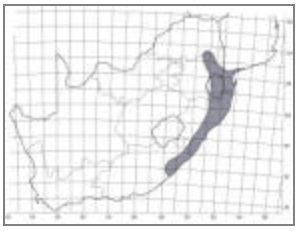
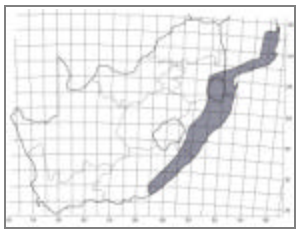


Figure 5.11. Diagram showing a hypothetical correlation between SSRF1 (temperature) and SSRF2 (moisture).

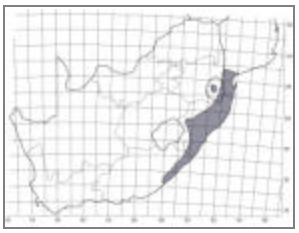

Brachylaena rotundata

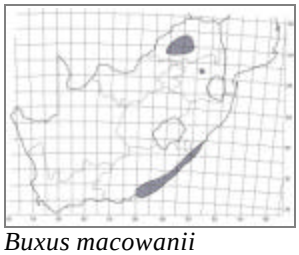

Kirkia wilmsii

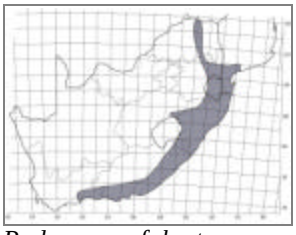

Sapium elipticum

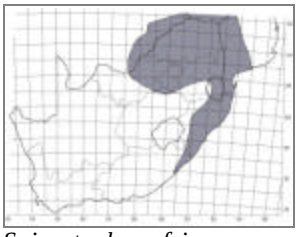

Brachylaena discolor

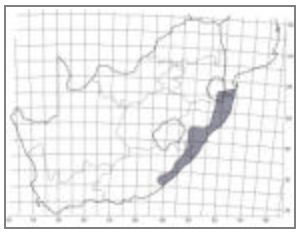

Mystroxylon aethiopicum

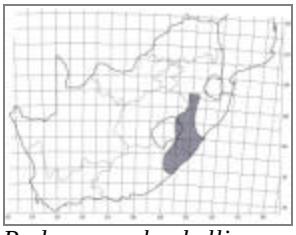

Sapium integerrimum


Buxus macowanii


Podocarpus falcatus

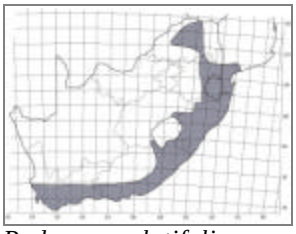

Spirostachys africana

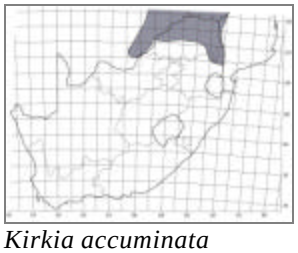

Buxus natalensis


Podocarpus henkelli


Ziziphus mucronata


Curtisia dentata


Podocarpus latifolius


Kirkia accuminata

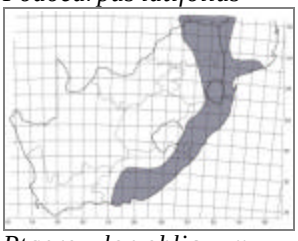

Ptaeroxylon obliquum

Figure 6.1. Distribution maps for taxa identified in the Howiesons Poort layers (GS, GR2 and GR)


Brachylaena discolor

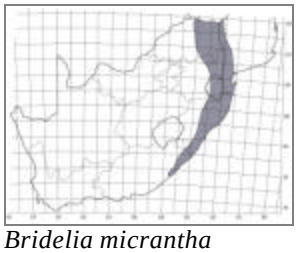

Erica caffra

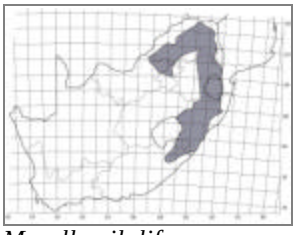

Ximenia americana


Bridelia cathartica

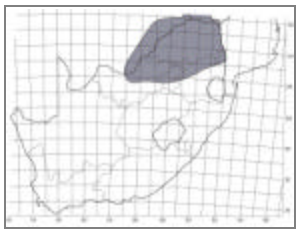

Leucosidea sericea


Ximenia caffra


Bridelia micrantha

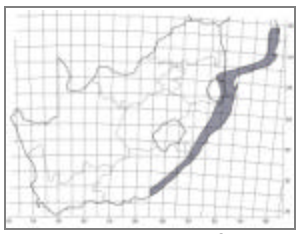

Morella pilulifera


Ziziphus mucronata

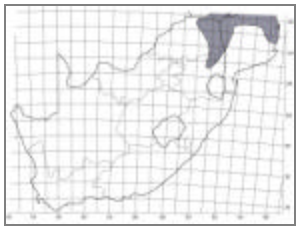

Bridelia mollis

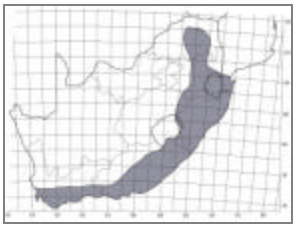

Mystroxylon aethiopicum

Figure 6.2. Distribution maps for taxa identified in layer Eb


Deinbollia oblongifolia

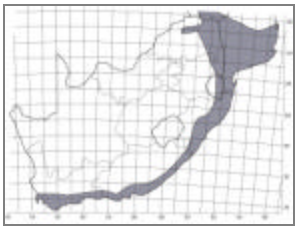

Ptaeroxylon obliquum


Deinbollia xanthocarpa


Rapanea melanophloeos

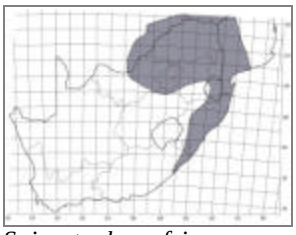

Calodendrum capense

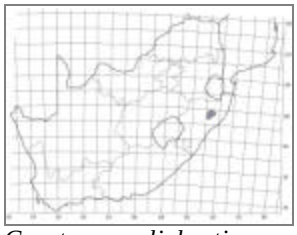

Podocarpus falcatus

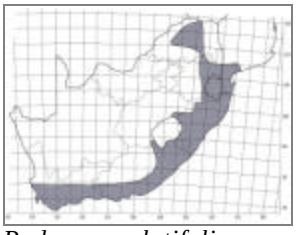

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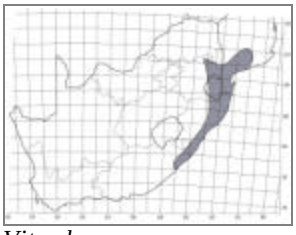

Celtis africana

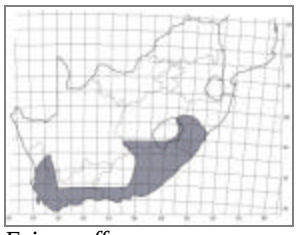

Podocarpus henkelli

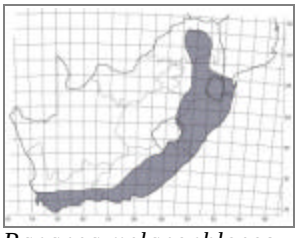

Spirostachys africana

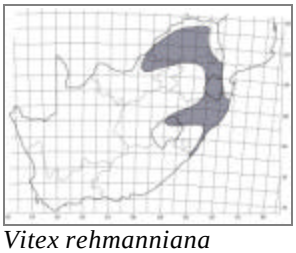

Cryptocarya liebertiana


Podocarpus latifolius

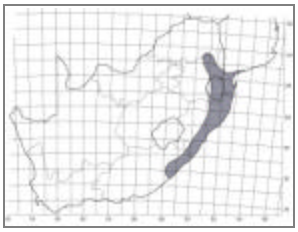

Vitex harveyana


Erica caffra


Rapanea melanophloeos


Vitex rehmanniana


Leucosidea sericea


Sapium elipticum

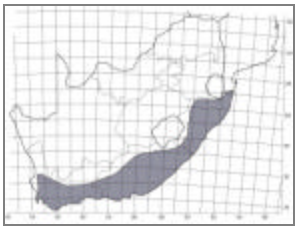

Ziziphus mucronata


Morella pilulifera

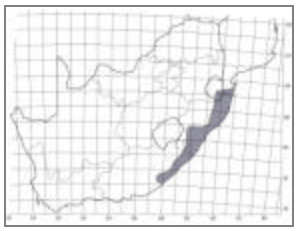

Sapium integerrimum

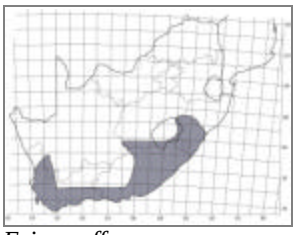
Figure 6.3. Distribution maps for taxa identified in the layer SPCA

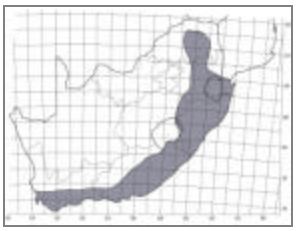

Buxus macowanii


Cunonia capensis

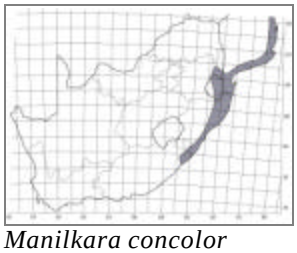

Ptaeroxylon obliquum


Buxus natalensis


Erica caffra

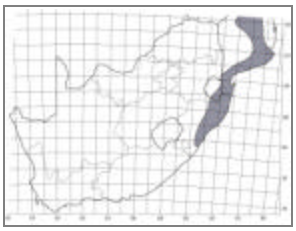

Rapanea melanophloeos

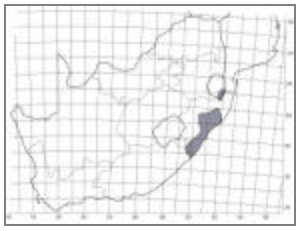

Calodendrum capense


Manilkara concolor


Ziziphus mucronata


Celtis africana


Manilkara discolor


Celtis mildbraedii

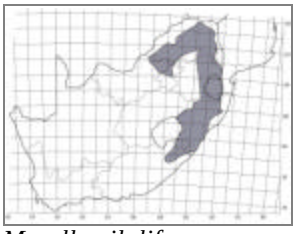

Morella pilulifera

Figure 6.4. Distribution maps for taxa identified in the layer BSp



Erica caffra



Podocarpus falcatus



Ximenia americana



Kirkia accuminata



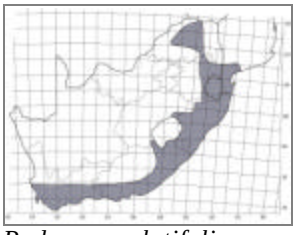
Podocarpus henkelli



Ximenia caffra



Kirkia wilmsii



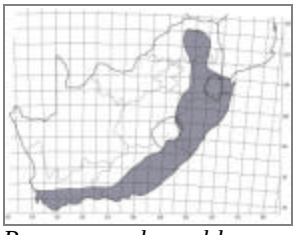
Podocarpus latifolius



Ziziphus mucronata



Mystroxylon aethiopicum



Rapanea melanophloeos

Figure 6.5. Distribution maps for taxa identified in the layer RSp



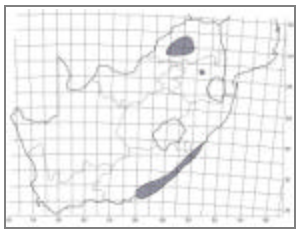
Afzelia quanzensis



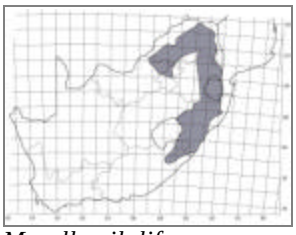
Erica caffra



Ziziphus mucronata

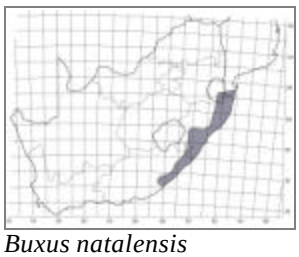


Buxus macowanii

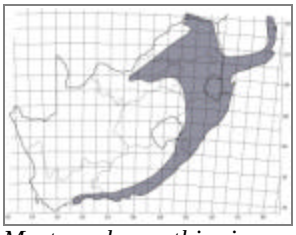


Morella pilulifera

Figure 6.6. Distribution maps for taxa identified in the layer OMOD



Buxus natalensis



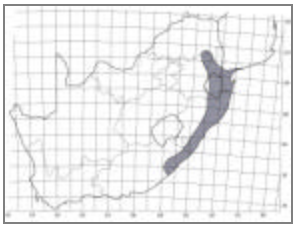
Mystroxylon aethiopicum



Bridelia cathartica



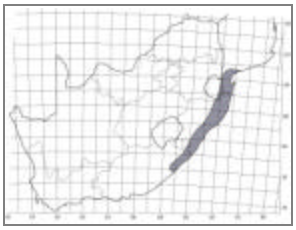
Erica caffra



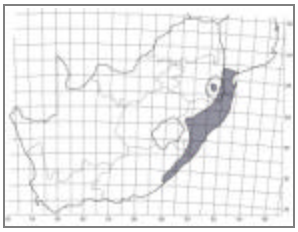
Sapium elipticum



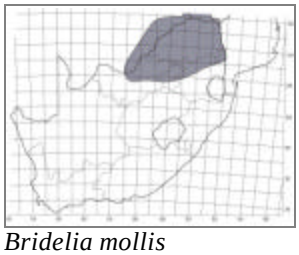
Bridelia micrantha



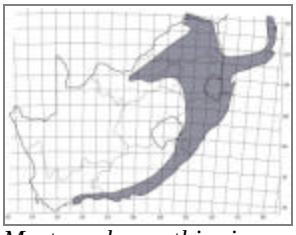
Macaranga capensis



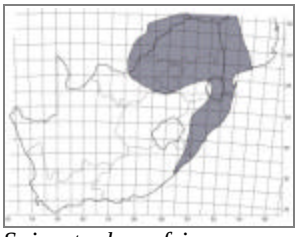
Sapium integerrimum



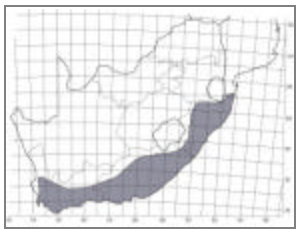
Bridelia mollis



Mystroxylon aethiopicum



Spirostachys africana



Cunonia capensis



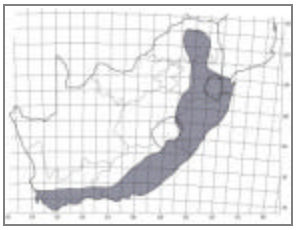
Pappea capensis



Ziziphus mucronata



Curtisia dentata



Rapanea melanophloeos

Figure 6.7. Distribution maps for taxa identified in the layer MOD



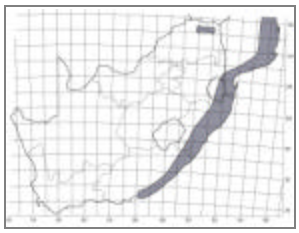
Brachylaena discolor



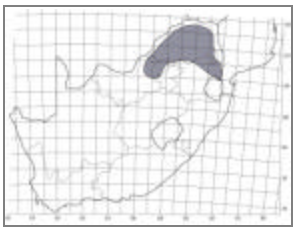
Kirkia accuminata



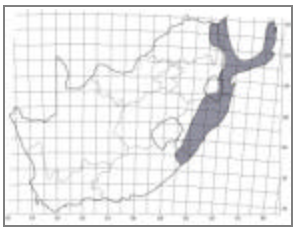
Phoenix reclinata



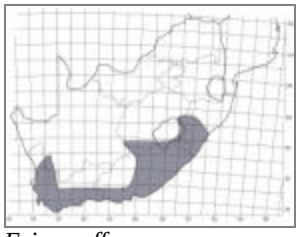
Clerodendrum glabrum



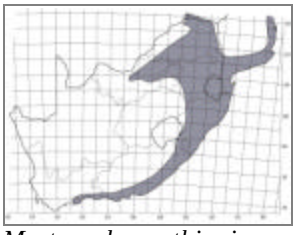
Kirkia wilmsii



Xylothecca kraussiana



Erica caffra



Mystroxylon aethiopicum

Figure 6.8. Distribution maps for taxa identified in the layer Bu

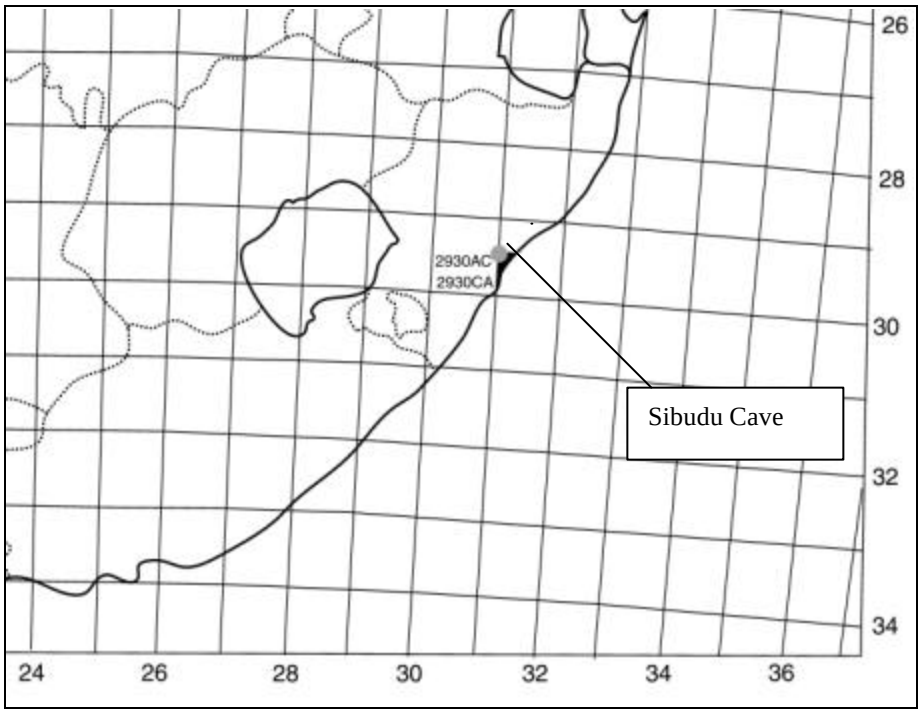
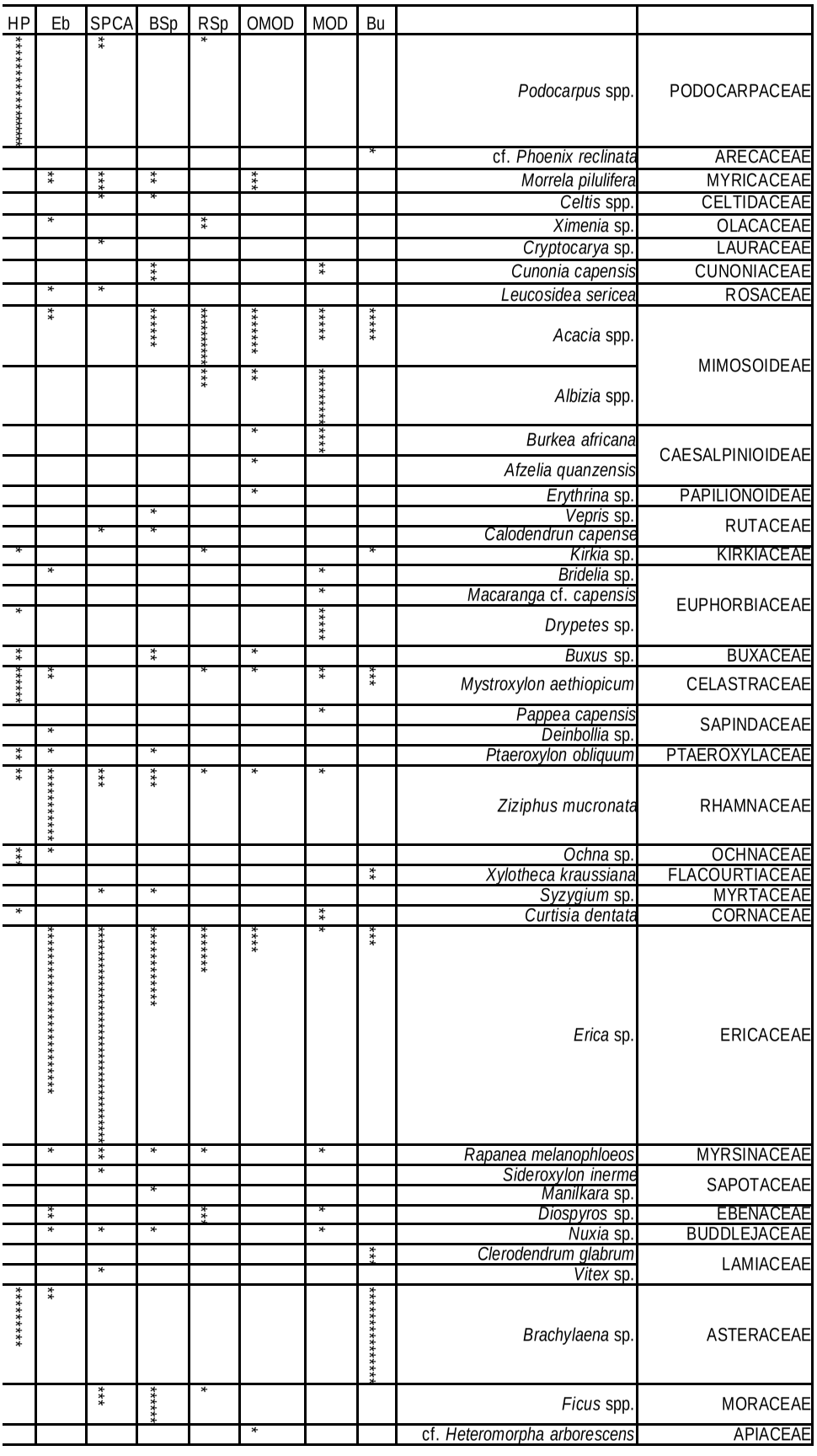


Figure 6.9. Location of PRECIS grid squares, 2931 AC and 2931 CA, and their proximity to Sibudu Cave

Figure 6.10. Graph showing identified taxa and fragment frequencies



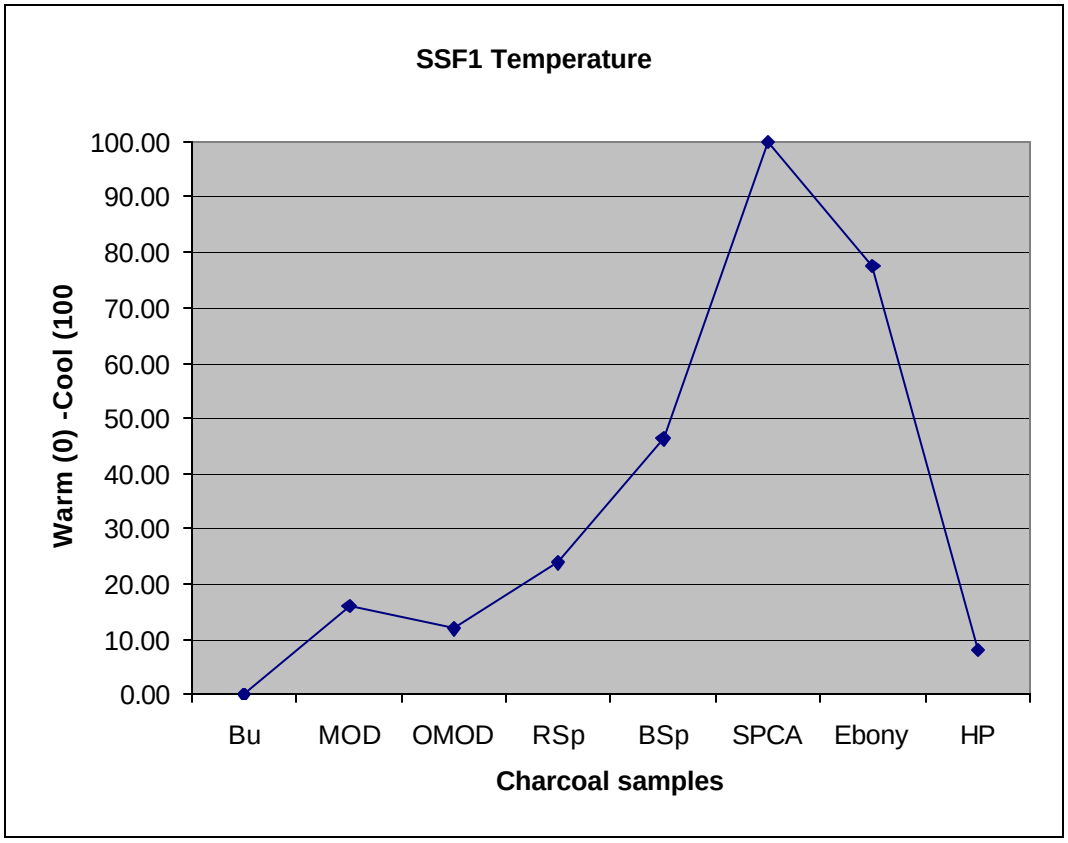


Figure 7.1. SSRF1 temperature (warmer–cooler conditions). The indices could also be interpreted as an indication of moisture availability

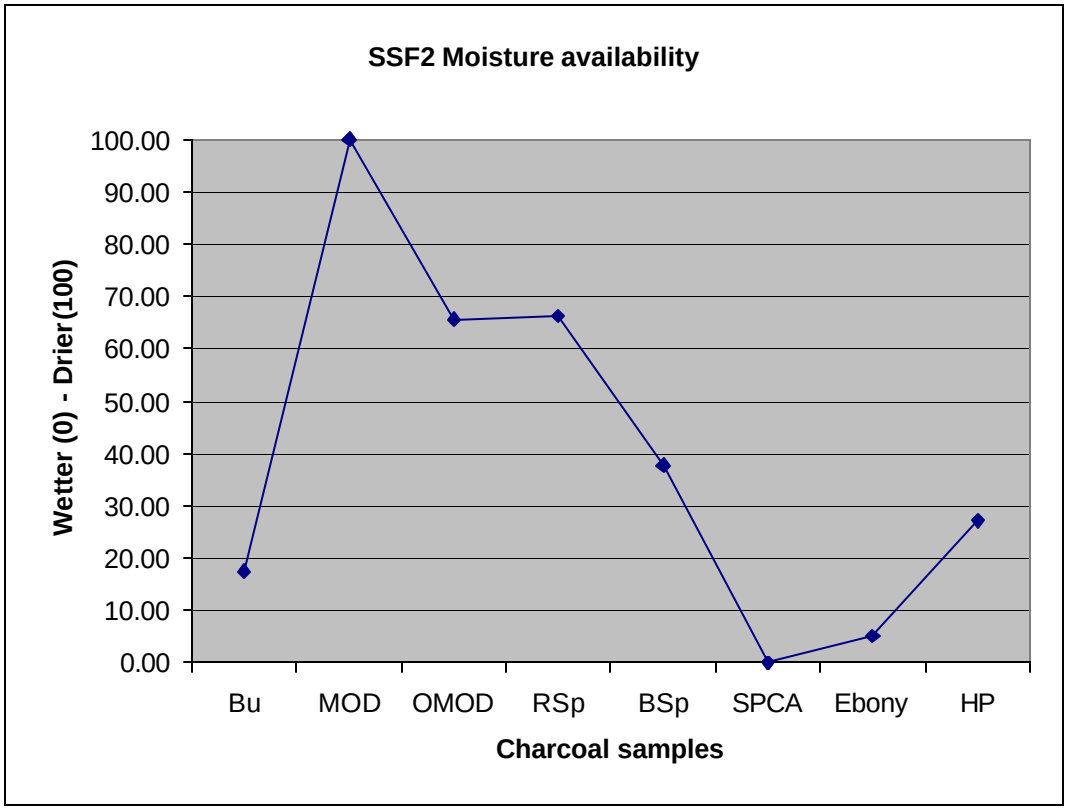


Figure 7.2. SSRF2 moisture availability (wetter conditions–drier conditions). The graph could also be interpreted as showing the presence of frost resistant plants vs more non–frost resistant taxa being present.

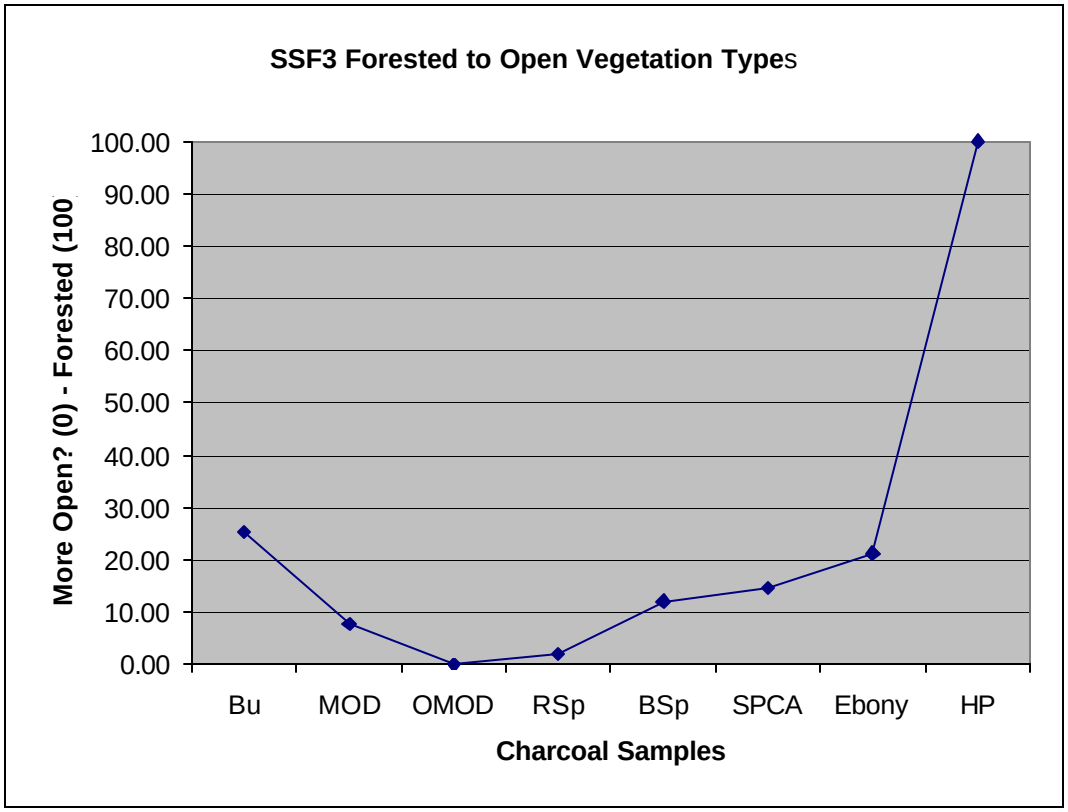


Figure 7.3. SSRF3 habitat niches – forest vegetation to less forested (or different forest) and more open vegetation

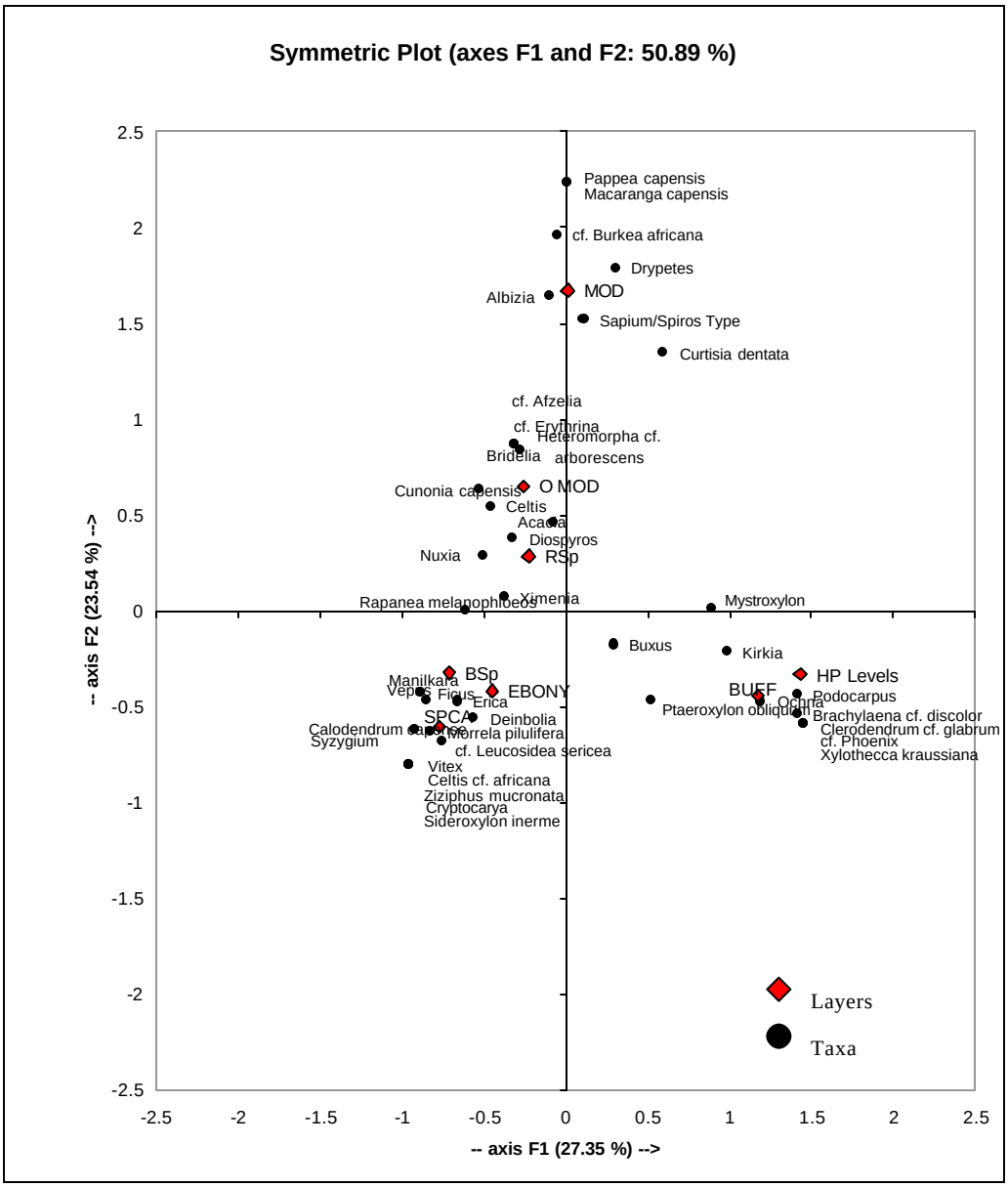


Figure 7.4. Correspondence Analysis graph Axis 1 and 2

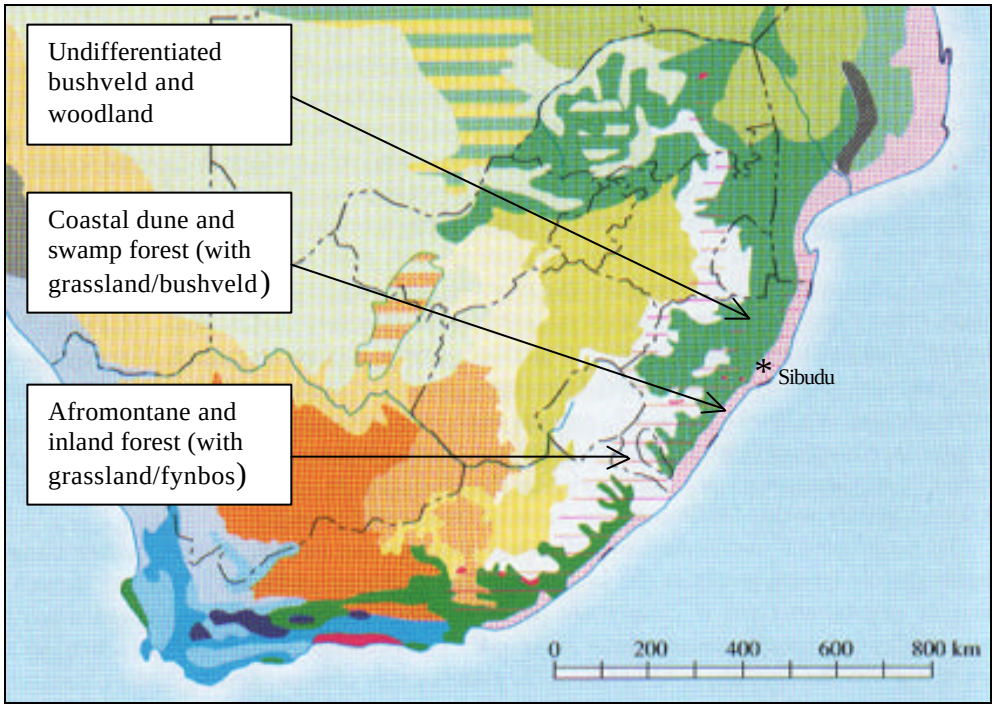


Figure 8.1. Vegetation Map (after van Wyk & van Wyk 1997) showing the modern vegetation around Sibudu Cave and the proximity of the Afromontane and inland forest vegetation to the site.

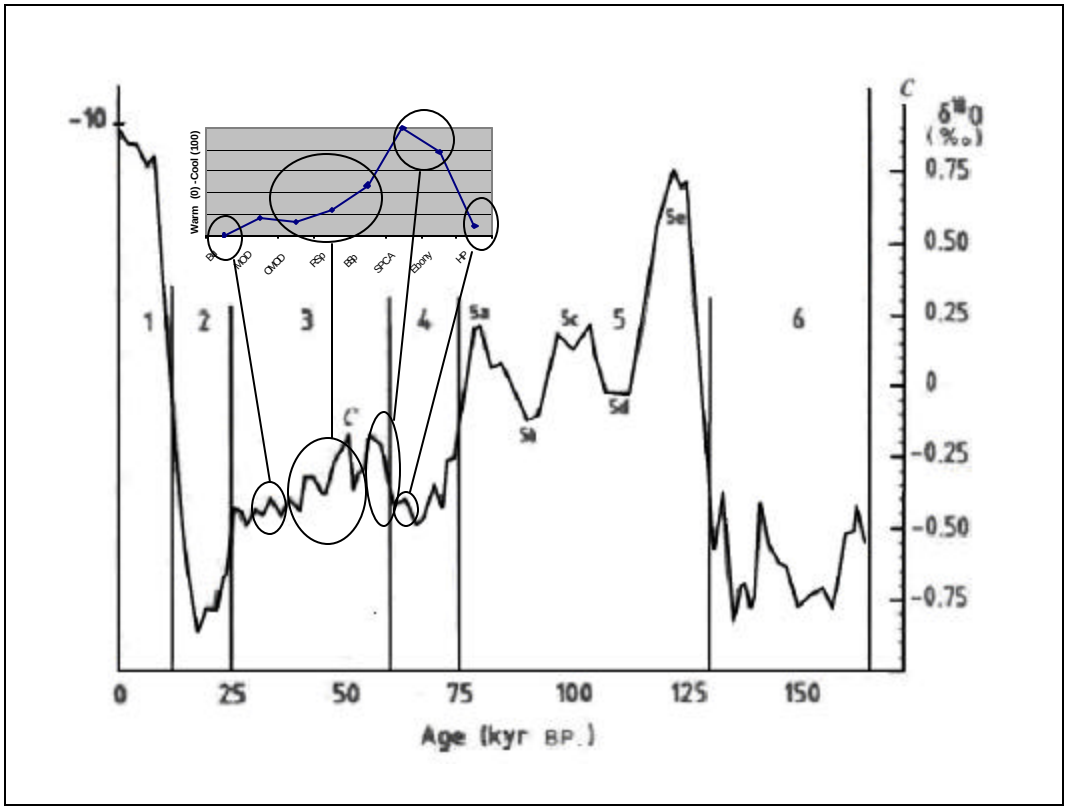


Figure 8.2. Deuterium isotope ratios for the Vostok Ice Core (Jouzel *et al.* 1997) (adapted from Thackeray 1992) and Summary Statistics index on Rotated Factor 1 (SSRF1), based on archaeological charcoal samples, showing the placement of the Sibudu Cave sequence.

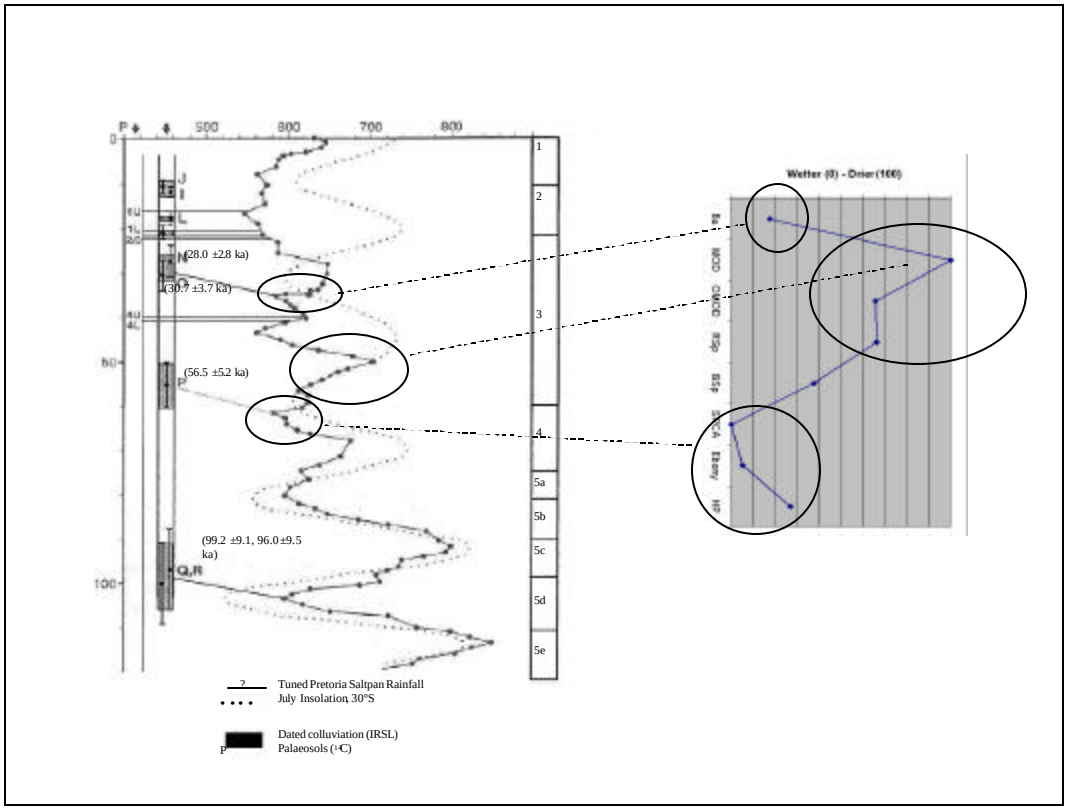


Figure 8.3. Tswaing Crater, Voordrag colluvium accumulations (Clarke *et al*. 2003) and Summary Statistics index on Rotated Factor 2 (SSRF2) showing discrepancies between the Sibudu Cave record for available moisture and the proxy rainfall record.

TABLES

Table 2.1. ^{14}C dates and relative sea levels (below mean sea level) for estuarine sediments (Maud 2000)

Years BP	Lab. No.	Sea level below m.s.l.	Location
>45 200 BP	Pta-4140	-42	Richards Bay
39 100 BP ±1530	Pta-4142	-52	Richards Bay
42 000 $\pm^{2800}/_{2100}$	Pta-1169	-15	St. Lucia
33 400 ±910 BP	Pta-1153	-7.6	St. Lucia

Table 2.2. Correlation of Klasies River Middle Stone Age Archaeological sequences with Avery's (1987) microfauna sample numbers, and Feathers's (2002) Luminescence dates

Lithic Industry	Sample Number (Avery 1987)	Luminescence dates (Feathers 2002)
MSA III	3-19	50 ka
HP	20-30	55-60 ka
MSA II	31-40	70-85 ka
MSA I	41	110-115 ka

Table 2.3. Correlations between old and revised ESR dates by Grün *et al.* (1990) and Grün & Beaumont (2001), respectively, and Butzer's (1984) unit numbers used by Avery (1982) (Correlation based on Avery's updated interpretation of micromammal data (Avery 1992).

Units. Beaumont (1980)	**ESR dates from Grün *et al.* (1990) Grün & Beaumont (2001)**		**Avery (1982) Butzer (1984)**	**Grün *et al.* (1990)**
1BS	LR	33 ±1 ka	2	
1WA	UP	39 ±3 ka		
	2	36 ±1 ka	3	26.2-34.2 ka
2BS	UP	41 ±2 ka	4	33.8-36.2 ka
	LR.C	48 ±1 ka	5c	35.3-57 ka
2WA		63 ±2 ka	6	46.7-52.6 ka
3BS	1	58 ±2 ka		
	2	66 ±3 ka	7a-b	42.2-59.1 ka
	3	74 ±4 ka		
3WA		66 ±2 ka	8	42.1-63.9 ka
1RGBS		76 ±4 ka	(9)	64.5-80.5 ka
4BS		82 ±2 ka	(9)	62.4-84.8 ka
4WA	1	118 ±4 ka		80.7-95.7 ka
	6	116 ±5 ka	11a	
	7	174 ±5 ka		119.0-130.0 ka
5BS	2	166 ±5 ka	(11b)	116.0-141.0 ka
	5	147 ±6 ka		
5WA	1	174 ±9 ka	(12,13)	
	2	227 ±11 ka		

Table 3.1. OSL dates and C^{14} dates (Wadley & Jacobs 2004), and provisional OSL dates Z. Jacobs (pers. comm.) for the Middle Stone Age deposits at Sibudu Cave.

Status	**Layer**	*Date*	**Method**	**Source**	**Stratigraphic location of levels with no dates.**
Provisional	Co	33.1 ±3.2 ka	OSL	D2 East	
Provisional	Lens G2	51.9 ±2.3 ka	OSL	B4 East	
	Buff	42 300 ±1 300 BP	^{14}C		
		35.2 ±1.8 ka	OSL		
					LB MOD
					Es; Ore; PB; Ore2
Provisional	RD Black	49.6 ±2.2 ka	OSL	D2 East	Cad; Pu
Provisional	MOD	52.2 ±3.1 ka	OSL	B6 West	
Old C^{14} date	MOD	26 000 ±420 BP	^{14}C		
	O MOD	51.8 ±2.1 ka	OSL		
					G MOD; B MOD
	RSp	53.4 ±3.2 ka	OSL		
					YSp
	BSp	56.7 ±2.3 ka	OSL		
					BSp 2
					SPCA
					BL
	Or	61.5 ±2.2 ka	OSL		
					Mi
	SS	57.0 ±2.3 ka	OSL		Che
					Eb
					Ma; MY
	P	59.6 ±2.2 ka	OSL		Bo; BP; OP; Iv; BM.
					Su
					Ch
					Su2
	Ch2	60.8 ±2.3 ka	OSL		
	Y1	59.0 ±1.9 ka	OSL		
	B/G Mix	58.1 ±2.5 ka	OSL		
					Bor Y Mix
					YA1
Provisional	GR2	62.4 ±3.2 ka	OSL	B5 East	
Provisional	GS	62.4 ±2.5 ka	OSL	B5 East	
Provisional	GS2	60.7 ±2.3 ka	OSL	B5 East	

Table 3.2. Data from palaeoenvironmental proxies, including seeds, phytoliths and macrofauna (Wadley 2004, Schiegl *et al.* 2004, and Plug 2004), respectively.

		SEEDS		PHYTOLITHS		MACROFAUNA	
POST HOWIESONS POORT	FINAL MSA	*MOD*	Evergreen & Deciduous C. mildbraedii, H. caffrum, A. dimidiata, G. occidentalis	Bu	Type II	MOD layers	2 primates and 4 carnivores. Elephant, hippo, rhinocerous. Poss. M*egalotragus priscus* Unknown prob extinct caprine. Burchell's Zebra Med-Lg bovids (esp. lg bovids) Sm bovids rare. Include blue duiker. Turtle (marine). Hinged tortoise = **warm, drier conditions**
		Ore 2 to Co	Deciduous sp. common *G. occidentalis, Z. mucronata, Asparagus* sp.	White lens above Ore (wlao)	Type II		
				Ore hearth	Type I		
		OMOD	Evergreen *C. mildbraedii, H. caffrum, P. longifolia, S. inerme, Asparagus* sp.	OMOD 3	Type II	Below MOD to BL	Greater Variety of species. Include giraffe, more bovid sp. scaly anteater, rodents, birds and reptiles (including crocodile). Similar to Final MSA fauna, but extinct Cape horse, giant buffalo and *Megalotragus* are now present. Med-Lg bovids. Lg Bovids dominant in bovid assemblages. Equids and Suids also present. Marine fish and Molluscs in small numbers. Giraffe = **Dry Savanna conditions** Hinged Tortoise = **Warmer, drier conditions**.

		BMOD – OMOD2	Evergreen: *H. caffrum, S. inerme* Deciduous: *Z. mucronata, O pulchra/ O. arborea, L. lasiantha/Vangueria* sp., *Canthium inerme*	RS p	Type I		
				RS p He art h	Type II		
		BSp - YSp	Wide range of taxa *Acacia* sp., *Euclea* sp., *C. mildbraedii, A. dimidiata, R. rhomboidea, Asparagus* sp., *S. inerme, P. longifolia, O. arborea/O. pulchra, H. caffrum, P. reclinata*	Y Ash under RSp	Type I		
				YS p	Type II		
				BS p	Type I		
		BSP2 - BSp	Forest sp. not very different from today. *Asparagus* sp., *E. emarginatum, A. dimidiata, Euclea* sp. *C. mildbraedii, Acacia* sp., *S. inerme*	W. As h in H2 in	Type II		
				Br/ Bl in H2 in BS	Type I		
				Ch est nut in H2 in	Type II		
				Y/ Or As h in H1 in	Type II		

		Or - SPCA	Evergreen and Deciduous *Asparagus* sp., *Acacia* sp., *E. emarginatum, H. caffrum, P. longifolia, Lagynias* sp./*Vangueria* sp.	SPCA	Type II	MSA Below BL	Species variety less than in either of younger MSA groupings. Lg and Very Lg bovids dominate. Sm. Bovids are least well represented Klipspringer present (needs hills and rocky outcrops). Same extinct large bovids as in younger MSA layers Rodents very rare. Marine molluscs present Giraffe = **Dry, savanna conditions**. Hinged Tortoise = **Warm, Drier conditions**. Conditions possibly **similar to modern day Eastern-Lowveld eg. Kruger National Park**.
		Su2 - Mi	*O. arborea/O. pulchra, Euclea* sp., *Acacia* sp. *Hardy Drought Resistant*	Hea rt in Mi	Type I		
				MY	Type I		
		YA1 – Ch2	Dry Cool and Windy conditions? *E. emarginatum, C. inerme, A. dimidiata, G. occidentalis, Z. mucronata, O arborea/O. pulchra, S. inerme, P. longifolia, R. rhomboidea, Asparagus* sp.	Hearth in Ch2	Type I		
				G	Type I		
				YA	Type II		

Table 6.1. Environmental requirements and preferred habitats of taxa identified through charcoal and seed analyses from Sibudu Cave

Family	**Genus**	**Species**	**Evergreen, Deciduous or Semi Deciuous**	**Requirements**	**Environment**
PODOCARPACEAE	*Podocarpus*	spp.	E	Needs water Tolerates frost	Forest, coast-mountains and forest margins. Occasionally swamp.
ARECACEAE	*Phoenix*	*reclinata*	E	Pioneer, frost tender, needs water	Water course, grassland, forest (can tolerate extreme dry cond.)
MYRICAEAE	*Morella*	*pilulifera*			Mountainous places, among rocks, along streams, on grassy slopes or fringing forest.
CELTIDACEAE	*Celtis*	*africana*	D	Canopy species, hardy, drought resistant	Open forest
	Celtis	*mildbraedii*	E	Canopy species, frost tender, doesn't need much light	Climax forest
MORACEAE	*Ficus*			Shrubs, trees and climbers	Wide range of habitats
OLACACEAE	*Ximenia*		D		Bushveld, coastal bushveld (*X. americana* and *X. caffra* respectively)
ANNONACEAE	*Monanthotaxis*	*caffra*		Climber or shrub, often liane	Coastal scrub and lowland forests. In evergreen forest
LAURACEAE	*Cryptocarya*	spp.	E	Canopy species, half hardy	Forest, riverbanks
MIMOSOIDEAE	*Acacia*	spp.			Wide range of habitats
ERYTHROXYLACEAE	*Erythroxylum*	sp.	E	Sub-canopy species, half hardy	Dry forest, scrub forest
RUTACEAE	*Calodendrum*	*capense*	D, S-D	Med-Lg tree, tolerates frost	Forest, wooded ravines, evergreen fringe forest, occ. in scrub (sea level – 2000m a.m.s.l.)
	Vepris		Var.	Generally small trees with tendency to scramble	Mostly in evergreen environments but var. depending on species. many habitats
KIRKIACEAE	*Kirkia*		D	Tolerates mild frost *(K. wilmsii*.).	Bushveld, rocky outcrops (Limpopo)
ANACARDIACEAE	*Harpephyllum*	*caffrum*	E	Canopy, half hardy	Coastal forest, riverbanks

	Protorhus	*longifolia*	E	Pioneer, Canopy, half hardy, drought resistant	Forest, forest margins
EUPHORBIACEAE	*Drypetes*		E	Var. depending on sp. often understorey	Evergreen forest and coastal forest or more open woodland depending on sp.
BUXACEAE	*Buxus*	sp.		Sm. tree, understorey, tolerates deep shade	Warm valleys, nr sea on coastal dunes *(B. macowanii)* Coastal evergreen forest and bush (*B. natalensis*) also inland outlying populations in Limpopo
CELASTRACEAE	*Cassine*	sp.			Many habitats
ICACINACEAE	*Apodytes*	*dimidiata*	E	Sub-Canopy, Frost Tender, Needs water	Forest, forest margins, many habitats

Table 6.1. Continued

Table 6.1. Continued

Family	***Genus***	***Species***	**Evergreen, Deciduous or Semi Deciuous**	**Requirements**	**Environment**
SAPINDACEAE	*Pappea*	*capensis*	D		Open woodland, riverine fringes, bush clumps and karroid vegetation
	Deinbolia	cf. *oblongifolia*		Slender/spindly tree or small shrub	Coastal open woodland, dune bush and forest. Along riverine fringes and in bush clumps (*D. oblongifolia*) Low alt. mixed woodland, riverine fringes and on rocky koppies (*D. xanthocarpa*)
	Allophyllus	sp.	E	Shrub	Forest, forest margins, bushveld
PTAEROXYLACACEAE	*Ptaeroxylon*	*obliquum*	D (Mostly)	Shrub – Large tree. Can withstand moderate frost. Is tolerant of drought but prefers higher rainfall conditions. Tends to prefer shale or limey soils. Also grows on sandy or rocky ground that is well drained.	Varying habitats. Low altiude woodland and scrub forest (small). Evergreen montane forest in mist-belt (larger)
RHAMNACEAE	*Ziziphus*	*mucronata*	D	Tree, drought resistant	Bush clumps, open woodland, often in alluvial soils along rivers. Variety of habitats
VITACEAE	*Rhoicissus*	*rhomboidea*	E	Liane, understorey, frost tender, needs water	Forest, forest margins
TILLIACEAE	*Grewia*	*occidentalis*	D	Shrub, hardy, needs water. Scrambling small tree and occasionally a climb er in closed evergreen forest.	Forest, forest margins, open woodland, bushveld and thicket
OCHNACEAE	*Ochna*	*pulchra/ arborea*	D	Pioneer, hardy	Bushveld, forest margins in scrub and bushveld, in evergreen forest and bush along streams (*O.*

					arborea) Med.-low alt. open woodland, bushveld, characteristic of rocky sandstone slopes and sandy areas.
FLACOURTIACEAE	*Xylothecca*	*kraussiana*		Shrub or small tree.	On coastal dunes and dune forest, scrub and bushveld, mainly at low altitudes.
MYRTACEAE	*Syzygium*	sp.		Can't withstand severe frost (*S. cordatum*), near water	Varying habitats depending in species
ARALIACEAE	*Cussonia*	*spicata*	E	Shrub, Half hardy	Bushveld, forest margins
CORNACEAE	*Curtisia*	*dentata*	E	Frost Tender, Med-Lg tree	Coastal forest to 1800m a.s.l. (Mountain forest), in evergreen forest, on grassy mountain slopes and in coastal scrub forest, as a small bushy tree.
ERICACEAE	*Erica*	spp.	E (*E. caffra*)	Water	*E. caffra* mountainous ravines, on cliffs, nr. strongly flowing streams
MYRSINACEAE	*Rapanea*	cf. *melanophloeos*	E	Med.-tall tree, Hardy, likes water	In evergreen forest, swamp, riverine fringe forest and occasionally in drier coastal and mountain forests.

Table 6.1. Continued

Table 6.1. Continued

Family	***Genus***	***Species***	**Evergreen, Deciduous or Semi Deciuous**	**Requirements**	**Environment**
SAPOTACEAE	*Manilkara*	sp.			Varying depending on species
	Chrysophyllum	*viridifolium*		Canopy species and emergent tree in coastal forest. Med.-Large tree	Evergreen forest, coastal forest and coastal scarp.
	Sideroxylon	*inerme*	E	Sub-canopy, half hardy, needs water	Dry forest, bush clumps
EBENACEAE	*Euclea*	sp.	E	Shrub, hardy, drought resistant	Many habitats
	Diospyros	sp.			Varying depending on species
BUDDLEJACEAE	*Nuxia*	sp.		Needs plenty of water and is frost tender. (*N. floribunda*)	Coast to med. alt. in evergreen forest, grassland and bushveld, on rocky koppies and in rocky gorges (*N. congesta*). In evergreen forest or at forest margins. (*N. floribunda*). Along rivers and streams, in riverine thicket and among rocks and reeds in the riverbed. (*N. oppositifolia*)
LAMIACEAE	*Clerodendrum*	sp.		Shrubs or small-med. trees. Resistant to salt spray (*C. glabrum*)	Coastal Dunes and evergreen coastal thicket (*C. glabrum*). Forest margins, open woodland and grassland, among rocks, often assoc. with termite mounds and along rivers. (*C. eriophyllum*).
RUBIACEAE	*Vangueria/Lagynias*		D	Shrub	Bushveld, forest margins
	Canthium	*inerme*	D	Shrub, Hardy	Many habitats

ASTERACEAE	*Brachylaena*	*discolor*	E	Shrub or small tree. Drought and frost resistant. Grows in shade or full sun. Prefers sandy to loamy soils. Can withstand coast conditions.	Dunes, coastal forests and associated bushveld. (seldom >2km from sea) – but at inland along rivers (eg. Tongati) and in woodland of low-lying bushveld-savanna.
	Brachylaena	sp.			Varying depending on species
ROSACEAE	*Leucosidea*	*sericea*		Hardy and need damp conditions	Pioneer of mountainsides, kloofs, valley bottoms and along streams at higher altitudes. Notable in Lesotho (most common indigenous tree)
CUNONIACEAE	*Cunonia*	*capensis*	E	Fire-resistant and fast growing, needs moist soil to germinate,	Occurs on stream banks and in moist forest. Abundant in wet, high forest of Knysna. Shrubby in harsher conditions.
ASPARAGACEAE	*Asparagus*	sp.	E	Liane, hardy	Forest, riverine forest

Table 6.1. Continued

Table 6.2. Fragment counts for Howiesons Poort (HP) charcoal identifications (from combined layers, GS, GR2 and GR).

Family	Genus	Species	Type	Fragments
PODOCARPACEAE	*Podocarpus*	spp.		18
RUB/APOC Type 1				18
ASTERACEAE	*Brachylaena*	cf. *discolor*		9
CELASTRACEAE	*Mystroxylon*	cf. *aethiopicum*		6
FABACEAE				3
KIRKIACEAE	*Kirkia*	sp.		3
OCHNACEAE	*Ochna*	sp.		3
PROTEACEAE				2
PTAEROXYLACEAE	*Ptaeroxylon*	*obliquum*		2
BUXACEAE	*Buxus*	sp.		2
RHAMNACEAE	*Ziziphus*	cf. *mucronata*		2
EBENACEAE				2
RUBIACEAE				2
FLACOURTIACEAE				1
STERCULIACEAE				1
EUPHORBIACEAE	*Sapium/Spiros* type			1
EUPHORBIACEAE	*Drypetes*	sp.		1
CORNACEAE	*Curtisia*	*dentata*		1
SAPOTACEAE				1
OLEACEAE				1
LAMIACEAE				1
APOCYNACEAE				1
			87	2
			89	1
			90	3
			91	1
			92	1
			93	1
			95	8
			96	1
			97	1
Unid				20
Totals				120

Table 6.3. Fragment counts for Eb charcoal identifications.

Family	Genus	Species	Type	Fragments
ERICACEAE	*Erica*	*caffra*	B	19
RHAMNACEAE	cf. *Ziziphus*	*mucronata*		11
ANACARD/BURSER				6
ERICACEAE	*Erica*	sp.		4
MYRICACEAE	*Morella*	cf. *pilulifera*		2
PROTEACEAE				2
FABACEAE				2
MIMOSOIDEAE	*Acacia*	spp.		2
CELASTRACEAE	*Mystroxylon*	*cf. aethiopicum*		2
ERICACEAE	*Erica*	sp.	C	2
EBENACEAE	*Diospyros*	sp.		2
RUBIACEAE				2
ASTERACEAE	*Brachylaena*	cf. *discolor*		2
OLACACEAE	*Ximenia*	sp.		1
LAURACEAE				1
ROSACEAE	*Leucosidea*	*sericea*		1
EUPHORBIACEAE	*Bridelia*	sp.		1
SAPINDACEAE	*Deinbolia*	sp.		1
PTAEROXYLACEAE	*Ptaeroxylon*	*obliquum*		1
OCHNACEAE	*Ochna*	sp.		1
COMBRETACEAE				1
MYRSINACEAE	*Rapanea*	*melanophloeos*		1
SAPOTACEAE				1
BUDDLEJACEAE	*Nuxia*	sp.		1
MYRTACEAE			S	4
			AA	1
			BB	1
			CC	1
			DD	1
			EE	1
			FF	1
			GG	2
			HH	1
			II	1
			JJ	1
			Q	2
			R	2
			Si	2
			T	2
			U	2
			V	1
			W	1
			X	2
			Y	2
			Z	2
Unid				18
Totals				120

Table 6.4. Fragment counts for SPCA charcoal identifications.

Family	Genus	Species	Type	Fragments
ERICACEAE	*Erica*	*caffra*	B	33
ANACARD/BURSER				4
MYRICACEAE	*Morella*	cf. *pilulifera*		3
MORACEAE	*Ficus*	sp.		3
ERICACEAE	*Erica*	sp.	C	3
RUBIACEAE				3
PODOCARPACEAE	*Podocarpus*	spp.		2
RHAMNACEAE				2
MYRSINACEAE	*Rapanea*	*melanophloeos*		2
SAPOTACEAE				2
CELTIDACEAE	*Celtis*	*africana*		1
ANNONACEAE				1
LAUREACEAE	*Cryptocarya*	sp.		1
ROSACEAE	*Leucosidea*	*sericea*		1
RUTACEAE	*Calodendrum*	*capense*		1
EUPHORBIACEAE				1
EUPHORBIACEAE	*Sapium/Spiros type*			1
RHAMNACEAE	*Ziziphus*	*mucronata*		1
MYRTACEAE	*Syzygium*	*sp.*		1
SAPOTACEAE	*Sideroxylon*	*inerme*		1
BUDDLEJACEAE	*Nuxia*	sp.		1
LAMIACEAE	*Vitex*	sp.		1
			E	1
			F	3
			G	1
			H	3
			I	1
			J	1
			K	1
			L	5
			M	1
			N	1
			O	1
			P	1
Unid				31
Totals				120

Table 6.5. Fragment counts for BSp charcoal identifications.

Family	Genus	Species	Type	Fragments
ERICACEAE	*Erica*	*caffra*	B	12
FABACEAE				10
MORACEAE	*Ficus*	sp.		6
MIMOSOIDEAE	*Acacia*	spp.		6
OLEACEAE				4
CUNONIACEAE	*Cunonia*	*capensis*		3
RUTACEAE	*Vepris*	sp.		1
LAMIACEAE				3
MYRICACEAE	*Morella*	cf. *pilulifera*		2
CAESALPINIOIDEAE				2
PAPILIONOIDEAE				2
EUPHORBIACEAE				3
BUXACEAE	*Buxus*	sp.		2
RUBIACEAE				2
CELTIDACEAE	*Celtis*	sp.		1
RUTACEAE	*Calodendrum*	*capense*		1
BURSERACEAE				1
PTAEROXYLACEAE	*Ptaeroxylon*	*obliquum*		1
RHAMNACEAE	*Ziziphus*	*sp.*		3
TILLIACEAE				1
MALVACEAE				1
STERCULIACEAE				1
MYRTACEAE	*Syzygium*	sp.		1
MYRSINACEAE	*Rapanea*	*melanophloeos*		1
SAPOTACEAE	*Manilkara*	sp.		1
BUDDLEJACEAE	*Nuxia*	sp.		3
			69	1
			87/69	1
			101	2
			102	4
Unid				38
Totals				120

Table 6.6. Fragment counts for RSp charcoal identifications.

Family	Genus	Species	Type	Fragments
MIMOSOIDEAE	*Acacia*	spp.		10
FABACEAE				9
ANACARD/BURSER				9
RUTACEAE				8
ERICACEAE	*Erica*	*caffra*	B	6
VERBENACEAE				4
RUBIACEAE				4
PROTEACEAE				3
MIMOSOIDEAE	*Albizia*	spp.		3
CAESALPINIOIDEAE				3
SAPOTACEAE				3
EBENACEAE	*Diospyros*	sp.		3
OLACACEAE	*Ximenia*	sp.		2
MIMOSOIDEAE				2
EUPHORBIACEAE				2
COMBRETACEAE				2
OLEACEAE				2
PODOCARPACEAE	*Podocarpus*	sp.		1
MORACEAE	*Ficus*	sp.		1
PAPILIONOIDEAE				1
KIRKIACEAE	*Kirkia*	sp.		1
BURSERACEAE				1
ANACARDIACEAE				1
CELASTRACEAE	Mystroxylon	cf. *caethiopicum*		1
RHAMNACEAE	*Ziziphus*	cf. *mucronata*		1
ERICACEAE	*Erica*	sp.		1
MYRSINACEAE	*Rapanea*	*melanophloeos*		1
BUDDLEJACEAE				1
RUB/APOC				1
			102	1
			104	1
			105	1
Unid				30
Totals				120

Table 6.7. Fragment counts for OMOD charcoal identifications.

Family	Genus	Species	Type	Fragments
FABACEAE				27
EUPHORBIACEAE				9
MIMOSOIDEAE	*Acacia*	spp.		7
MIMOSOIDEAE				4
CELTIDACEAE	*Celtis*	sp.		3
ERICACEAE	*Erica*	*caffra*	B	3
MIMOSOIDEAE	*Albizia*	spp.		2
ANACARDIACEAE				2
RHIZOPHORACEAE				2
LAMIACEAE				2
PROTEACEAE				1
ANNONACEAE				1
CAESALPINOIDEAE				1
CAESALPINOIDEAE	cf. *Burkea*	*africana*		1
CAESALPINOIDEAE	cf. *Afzelia*	sp.		1
PAPILIONOIDEAE	cf. *Erythina*	sp.		1
MELIACEAE				1
CELASTRACEAE	*Mystoxylon*	sp.		1
RHAMNACEAE	*Ziziphus*	sp.		1
MALV/TILL				1
APIACEAE	cf. *Heteromorpha*	*arborescens*		1
ERICACEAE	*Erica*	spp.		1
BUXACEAE	*Buxus*	sp.	76	1
OLEACEAE				1
BUDDLEJACEAE				1
APOCYNACEAE				1
RUB/APOC				1
RUBIACEAE				1
			66	2
			67	1
			68	1
			69	4
			70	1
			71	7
			72	1
			73	1
			74	1
			75	1
			77	1
			78	1
			79	3
			80	1
			81	1
			82	1
			83	1
			84	1
			85	2
			86	1
Unid				8
Totals				120

Table 6.8. Fragment counts for MOD charcoal identifications.

Family	Genus	Species	Type	Fragments
FABACEAE				13
MIMOSOIDEAE	*Albizia*	spp.		9
ANACARD type 1				8
SAPOTACEAE				8
RUTACEAE				6
EUPHORBIACEAE	*Sapium/Spiris type*			6
MIMOSOIDEAE				5
MIMOSOIDEAE	*Acacia*	spp.		5
ANACARDIACEAE				5
EUPHORBIACEAE	*Drypetes*	sp.		5
CAESALPINOIDEAE	*Burkea*	*africana*		4
OLEACEAE				4
LAMIACEAE				4
TILLIACEAE				3
EUPHORBIACEAE				3
CUNONIACEAE	*Cunonia*	*capensis*		2
PAPILIONOIDEAE				2
CELASTRACEAE	*Mystroxylon*	sp.		2
STERCULIACEAE				2
CORNACEAE	*Curtisia*	*dentata*		2
PROTEACEAE				1
ANACARD/BURSER				1
EUPHORBIACEAE	*Bridelia*	sp.		1
EUPHORBIACEAE	*Macaranga*	cf. *capensis*		1
SAPINDACEAE	*Pappea*	*capensis*		1
RHAMNACEAE	*Ziziphus*	sp.		1
FLACOURTIACEAE				1
ERICACEAE	*Erica*	spp.		1
MYRSINACEAE	*Rapanea*	*melanophloeos*		1
EBENACEAE	*Diospyros*	sp.		1
BUDDLEJACEAE	*Nuxia*	sp.		1
			71	3
			87/69	2
			106	1
			107	1
			108	3
			109	1
Unid				0
Totals				120

Table 6.9. Fragment counts for Bu charcoal identifications.

Family	Genus	Species	Type	Fragments
ASTERACEAE	*Brachylaena*	sp.		15
ANACARD/BURSER				9
FABACEAE				5
MIMOSOIDEAE	*Acacia*	spp.		5
CELASTRACEAE	*Mystroxylon*	*aethiopicum*		3
ERICACEAE	*Erica*	spp.		3
LAMIACEAE	*Clerodendrum*	*glabrum*		3
FLACOURTIACEAE	*Xylothecca*	*kraussiana*		2
RUB/APOC				2
ARECACEAE	cf. *Phoenix*	*reclinata*		1
PAPILIONOIDEAE				1
KIRKIACEAE	*Kirkia*	sp.		1
SAPOTACEAE				1
RUBIACEAE				1
			53	2
			54	1
			55	7
			56	1
			57	1
			58	1
			59	1
			60	1
			61	2
			62	1
			63	1
			64	4
			65	1
			KK	1
			LL	1
			MM	2
			NN	1
			OO	1
			PP	1
			QQ	1
			RR	1
			SS	1
			TT	4
			UU	2
			VV	1
			WW	1
			XX	1
			YY	1
			ZZ	1
Unid				23
Totals				120

Table 7.1. Eigenvalues of the Correlation Matrix. Column 5 shows the cumulative percentage contribution of each factor to the data.

Eigenvalues of the Correlation Matrix					
Factors	Eigenvalue	Difference	Proportion	Cumulative	Cumulative Percentage
F1	7.965701	1.637023	0.3186	0.3186	31
F2	6.328679	2.833503	0.2531	0.5718	57
F3	3.495175	0.566613	0.1398	0.7116	71
F4	2.928562	0.797454	0.1171	0.8287	83
F5	2.131108	0.417097	0.0852	0.914	91
F6	1.714011	1.277247	0.0686	0.9825	98
F7	0.436764	0.436764	0.0175	1	100

Table 7.2. Factor Pattern with values less than 0.3 and greater than –0.3 blanked out. Negative Values highlighted.

	F1	F2	F3	F4	F5	F6
ERICACEAE	-0.48096	-0.82657				
FABACEAE	0.7209		0.4065	-0.39794		0.38721
MIMOSOIDEAE *Acacia*	0.80366			-0.45887		
ASTERACEAE	-0.45573	0.56759		-0.35939	-0.41804	-0.40041
PODOCARPACEAE	-0.49678	0.71511				
CELASTRACEAE	-0.37304	0.89364				
MIMOSOIDEAE *Albizia*	0.82527			0.45889		
RUTACEAE	0.73233		-0.54919			
LAMIACEAE	0.85732				0.40903	
CAESALPINOIDEAE	0.97124					
MIMOSOIDEAE	0.8841					0.36212
MORACEAE		-0.52018	0.45235		0.53407	-0.45328
PROTEACEAE		0.4157	-0.6617		0.42707	0.4057
EUPHORBIACEAE1	0.48775			0.71805	-0.46114	
MYRICAEAE	-0.50207	-0.79589				
PAPILIONOIDEAE	0.77118		0.38599			-0.45727
MYRSINACEAE		-0.77364		0.54808		
CELTIDACEAE		-0.31426	0.56842	-0.47621		0.50539
BUXACEAE		0.40591	0.6989		0.54417	
STERCULIACEAE		0.59839	0.39161	0.68335		
PTAEROXYLACEAE	-0.60116	0.50547			0.41351	
OCHNACEAE	-0.58562	0.68821				
OLACACEAE			-0.83805		0.48268	
KIRKIACEAE		0.68028	-0.46049			-0.35884
ROSACEAE	-0.55037	-0.65544				0.3009

Table 7.3. Factor Loadings for Factor 1 (**F1**) before varimax rotation was applied. (Taxa ordered from highest to lowest Factor Loadings)

Taxa	**Factor Loading**
Caesalpinioideae	0.97
Mimosoideae	0.88
Lamiaceae	0.86
Mimosoideae *Albizia*	0.8
Mimosoideae *Acacia*	0.82
Papilionoideae	0.77
Rutaceae	0.73
Fabaceae	0.72
Euphorbiaceae 1	0.49
Celastraceae	-0.37
Asteraceae	-0.45
Ericaceae	-0.48
Podocarpaceae	-0.49
Myricaceae	-0.5
Rosaceae	-0.55
Ochnaceae	-0.58
Ptaeroxylaceae	-0.6

Table 7.4. Factor Loadings for Factor 2 (**F2**) before varimax rotation was applied. (Taxa ordered from highest to lowest Factor Loadings)

Taxa	**Factor Loading**
Celastraceae	0.89
Podocarpaceae	0.71
Ochnaceae	0.69
Kirkiaceae	0.68
Sterculiaceae	0.6
Asteraceae	0.57
Ptaerocylaceae	0.5
Proteaceae	0.41
Buxaceae	0.4
Celtidaceae	-0.31
Moraceae	-0.52
Rosacaea	-0.65
Myrsinaceae	-0.77
Myricaceae	-0.79
Ericaceae	-0.83

Table 7.5. Factor Loadings for Factor 3 (**F3**) before varimax rotation was applied. (Taxa ordered from highest to lowest Factor Loadings)

Taxa	Factor Loading
Buxaceae	0.7
Celtidaceae	0.57
Moraceae	0.45
Fabaceae	0.41
Sterculiaceae	0.39
Papilionoideae	0.38
Kirkiaceae	-0.46
Rutaceae	-0.55
Proteaceae	-0.66
Olacaceae	-0.84

Table 7.6. Factor Loadings for Rotated Factor 1 (**RF1**) (after varimax rotation was applied). (Taxa ordered from highest to lowest Factor Loadings)

Taxa	Factor Loading
Ericaceae	0.92
Myricaceae	0.89
Rosaceae	0.88
Myrsinaceae	0.87
Moraceae	0.38
Papilionoideae	-0.35
Fabaceae	-0.41
Celastraceae	-0.49
Mimosoideae *Acacia*	-0.5
Asteraceae	-0.6
Kirkiaceae	-0.66

Table 7.7. Factor Loadings for Rotated Factor 2 (**RF2**) (after varimax rotation was applied). (Taxa ordered from highest to lowest Factor Loadings)

Taxa	Factor Loading
Euphorbiaceae 1	0.96
Mimosoideae *Albizia*	0.95
Mimosoideae	0.76
Caesalpinioideae	0.7
Sterculiaceae	0.66
Lamiaceae	0.65
Rutaceae	0.62
Papilionoideae	0.54
Myricaeae	-0.31
Ericaceae	-0.34
Asteraceae	-0.36

Table 7.8. Factor Loadings for Rotated Factor 3 (**RF3**) (after varimax rotation was applied). Taxa ordered from highest to lowest Factor Loadings.

Taxa	Factor Loading
Ochnaceae	0.93
Ptaeroxylaceae	0.93
Podocarpaceae	0.9
Buxaceae	0.7
Celastraceae	0.68
Sterculiaceae	0.66
Proteaceae	0.32
Papilionoideae	-0.37
Mimosoideae *Acacia*	-0.58