Woody taxa from charcoal in Sibudu's Middle Stone Age Hearths

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DECLARATION

I declare that this thesis is my own unaided work. It is being submitted for the Degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Name:  Sandra J. Lennox, Johannesburg

Date: 9th September, 2016

ABSTRACT

Sibudu rock shelter was occupied by hunter gatherer groups of modern humans during the Middle Stone Age between 77 and 38 000 (38 ka) years ago. Sibudu is in the summer rainfall region and is situated about 15 km inland of the eastern coast of South Africa. The site includes technological industries such as Still Bay and Howiesons Poort that are distinguished by specific stone tool types. Woody taxa identified from archaeological charcoal in this site, indicate changes in vegetation and wood use. Archaeological charcoal specimens, specifically from hearths on three putative occupation floors, were analysed for behavioural information about wood selection and use. Two of the stratigraphic layers, BYA2 (i) and SPCA, are approximately 58 ka old and the MOD layer is approximately 49 ka old. All three layers contain tools from the post-Howiesons Poort industry. Identifications of woody taxa were made by means of a comparative charcoal reference collection and the InsideWood database. Charcoal was studied under stereo and reflective light microscopes. Woody taxa identified confirmed that the coldest, driest phase of occupation was at approximately 58 ka. Bushveld woods, including five *Acacia* types, have been identified in charcoal from MOD layer, ~49 ka. The vegetation mosaic was different from today's coastal forest and savanna near Sibudu. The availability of natural wood around Sibudu, visible in the type of wood burnt in hearths, has changed since 58 ka and 49 ka for either climatic or anthropogenic reasons or for a combination of these. In all three layers, the wood bundles include tinder, fuel, and a selection of woody plants that today are known to have medicinal bark, leaves and wood. People may have selected wood for burning properties (for example, temperature, light and coal production) and for medicine. Woods suitable for making firesticks for starting fires by means of friction are present. Wood from *Spirostachys africana* (tambotie) occurs in one hearth in each of the three layers. Since *Spirostachys africana* is normally avoided in cooking fires as it is poisonous, this suggests that the wood was selected deliberately and burnt for insecticidal smoke or other medicinal purposes. *Tarchonanthus parvicapitulatus* (syn. *T. camphoratus*) charcoal occurred in layer SPCA. This adds to the previous evidence of the use of aromatic plants at Sibudu, where sedge bedding was topped with aromatic, insecticidal *Cryptocarya woodii* (river-quince) leaves (Wadley *et al*. 2011. Science 334 (6061): 1388-1391). Wood use is different between hearths and surrounding sediments and between occupations dating 58 ka and 49 ka.

Keywords: phytomedicine, Sibudu, *Spirostachys africana, Acacia,* charcoal analysis, wood anatomy

ACKNOWLEDGEMENTS

I thank Christine Sievers who introduced me to Sibudu rock shelter with the sedge bedding, medicinal leaves and charcoal. I thank Lyn Wadley for accepting my request to do a PhD, for enabling me to study Sibudu charcoal. I thank Marion Bamford who agreed to supervise this anthracology research project and for enabling technology. I thank my husband Pat and family for loving support. I thank the Sibudu team for excellent research material, expertise and high standards. I thank friends and colleagues of the Evolutionary Studies Institute, ESI and Centre of Excellence, CoE, Palaeontology at University of the Witwatersrand, WITS, for facilitating essential microscopy. This anthracology project was made possible by timeous NRF-funding and by timely grants from PAST-Scatterlings and from both supervisors at different times. I thank the editors and reviewers of SAAB and SAJS for assessing submitted manuscripts critically, enabling publication and leading to this final result. I thank previous teachers, Jennifer Thomson and Ed Rybicki, in addition to Kobus Eloff and Hannes de Lange for research on the association of people and plants via micropropagation and molecular biology. The results and interpretation of this work are however, my responsibility. I am inspired by the prayer of St. Francis of Assisi, patron saint of animals and the environment.

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NOMENCLATURE

MSA: Middle Stone Age

ka: a thousand years

BYA2(i): Brown Under Yellow Ash (i)

SPCA: Spotty Camel

MOD: Mottled Deposit

IAWA: International Association of Wood Anatomists

Unique anatomical features refer to anatomical, IAWA features

Restricted or unique woods are restricted in distribution, occur in only one hearth, in one hearth and in sediment, only in sediment and may be unique to a layer

Rarely found woods are restricted in distribution and occur in only one hearth

Folk medicine refers to herbal medicine used as a traditional remedy for a medical or health ailment in modern times, in this case African traditional medicine

CHAPTER 1
INTRODUCTION

1.1 Background

The rock shelter is set in a low cliff above the uThongathi River which flows east towards the KwaZulu-Natal coast 15 km away (Fig. 1.1). Sibudu is an archaeological site with deposits from before 77 ka to approximately 39 ka. The sequence has yielded artefacts such as stone and bone tools, yellow and red ochre, bone points, a plentiful supply of seed, charcoal, phytoliths and some pollen, in addition to an assemblage of bones from mammals and birds (Wadley 2006, 2015).

More than one hundred publications have been produced about the human behaviour and environment since the site was excavated by a team led by Prof Lyn Wadley, University of the Witwatersrand, Johannesburg, and is currently being led by Prof Nicholas Conard, University of Tübingen. Technology such as evidence of hafting, and a milk and ochre paint are evidence of complex cognition (Wadley 2015). The ages of the layered sediments (Fig. 1.2) excavated in the rock shelter derive from single- grain OSL (optically stimulated luminescence) dating (Jacobs *et al*. 2008a, b; Wadley 2015: 165).

A combination of the identified charcoal and seed taxa has shown an environment of mostly evergreen trees from before 60 ka, whereas from ~58 ka there was less evergreen forest and more savanna and from ~49 ka there was more bushveld (Allott 2006). The seeds have shown a shift from evergreen to deciduous vegetation (Sievers 2006). A GIS-based Coexistence Approach (CA_{GIS}) climate study of seeds and charcoal showed that temperatures cooled at ~58 ka from before 60 ka, then warmed to ~49 ka (Bruch *et al*. 2012). A multiproxy record from fauna, charcoal, seed, phytoliths, pollen and from the stable isotopes of charcoal has shown an increase in savanna at the expense of forest from the Howiesons Poort (HP), 65-62 ka, to the post- Howiesons-Poort, 58 ka (Hall *et al.* 2014). A study of the fauna has shown a similar shift from the Howiesons Poort to the post-Howiesons Poort (Clark 2013; Dusseldorp 2014).

The Sibudu layers are characterised by hearths visible in the sequence as ash deposits of red burnt layers, black centres and white top (Wadley 2012a). A study of campfires from Sibudu has shown that the hearths do differ in the types of fires burnt there (Bentsen 2012, 2013,
2014 a,b).

Sibudu rock shelter has sedge bedding from the Middle Stone Age (MSA). Nutlets from sedges have been identified as *Scleria natalensis*, *S. melanomphala* and *Cladium mariscus* (Miller and Sievers 2012; Sievers 2013a, b; Sievers and Muasya

2011). The discovery of bedding adds to our knowledge about the behaviour of people who lived at Sibudu (Wadley *et al*. 2011), bearing in mind that chimpanzees make beds (van Lawick-Goodall (1971) and birds use aromatic plants in nests, for example, starlings use marigolds. The sedge bedding was burnt from the time of the pre- Still Bay technocomplex at ~73 ka (Wadley *et al.* 2011). Fossilized leaves were found layered on top of the bedding which was not burnt, from ~77 000 years ago. These aromatic *Cryptocarya woodii* leaves are known to be insecticidal and are the earliest known use of a medicinal plant (Wadley *et al.* 2011).

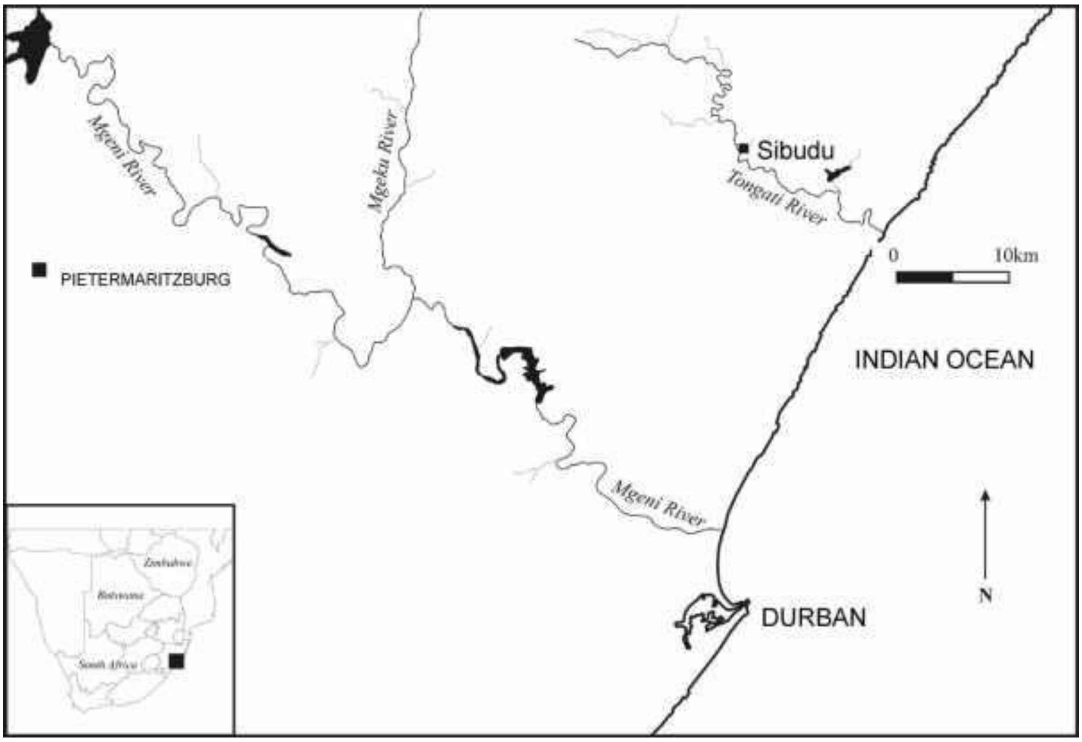

Figure 1.1: Location of Sibudu rock shelter (after Wadley 2006).

The sedge bedding and medicinal leaves suggested that there may be more herbal medicines (Wadley 2012b). The *Spirostachys africana* charcoal had tentatively been found in the charcoal assemblage (Allott 2006; Wadley 2013). This was unusual as the smoke is known to cause nausea and food poisoning (Wink and Van Wyk 2008) and would therefore not be used for cooking fires (Wadley 2013b). The charcoal is easily confused with *Sclerocroton integerrimus* (also Euphorbiaceae), a tree from the area which does not produce poisonous smoke when burnt. Using poison requires evading self-poisoning and utilizing small quantities so as not to inflict harm.

The hypothesis is that people collected wood deliberately for a purpose and that this would show in the wood burnt in the hearths (Fig. 1.2). People of the MSA selected wood for their burning properties such as temperature, coal formation, the amount of light produced and medicinal properties (Abbott *et al.* 1997; Gelabert *et al*. 2011; Shackleton 1993; Shackleton and Prins 1992). The primary aim was to examine and identify the charcoal from Sibudu concentrating on all hearths within three layers from the last Glacial, from Hearth 1 in BYA2(i) and SPCA from early and late 58 ka and MOD from approximately 49 ka (Allott 2006; Miller and Sievers 2012; Sievers 2013; Wadley and Jacobs 2006; Wadley *et al*. 2011), to discover whether specific wood types were associated with individual hearths across a single occupation floor. On the one hand, if all the hearths contained the whole range of woods identified in charcoal from one layer, then the wood may have been indiscriminately collected from that which was available nearby. On the contrary, if individual taxa were solely burnt in one of the hearths, then it would seem that the wood was deliberately selected for particular plant properties.

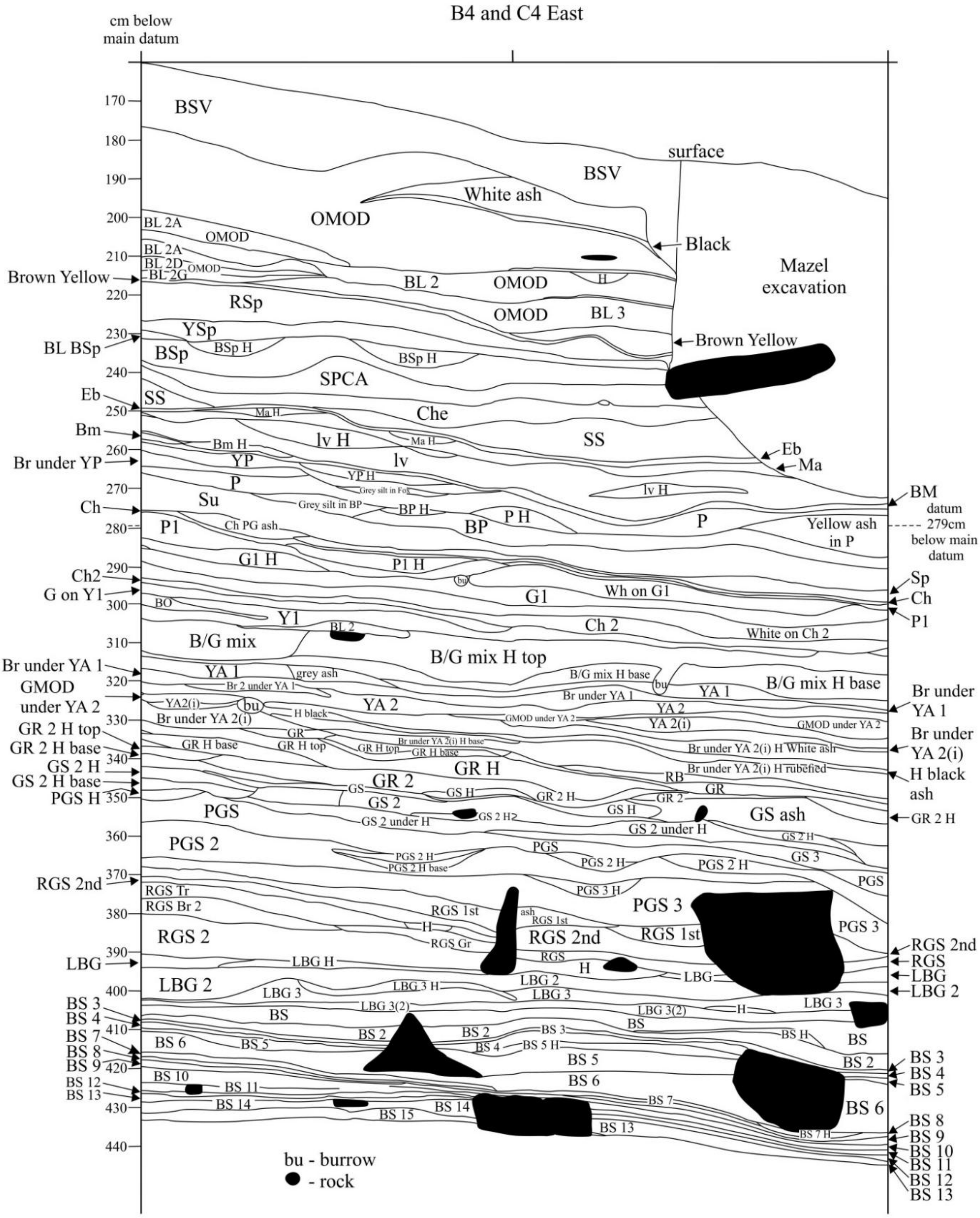

Figure 1.2: Stratigraphy of Sibudu east wall squares B4 and C4 (figure courtesy of L. Wadley), the stratigraphy of the north wall squares B5 and B6 is further along in chapter 7.

The objectives were to look in depth at hearths in selected occupations of Sibudu, to investigate which types of firewood were burned in single hearths by means of charcoal analysis and discover whether people were using different types of fires in different parts of the shelter. The wood burning properties and possible medicinal use of the plants were assessed from the literature (Appendix D; Venter and Venter 2012) and linked to possible activities that took place around the hearths. Accidental use of small quantities is precluded for the poisonous *Spirostachys africana.* A comparison was made to discover whether species diversity in the hearths differed significantly from that in the surrounding sediments sampled by Allott (2004, 2005, 2006). The data were tied into changes in vegetation due to climate through time (Allott 2004, 2005, 2006; Boon 2010; Hall *et al*. 2014; Lennox *et al*. 2015; Scholes *et al*. 2015; Sievers 2006; Val 2014; Van Wyk and Van Wyk 2013; Wadley 2004, 2006b, 2013a; Wadley and Jacobs 2006).

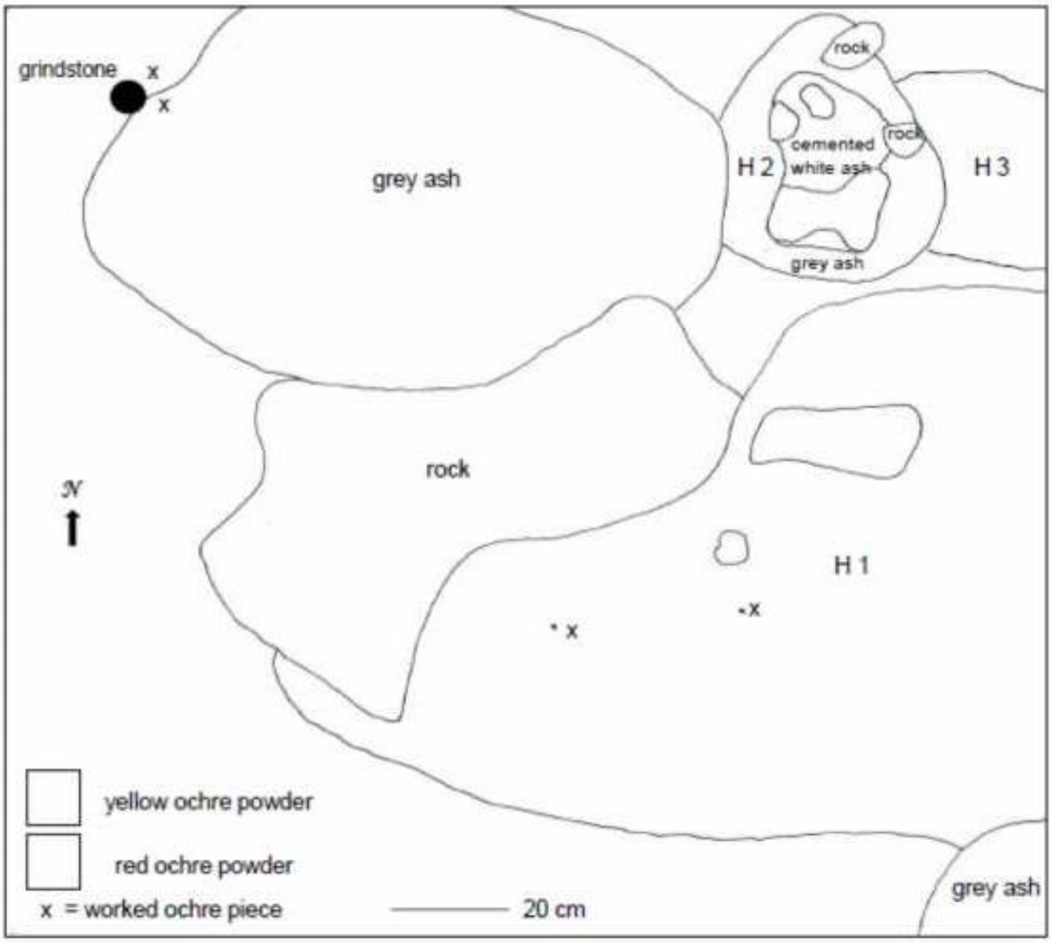

Figure 1.3: Brown under Yellow Ash 2(i) occupational floor showing the relative position of three hearths in a portion of each of squares B4 and C4 (figure courtesy of L. Wadley).

The significance of this study is to discover how people of the Middle Stone Age used firewood when they visited Sibudu, to learn about their technological development during the post-Howiesons Poort in contrast to the earlier occupations, and to contribute to an understanding of complex cognition, as well as to find out about the environment they lived in during MIS 3 in contrast to MIS 4 (Allott 2006; de la Peña 2015; Hall et al. 2014; Dusseldorp 2014; Wadley 2013a). The ability to use herbal medicines has a long history in antiquity, for example the use of *Cryptocarya woodii* insecticidal leaves (Wadley *et al*. 2011), the poisonous smoke (Allott 2006; Lennox and Bamford 2015; Wadley 2012b, 2013b, 2015) and latex in arrow poison (Bradfield *et al*. 2015; Wadley *et al.* 2011) from *Spirostachys africana*. The study of the structure of campfires and associated activities at Sibudu (Bentsen 2012, 2013, 2014a, b) is a study of an aspect of culture and contributes to an understanding of what makes us modern humans. Comparing the woody taxa from the layers during the MIS 3 with those presently near Sibudu suggests those which are lost for environmental reasons such as a change in climate and those which may be lost due to anthropogenic disturbance such as habitat destruction due to logging, farming, hunting or another unknown reasons (Dusseldorp 2014; Hadly 2015; Hoffman 2003; Potts 2013; Scholes *et al*. 2015).

Anthracology is the study of charcoal by referring to wood anatomy **(**Metcalfe and Chalk, 1950; Jane 1970; Cutter 1971; Carlquist 1975; Kromhout 1975; Schweingruber 1990; Ilic 1991; Desch and Dinwoodie 1996; Evert and Esau, 2006; Neumann *et al*. 2000). The anatomical features of archaeological charcoal are recorded according to the IAWA (International Association of Wood Anatomists) *List of Microscopic Features for Hardwood Identification* (Wheeler *et al*. 1986; Wheeler *et al.* 1989). Early studies of archaeological charcoal differed over the feasibility of anthracology being used to study prehistoric environments (Couvert 1968, 1976; Godwin and Tansley 1941; Momot 1955; Salisbury and Jane 1940; Santa 1961) and this debate slowed the application of the technology (Tusenius 1986). Methods in anthracology have been developed by Western (1971), Leney and Casteel (1975), Barefoot and Hankins (1982), Figueiral and Mosbrugger (2000) and Neumann (1989). A succession of improvements has been made by anthracologists such as Asouti and Kabukcu (2014), Chrzazvez *et al*. (2014), Dotte-Sarout *et al*. (2015), Gonçalves *et al*. (2012), Hubau *et al.* (2012, 2013, 2014), Py *et al*. (2013), Scheel-Ybert *et al*. (2003, 2007, 2014), Théry-Parisot (2001, 2002), Théry-Parisot *et al*. (2010 a, b), Théry-Parisot and Henry (2012,2014) and Scheel-Ybert (2000, 2001, 2002), including studies into pedo-anthracology as reviewed by Nelle *et al.* (2013). Charcoal studies have shown the use of fuel and the past environment (Asouti and Austin 2005; Asouti 2012; Byrne *et al.* 2013; Cartwright 2013; Chikumbirike 2014; Dotte-Sarout *et al.* 2014; Esterhuysen and Mitchell 1996; Höhn *et al.*2008; Hubau *et al.* 2014; Py *et al*. 2013; Scheel-Ybert *et al*. 2007; Théry-Parisot and Henry 2014; Vogelsang *et al*. 2010; Wadley *et al.* 1993; Wadley and Laue 2000). Anthracology in South Africa has been developed over time by studies which include those by Deacon (1983), Scholtz (1986), Tusenius (1986), Esterhuysen and Mitchell (1996), Cartwright and Parkington (1997), February (2000), Allott (2004, 2005, 2006), Cartwright (2013), Backwell *et al*. (2014), Chikumburike (2014) and Bamford (2015a, b). Factors which influence anthracology include charcoal preservation, fragmentation and wood collecting strategies. Charcoal identification is affected by preservation and these physical aspects include cracks (Théry-Parisot and Henry 2012), diagenesis, shrinkage (Gonçalves *et al*. 2012; Bamford and Henderson 2003) and vitrification.

Figure 1.4: Hearth 1 base in Brown under Yellow Ash, BYA2(i). In addition to Hearth 1, charcoal was identified from two of the other hearths and from the ash dumps. Scale: B6=1m^2. Note the burnt sedge culms, ochre, bone and flake (Bentsen 2014b, Wadley 2012a; figure courtesy of L. Wadley).

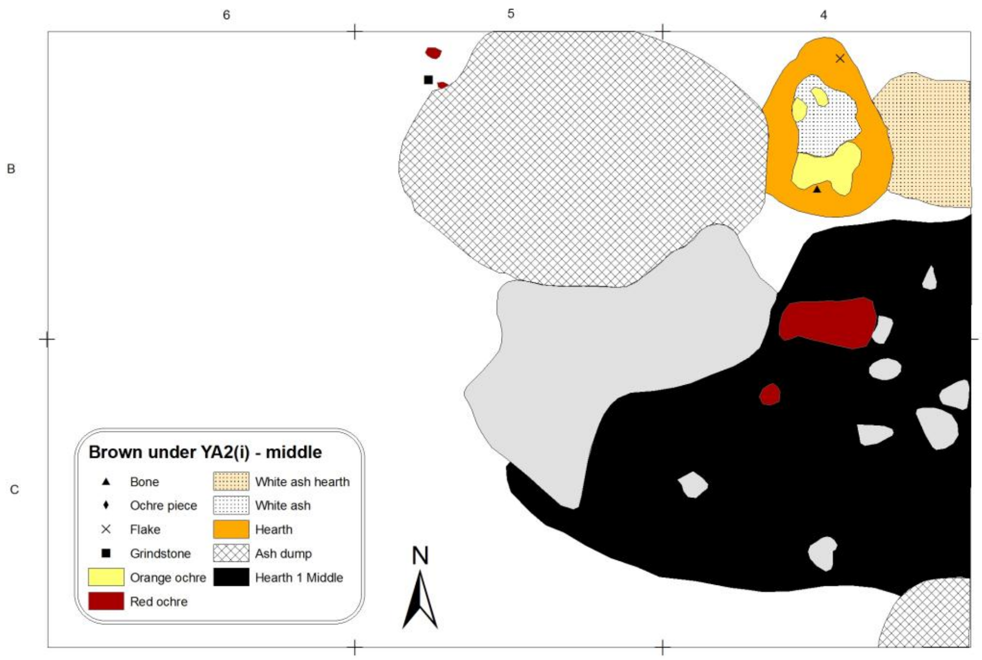

Figure 1.5: Brown under Yellow Ash, BYA2(i), Hearth 1 middle. Scale: B6=1m^2 (Figure: L. Wadley).

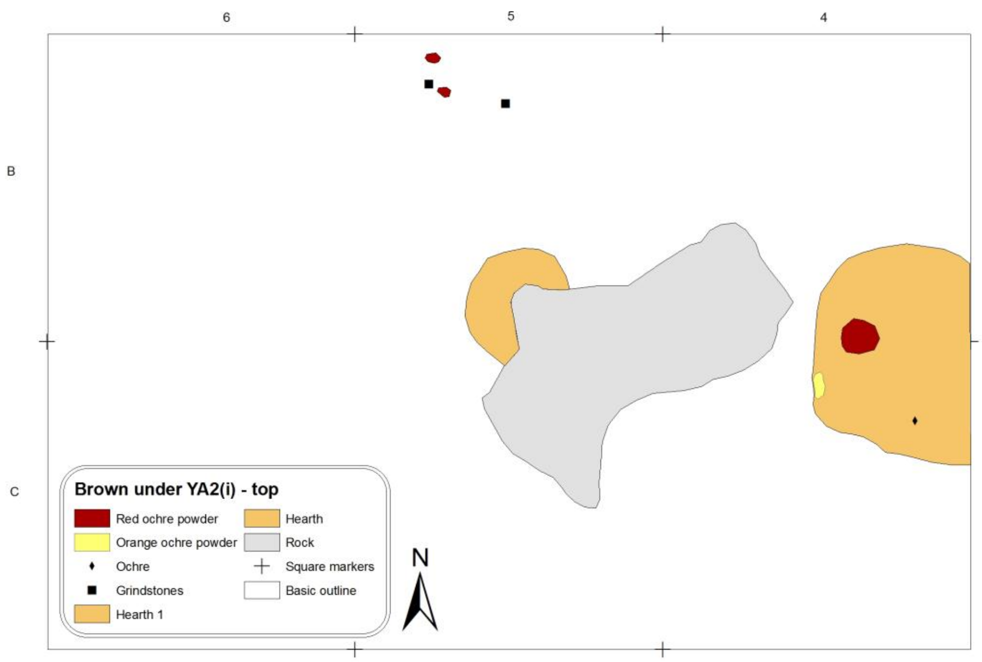

Figure 1.6: Brown under Yellow Ash, (BYA2(i), Hearth 1 top. Scale: B6=1m^2 (Figure: L. Wadley).

Table 1.1: The layers at Sibudu layers with cf. *Spirostachys africana* and *Cryptocarya sp.* The BYA2(i), SPCA and MOD layers are shaded.

Table 1.1 A: Sibudu layers with cf*. Spirostachys africana*

Layer	Age	Charcoal pieces	Hearths in layer
BYA2(i)	Somewhere between 62 and 58 ka	2	3
SPCA	~58 ka (top)	1	5
MOD	~49 ka	6	4

Table 1.1 B: Sibudu layers with *Cryptocarya* sp.

Layer	Age	Charcoal pieces	Hearths in layer
BS6	~77 ka	1	1
LBG 3	~73 ka	1	-
RGS 2	~71 ka	2	-
BYA2(i)	Somewhere between 62 and 58 ka	2	3
Black under Br Grey Mix	~58 ka (top)	7	6
SPCA	~58 ka (top)	1	5

1.2 Thesis outline

Charcoal was identified from hearths in three Sibudu layers. The charcoal examined and identified for this study was from BYA2(i) (Brown under Yellow Ash 2(i)) layer ~58 ka lower, SPCA (Spotty Camel) ~58 ka upper and MOD (Mottled Deposit) ~49 ka (Table 1). These three layers were selected for study since *Spirostachys africana* charcoal had been tentatively identified in charcoal from sediments in them together with *Cryptocarya* sp. from BYA2(i). These are medicinal plants and there may be others amongst the charcoal in hearths on these layers (Allott 2006; Bradfield *et al*. 2015; Wadley 2012 b, 2013 b; Wadley *et al*. 2011; Wadley 2015). There are areas in the study of charcoal from Sibudu where more detail has been required. Hearth charcoal and certain layers, such as BYA2(i) to G1 which give the coldest geomagnetic signal (Herries 2006; Pickering 2006) were not examined by Lucy Allott (2005). The study to examine and identify woods of a selection of Sibudu's charcoal in hearths extends anthracology research and utilises the modern charcoal reference collection (Allott 2005, 2006).

Brown under Yellow Ash 2(i) is the oldest layer in the post-Howiesons Poort sequence at Sibudu (Wadley 2012a; Wadley and Jacobs 2006). It has not been dated, but occurs between GR2, with an age of 61.7 ± 2.0 ka and layer B/G Mix with an age of 58.2 ± 2.4 ka (Jacobs *et al*. 2008 a, b; Wadley 2015: 165). The layers are visible in the diagrammatic representation of the stratigraphy of the east wall of squares B4 and C4 (Fig.1.1). The Munsell Chart reading of Brown under Yellow Ash 2(i) is 5 YR 3/2 greyish-brown, which describes the dominant matrix colour without taking into account the mottling. The bright, unusual sediment colours, partly due to specific burnt wood as well as gypsum, iron and manganese occur in all the layers with ages of ~58 ka and younger (Schiegl and Conard 2006; Wadley and Jacobs 2006). The hearth shape is flat, and consists of white ash, partly cemented black center, and rubefied base (Bentsen 2014b; Wadley 2012a). SPCA layer is spotted with ash and gypsum, it is a distinct camel-coloured brown. The Munsell Chart reading of 10YR 5/4 yellowish-brown describes the dominant colour without mottling. MOD layer, 49.1 ±2.5 ka has mottled brown, silty sand with flecks and nodules of white ash, gypsum and charcoal (Wadley and Jacobs 2006; Wadley *et al*. 2011).

Three hearths in BYA2(i) are included in this study. The charcoal had been excavated from Hearth 1 base, light base, middle and top, from the ash dump and ash heap and from sediments adjacent to Hearth 1. Hearth 1, the largest hearth in BYA2(i), has a rubefied base, black ash centre and white ash top. Hearth 1 is truncated by the section wall in Squares B4 and C4 (Wadley 2012a). Based on the excavated area, Hearth 1 is likely to span approximately 350 x 300 cm, with a depth of 12 cm. The white ash is slightly acidic, pH 6.08 and the black hearth centre is slightly more so, pH 5.83 (Wadley 2012a). Hearth 1 has a large flat rock at its north- western boundary. On the north-eastern edge of the hearth is a patch of red powdered ochre. This is associated with a polished and worked red ochre piece. The ochre is buried within the black base of the hearth. Nearby was a piece of giraffe-sized tibia and a patch of carbonized culms (Wadley 2012a). Based on its size, Hearth 1 may have been reused several times, perhaps after raking out old ash and coals. If this is the case, it would explain the ash dumps adjacent to it. A micromorphological block, about 15 cm wide, was removed from the south wall of square C4, and analysed by Christopher Miller. His conclusion was that at least part of what was called Hearth 1 during excavation is, in fact, burnt bedding because stratified layers of burnt phytoliths resemble burnt layers of monocotyledonous plant material (Wadley *et al*. 2011). It is therefore recognised that the combustion feature labelled Hearth 1 (base, middle and top) may represent a complex set of behaviours (Bentsen 2014). Hearth 2 is 4 cm deep, with an area of 60 x 40 cm. It is only a few centimetres away from Hearth 1. This suggests that it may be associated with the larger combustion feature, possibly as a special purpose working area, and perhaps used only for a short time only. The white ash surface is partly cemented. There is powdered orange ochre on this hard surface. Fragments of bone that have taken on an orange colour lie under the hearth. Hearth 2 is represented by charcoal from the base, orange base and top. Hearth 3 is even smaller and more ephemeral. Other BYA2(i) hearths, not studied here, include a large hearth in C6 which has been truncated by the section wall and smaller hearths in B6, which appear to be sheltered by large rocks on the western side of the excavation grid. The five hearths from SPCA are described in chapter 6 and four hearths from MOD (Lennox et al. 2015) are described in chapter 7, though not studied as extensively as Hearth 1 from BYA2(i) (Bentsen 2014b; Wadley 2012a).

A detailed charcoal anatomical study was done to distinguish *Spirostachys africana* from *Sclerocroton integerrimus* and *Shirakiopsis elliptica* (Lennox and Bamford 2015). The noxious fumes would have had a knock-down effect on insects (Allott 2006; Wadley 2013b). A detailed anatomical study of a selection of woody Asteraceae from KZN was done to distinguish *Tarchonanthus parvicapitulatus* from *Brachylaena discolor*.

The charcoal was identified from all hearths from BYA2(i), SPCA and MOD. The distribution of woods in each layer was assessed. The woods with a restricted distribution were noted. The possible uses were suggested, particularly for woods with restricted distribution and especially those with aromatic smoke from plants with medicinal bark or wood. The vegetation around Sibudu for BYA2(i), SPCA and MOD was described. Woods which no longer occur near Sibudu and which may have been lost for environmental reasons were noted. Woods which no longer grow near Sibudu but which continue to grow in nature reserves and in ravines nearby were noted as these may have been lost for anthropogenic reasons to the influence of land disturbed by human activity such as farming, logging or other unknown activities. The succession of vegetation from BYA2(i), SPCA and MOD was compared to previous studies of the past environment from charcoal, a multi-proxy study and from a study of fauna from the Howiesons Poort, MIS 4 to the post-Howiesons Poort, MIS 3 (Allott 2006; Bruch *et al.* 2012; Clark 2013; Clark and Plug 2008; Dusseldorp 2014; Hall *et al.* 2008; Hall *et al*. 2014; Val 2014; Wadley 2006).

1.3 History and status of the study

Sibudu at 29.522627°S, 31.085895°E has been the subject of multidisciplinary research for more than a decade. Behavioural innovations, expansions of modern humans within and out of Africa and occasional population bottlenecks occurred during the Middle Stone Age (Wadley *et al*. 2011). Modern human populations expanded and moved out of Africa approximately 80 to 60 ka as one of several waves of migration that began before a million years ago. This MSA migration has been tentatively linked to people who made Still Bay and Howiesons Poort industries, characterised by certain styles of tools as well as symbols and personal ornaments. These two industries may have been relatively short lived (5000 years or less) and were separated by about 7000 years (Jacobs *et al*. 2008a, b). The context of this work is what is known about patterns of behavioural change in Africa and Eurasia during the Middle and Late Pleistocene (Ambrose 2001; Conard 2005; Deacon and Deacon 1999; Klein and Edgar 2002). Technological progression as humans adapted to their environment (d'Errico *et al.* 2008; Henshilwood *et al*. 2002, 2004, 2011; Marean *et al*. 2012; Wadley *et al*. 2009, 2011; Wurz 2013) may indicate growing behavioural complexity (Ambrose 2010; Shea 2011; Tattersall 2009) and complex cognition (Wadley 2013b, 2015).

Complex cognition describes the competency of *Homo sapiens* in the MSA (Wadley 2015: 157). Attributes of complex cognition appear in the African MSA record as part of an adaptive process. The action requires the ability to innovate through multi-tasking or the use of an analogy (Wadley 2013b, 2015). A milk and ochre paint applied to surfaces from 49 000 years ago suggests a source of milk which predated the cattle of pastoralists (Villa *et al*. 2015). Compound adhesives made from red ochre mixed with plant gum were used as adhesives to haft handles onto stone tools in the MSA at Sibudu (Wadley *et al.* 2009). The qualities and use of ochre have been studied by Hodgskiss (2010, 2012a, 2012b, 2013). Several lithic studies at Sibudu reveal change through time (Cochrane 2006; de la Peña 2015 a and b; de la Peña and Wadley 2014 a and b; de la Peña *et al*. 2013) for example the use of crystal quartz backed tools (Delagnes *et al*. 2006) and ochre hafted points (Lombard 2006 a; b) that were used as hunting weapons (Lombard and Phillipson 2010; Villa and Lenoir 2006). The *Scleria natalensis*, *S. melanomphala* and *Cladium mariscus* sedge bedding is an indicator of the human behaviour involved in collecting the sedge stems from the river, carrying these up to the rock shelter (with mud still attached proving that these were collected and not blown into the site), laying the stems down to sleep, work and eat upon, with stone tools and bones remaining on the surface of the bedding (Miller and Sievers 2012; Sievers 2013 b; Wadley *et al*. 2011). Contingency planning which requires thinking in advance and delayed gratification includes the use of insecticidal plant leaves on sedge bedding (Wadley *et al*. 2011, Wadley 2013b) and the use of toxic smoke or wood to repel insects (Allott 2006; Lennox and Bamford 2015; Wadley 2013b: 167, Wadley 2015). Aromatic *Cryptocarya woodii* leaves found on top of sedge bedding (*Scleria natalensis* and *S. melanomphala*) at approximately 77 ka indicated early use of medicinal plants as an insecticidal compound (Wadley *et al*. 2011). There may be more evidence of medicinal plant use at Sibudu.

There is an archaeo-botanical record for Sibudu from charcoal (Allott 2004, 2005, 2006), seeds (Scott (Sievers) 2005; Sievers, 2006; Sievers, 2011; Sievers and Muasiya 2011; Wadley 2004; Wintjes and Sievers, 2006), pollen (Renaut and Bamford 2006) and phytoliths (Schiegl and Conard 2006; Schiegl *et al*. 2004; Wadley *et al*. 2011). There have been studies on the past climate (Bruch *et al*. 2012; Hall *et al*. 2008; Hall *et al*. 2014; Herries 2006), geology (Pickering 2006) and the chemical composition of the sediments excavated (Schiegl and Conard 2006) at Sibudu. Environmental data have also been produced on changes in vegetation and mammal communities (Reynolds 2006) and on fauna (Cain 2006;

Clark 2009, 2011, 2013; Clark and Plug 2008; Wadley *et al.* 2008), micromammals (Glenny 2006), aquatic animals (Plug 2006) and birds (Val 2014).

The Howiesons Poort technocomplex at Sibudu is ~65–62 ka, during Marine Isotope Stage 4 (MIS) and the post-Howiesons Poort is ~58 ka, during MIS3, during the last Glacial period (Dusseldorp 2014; Jacobs *et al.* 2008 a, b; Wadley 2013a, 2015: 165; Wadley *et al.* 2011). Marine Isotope (MIS) Stages 8-2 are a series of cooling and warming trends from ~291 ka to ~24 ka. MIS 4 was a cool temperature regime concurrent with Mount Toba volcano super-eruptions and associated with the Still Bay and Howiesons Poort technocomplexes which included marine shell beads, diverse bone tools, compound adhesives and engraved eggshell. MIS 3 was a cool temperature regime with warm oscillations associated with the post-Howiesons Poort technocomplexes and possible *Homo sapiens* migrations out-of-Africa (Martinson *et al*. 1987; Shackleton *et al*. 2003; Svensson *et al*. 2008; Wadley 2015).

Many hearths are present at Sibudu (Wadley 2006, 2012a). A hearth is a primary feature. It is generally comprised of an upper layer of ash which is usually white and a middle layer of organic matter which is usually a blackish stratum rich in charcoal. The lower layer of heat- affected, rubefied sediment is often not present. Hearths are domestic fireplaces associated with cooking and other activities (Bentsen 2014; Dibble *et al*. 2009; Schiegl *et al*. 1996). An ash dump is a secondary deposit, a mixture of ash, charcoal and burnt bone, usually grey and is associated with site maintenance such as scraping out ash from hearths (Goldberg *et al*. 2009). An ash feature is rich in ash, similar to an ash dump, associated with site maintenance and badly preserved hearths (Goldberg *et al*. 2009). Combustion features and their uses at Sibudu, between ~65 and ~58 ka have been studied by Wadley (2012a) and Bentsen (2012, 2013, 2014 a, b) and selected Sibudu layers in which described hearths occur are discussed. The quality of fires in hearths determined by the type of wood identified there has been investigated by experimenting with burning properties of woods (Braadbaart *et al.* 2009; Munalula and Meincken 2009). During the MSA wood fires are ubiquitous (Bentsen 2013, 2014 a).

Charcoal fragments may be interpreted in different ways. Fragments may be interpreted as a measure of the volume of species of wood (Asouti 2006; Chabal 1990, 1992, 1997; Chabal *et al* 1999; Figueral 2005; Théry-Parisot *et al*. 2010b) and the comparative proportion of species in the assemblage. This approach seems to be most apparent in regions of low biological diversity, for example where approximately 30 to 40 woody taxa may be identified in a charcoal assemblage from the Pleistocene (Théry-Parisot *et al.* 2010b). On the contrary, as has been done in this study, fragments may be interpreted as a measure of the presence or absence of species of wood. This approach seems to be apparent in a region with high biological diversity on account of varying densities. Studies which take this approach include southern African studies by Scholtz (1986), Tusenius (1986), Esterhuysen and Mitchell (1996), Cartwright and Parkington (1997), February (2000), Allott (2004, 2005, 2006), Cartwright (2013), Backwell *et al*. (2014), Chikumburike (2014), Bamford (2015 a, b) and Lennox et al. (2015). In this instance, wood logs from different species may burn down to fragments and ash or just to ash depending on the wood densities (Chrzazvez *et al.* 2014).

Wood collecting strategies which influence the wood diversity represented in the charcoal, inferred from archaeological studies of prehistory (Asouti and Austin 2005; Shackleton and Prins 1992; Théry-Parisot *et al*. 2010 b) may not be directly extrapolated from wood collecting in modern times. In addition to this, the historical use of traditional fuel or medicinal plants does not necessarily indicate the pre-historical use of the same product or method. It is difficult to ascertain whether or not people knew about these plant attributes or even if some knowledge had been lost, for example the glue, adhesives and poisons on Ju/'oan weapons (Wadley *et al.* 2015) or the combinations of plants used in the recipes for Bushman arrow poison (Bradfield *et al.* 2015). Nevertheless, the factors which affect firewood management (societal and natural) and the differential preservation of charcoal (sediment, settlement, society and climate) have been modeled to show the flow of resources in apparent archaeological ecosystems (Théry-Parisot *et al*. 2010 b). According to the Principle of Least Effort (PLE) people collected wood from the nearest area making use of what was available (Shackleton and Prins 1992). Studies of the current fuel collection strategies inform a general understanding of wood collection in prehistory, for example, rural villagers such as in the Fang villages of Equatorial Guinea, central Africa (Gelabert *et al*. 2011), in the Lowveld of South Africa (Shackleton 1993), in Botswana (Tietema 1991) and in Malawi (Abbott *et al.* 1997) where certain woods are preferred, considered good wood or even avoided. The concept of good fuel wood is considered to be modern. In this study, selecting wood for burning properties for particular hearths is tested as explained earlier (Cunningham 2001; Wheeler *et al*. 1989; Lennox et al. 2015; Wadley 2013b). As can be seen from the models of firewood management and charcoal preservation, which include wood collecting strategies, there are many reasons for the charcoal to be present in the sediments, so other hypotheses remain to be tested.

The wood burning properties of woods differ in that some woods burn hotter or longer than others. The energy content of wood is determined by the density, elemental composition and the amount of ash remaining after the wood has burnt away (Munalula and Meincken 2009). Fuel wood is primarily energy efficient, producing hot coals with little smoke and leaving very few ash remnants (Munalula and Meinken, 2009). Wood density affects the burning properties of indigenous southern African woods, as high density woods produce most energy, having a high calorific value, MJ/kg which is a measure of how hot the wood burns (Appendix D; Munalula and Meincken 2009). Low density or light wood is approximately 500 to 650 kg/m^3 , medium density/ heavy wood is approximately 700 to 850 kg/m^3 and heavy or dense wood is approximately 850 to 1 100 kg/m^3 (Venter and Venter 2002). Low density woods include *Cussonia spicata* of ~500 kg/m^3, *Ficus burkei* of 510 kg/m^3, *Ficus ingens* of 570 kg/m^3 and *Kirkia acuminata* of 640 kg/m^3. Medium density woods include *Acacia karoo* of 800 kg/m^3, *Pterocarpus rotundifolius* of 848 kg/m^3, *Rapanea melanophloeos* of 737 kg/m^3, *Syzigium cordatum* of 750 kg/m^3 and *Ximenia caffra* 830 kg/m^3. Dense woods include *Acacia caffra* of 980 kg/m^3, *Acacia nilotica* of 1 100 kg/m^3 and *Acacia tortillis* of 990 kg/m^3 in addition to *Gardenia volkensii* of 880 kg/m^3, *Mimusops zeyheri* of 850 kg/m^3, *Nuxia floribunda* of 994 kg/m^3, *Olea africana* of 1 100 kg/m^3, *Pappea capensis* of 864 kg/m^3, *Peltophorum africanum* of 912 kg/m^3, *Ptaeroxylon obliquum* of 1 040 kg/m^3, *Searsia lancea* of 1 040 kg/m^3, *Searsia leptodictya* of 1 010 kg/m^3, *Spirostachys africana* of 960 kg/m^3 and *Ziziphus mucronata* of 888 kg/m^3. The families of plants could collectively represent types of fuel wood.

In addition to taxonomy, the calibre of wood collected affects the wood burning properties, for example green and wet or dry wood, rotten or fresh wood, branch or trunk wood (Munalula and Meincken 2009; Théry-Parisot and Henry 2012; Wheeler et al. 1989). Presently, dry wood is used for cooking fires (Rodin, 1985).

The wood use categories in this thesis are based on the literature about wood burning properties and medicinal plants which were then linked to possible activities that took place around the hearths, recognizing that most woods could be used as fuel wood but most woods would not be burnt for medicinal purposes. In the previous charcoal analysis at Sibudu approximately half of the woody taxa represented fuel wood (Allott 2006; Wadley 2006). In the literature woods have multiple uses. The preferred use as fuel is not necessarily recorded so the dense, fine grained woods with narrow, long plant fibres favoured by wood carvers and which tend to be used as sticks, handles and boards, are noted as good fuel woods as the denser woods tend to produce good burning coal. Fuel woods may be determined culturally by people relying on natural resources who are able to recognise burning properties (Cunningham 2001), supported by the characteristics such as the type of ash produced by a burning stick listed amongst the identifying IAWA features used by wood anatomists (Wheeler *et al*. 1989).

Tinder woods were those which would preferentially be used for kindling or tinder and would ignite quickly, mostly from shrubs less than 3 m high or from softwood for example *Afrocarpus*/ *Podocarpus* spp. which are tall trees, higher than 15m (Appendix D).

Firesticks of particular species may be used to start fires by rolling a long, thin drill-stick (45 cm x 1 cm) in a notch made in the short, thick base-stick (23 cm x 1 cm), until a glowing ember forms. Grass kindling enables the spark to catch alight (Dee 1925; Van Wyk and Gericke 2000). Dry, friable woods are selected as firesticks and the type of wood favoured varies between regions (Dee 1925), for example a *Grewia flava* drill stick used with *Commiphora schimperi* base stick by !Kung San in Namibia (Marshall 1976; Lee 1979).

The wood use category of medicinal wood includes plants with medicinal or poisonous properties. Plants with medicinal bark, wood or leaves may be burnt for aromatic smoke, although little is known about the aromatic smoke from medicinal plants. Most phytomedicines are from medicinal bark, few are from medicinal wood (Appendix D). Plants with volatile and essential oils may produce aromatic smoke, for example *Tarchonanthus* species wood and leaves are burnt for camphor smoke, although charcoal is not direct evidence of leaves having been burnt for smoke. The aromatic smoke from burnt *Cryptocarya liebertiana* bark is inhaled. *Gardenia volkensii* smoke may be used as a fumigant. *Curtisia dentata* and *Dombeya rotundifolia* have medicinal bark. *Calodendrum capense* has medicinal seed oil. Snuff may be made from the bark of *Dalbergia obovata* which also has antiseptic, aromatic leaves. *Nuxia floribunda* has medicinal bark. *Commiphora marlothii* and *Commiphora harveyi* have aromatic resin. Myrrh is produced from *Commiphora myrrha*. *Ptaeroxylon obliquum* wood may be used as an insect repellent.

The wood use category of plants with poisonous properties include, *Croton sylvaticus* with analgesic bark, *Protorhus longifolia* with aromatic bark and leaves for aromatic smoke, *Hippobromus pauciflorus* with strongly aromatic leaves when bruised or crushed, and wood that when burnt may produce aromatic smoke (Appendix D). Finally, the *Spirostachys africana* tree and its wood are dangerous to work with, but useful in small quantities (Allott 2006; Bradfield *et al.* 2015; de la Peña 2015; Lennox and Bamford 2015; Lennox *et al*. 2015; Van Wyk *et al.* 2002; Wadley 2013 a and b, 2015; Wadley *et al.* 2015; Wink and Van Wyk 2008). Other uses of medicinal plants, for example seed oil (eg from *Pappea capensis)*, latex for bird lime (eg *Ficus lutea)* and antiseptic latex for eyes *(eg Sclerocroton integerrimus*)*,* have been set aside, to focus on the plants which may have produced aromatic smoke.

The palaeoenvironment associated with Sibudu has been described as the past vegetation communities were studied by means of the charcoal by Lucy Allott (2004, 2005, 2006). The pioneering anthracological study included charcoal in sediments from GS (Grey Sand), GR2 (Grey Rocky 2) and GR (Grey Rocky) from pre-60ka, Eb, SPCA and BSp, (approximately 58ka), RSp, OMOD and MOD (approximately 49ka), in addition to Bu (approximately 38ka) (Allott 2006; Jacobs et al. 2008 a, b; 2015: 165). This revealed vegetation change of woody plants as the climate changed and sea levels shifted. The charcoal in the shelter deposits indicated wood use by the people who visited and occupied the site during the MSA (Allott 2006; Wadley 2006)

At Sibudu, during the Howiesons Poort (HP) occupations, pre-60 ka, there was an evergreen forest including *Podocarpus* sp., *Buxus* sp., *Brachylaena* sp., *Spirostachys africana, Sclerocroton integerrimus (*syn*. Sapium integerrimum), Shirakiopsis elliptica* (syn. *Sapium* ellipticum) and *Ptaeroxylon obliquum*. A warm, woodland savanna beyond the forest vegetation is indicated by *Kirkia* sp. Woody taxa identified in charcoal from layers older than 60ka, GS , GR2 ,and GR , included *Brachylaena* spp*., Buxus* sp*., Curtisia dentata, Drypetes* sp*., Kirkia* sp*., Mystroxylon* cf*., aethiopicum, Ochna* sp*., Podocarpus* spp*., Ptaeroxylon obliquum, Ziziphus* cf. *mucronata*, in addition to charcoal representing the Apocynaceae, Ebenaceae, Fabaceae, Flacourtiaceae, Lamiaceae, Oleaceae, Proteaceae, Rubiaceae, *Sapium/Spirostachys* type, Sapotaceae and Sterculiaceae (Allott, 2006). The identification of 65 seeds from YA2 to G1, lower ~58 ka, included 31 Type 5 (cf. *Olea* sp.) and 16 Cyperaceae and as well as *Asparagus* sp., *Euclea* sp., *Grewia* sp., *Pavetta* sp., *Protorhus longifolia*, *Searsia* sp., *Sideroxylon inerme* and cf., *Erythroxylum emarginatum* (Sievers 2006: 207).

This was followed ~58 ka ago, by an evergreen, riverine forest including *Erica* spp, *Leucosidea sericea* and *Rapanea melanophoeos.* This shift in vegetation may have been due to a lowered sea level and slightly cooler climates enabling vegetation from the mountain foothills to grow closer to the rock shelter than at present. Woods were previously identified from charcoal in similarly aged layers, Eb, SPCA and BSp (Allott 2006), from ~58 ka, which are stratigraphically younger than BYA2(i) (Jacobs et al. 2008 a, b; Wadley 2015: 165). The river probably flowed at ~58 ka because taxa preferring riverine habitats such as *Erica caffra, Leucosidea sericea* and *Syzigium* sp. were present (Allott 2006). In addition to habitats near running water, the trees at ~58 ka represented evergreen forest (*Buxus* sp*., Cryptocarya* spp., *Cunonia capensis, Morella* spp., *Podocarpus* spp. and *Rapanea melanophloeos*), forest margins and open woods (*Brachylaena* sp*., Bridelia sp., Diospyros sp., Morella pilulifera, Mystroxylon aethiopicum, Nuxia sp., Sideroxylon inerme, Vepris sp., Ziziphus* spp.), deciduous forest (*Calodendrum capense, Celtis africana, Deinbollia* sp*., Ficus* sp*., Ptaeroxylon obliquum, Ximenia sp.*) and bushveld (*Acacia* sp*., Nuxia* spp. and *Vitex* spp.) (Allott 2006). The 57 seeds identified from layers BL, Or (Black Lens/Orange) and SPCA, ~58 ka, were mostly Cyperaceae nutlets (28) and *Asparagus* spp. seeds (24). In addition, *Calodendrum capense*, *Cordia* cf. *caffra*, *Grewia* sp., *Olea* sp., *Pavetta* spp. and *Protorhus longifolia* were represented (Sievers 2006: 207). Seeds can enter an archaeological site through a variety of non-human and human agents, whereas the presence of charcoal is more likely to reflect the anthropogenic selection of woody material. Seed taxa richness increases considerably in younger layers like SPCA compared with the older ones (Sievers 2006), but these upper layers yielded an immense volume of deposit and large sample sizes. Bushveld taxa common today in northern, drier regions of South Africa seem to have replaced evergreen forest around Sibudu ~49 ka ago. More charcoal pieces of *Acacia* species; *Fabaceae* taxa and fewer *Erica* species were found in these layers. This may have been due to environmental conditions, but could also have been due to a change in wood selection by Sibudu occupants or charcoal fragmentation (Allott 2006).

A GIS-based Coexistence Approach (CA_{GIS}) analysis made use of the seed and charcoal data to make a climatic interpretation (Bruch *et al*. 2012). The CA_{GIS} analysis of archaeobotanical material demonstrated that the post Howiesons Poort, ~58 ka, was cooler than the late MSA, ~49 ka, especially during winter (Bruch *et al.* 2012). Concurrently, summer precipitation was marginally less than during the late MSA, with more open vegetation than the late MSA. The seasonal precipitation parameters produced by the CA_{GIS} implied that the wet season, summer, was drier than today, with more open vegetation than today (Bruch *et al*. 2012). The precipitation near Sibudu is linked to Indian Ocean sea surface temperatures (Chase 2010). The CA_{GIS} results are supported by isotope data from *Podocarpus* charcoal collected from layer SPCA at Sibudu (Hall *et al.* 2014).

Acacia, Afrocarpus/Podocarpus, Erica may indicate conditions of the environment and anthropogeny. The past vegetation and environment within the home range of Sibudu are indicated by the firewood (Allott 2006; Wadley 2006). The occurrence of charcoal from *Afrocarpus/Podocarpus* spp. and *Acacia* spp. were mutually exclusive in the early study of archaeological charcoal from Sibudu (Allott 2006; Wadley 2006). Charcoal was identified as *Podocarpus* spp. from GS, GR2 and GR (Grey Sand, Grey Rocky 2 and Grey Rocky) older than 60 ka, SPCA ~60 ka and RSp (Red Speckled) ~50 ka (Allott 2006; Jacobs et al. 2008 a and b; Wadley 2015: 165). Seed fragments were identified as *Afrocarpus falcatus* in layers Su (Sulphur) to Mi (Midnight) from ~60 ka (Sievers 2006: 207; Jacobs et al. 2008 a and b; Wadley 2015: 165). Charcoal was identified as *Acacia* spp. from Eb and BSp ~60ka, from RSp, OMOD and MOD ~50ka and from Bu ~37ka (Allott 2006; Jacobs et al. 2008 aand b; Wadley 2015: 165). Trees such as *Afrocarpus/Podocarpus* spp. which no longer occur at Sibudu suggest an environment different from today, though it is possible that the timber was overexploited in the last century. Although *Erica caffra* has been identified in charcoal from Sibudu (Allott 2006) in Eb, SPCA and BSp from ~ 58 ka, RSp and OMOD from ~ 49 Ka (Allott 2006; Jacobs et al. 2008 a and b; Wadley 2015: 165), it does not occur in the modern day vegetation at Sibudu. Woody taxa which occur in nearby nature reserves and ravines suggest an anthropogenic disturbance (Hoffman 2003; Jonas *et al.* 2006; Rouget *et al.* 2006), for example *Erica caffra* in the Karkloof (Boon 2010).

Modern vegetation from the escarpment to the coast, where Sibudu rock shelter is situated, represents the Forest (Mucina and Geldenhuys 2011), Indian Ocean Coastal Belt (Mucina *et al*. 2011) and the Savanna Biome (Rutherford *et al*. 2006). The Forest Biome includes plants representing the Afrotemperate, Subtropical, Scarp and Northern Coastal Forest vegetation units (Mucina and Geldenhuys, 2011). The Indian Ocean Coastal Belt (Subtropical Coastal Forest Biome) includes the KwaZulu-Natal Coastal Belt Forest (Mucina *et al*. 2011). The Savanna Biome includes plants from the Savanna Lowveld and Sub-Escarpment, for example the KZN Sandstone Sourveld and the Ngongoni Veld (Rutherford *et al*. 2011).

The Forest Biome consists of Afrotemperate, subtropical and azonal forest. The trees are evergreen, vary in height and composition and exist in scattered patches along the East Coast of Southern Africa. There are 12 vegetation units including Afrotemperate, Scarp, Southern Mistbelt and Northern KZN Coastal Forest. The forest patches are affected by climate and fire. There are three hydrophilic, edaphic, azonal forest types. The forests exist on steep slopes and the transition between forest and other biomes is sharp (Neumann and Bamford 2015). The species diversity and past expansion and contraction are caused by landscape (Geldenhuys 1997), climate change and fire (Neumann and Bamford 2015). The mist precipitation along the Great Escarpment and some exposed mountain ranges as well as in protected kloofs and along rivers supplements rainfall (Von Malitz *et al*. 2003) and high winds may cause trees to fall, causing gaps in the forest (Mucina and Geldenhuys, 2011: 593). Forest patches may survive in fire-prone ecosystems (Bond *et al*. 2003b), including the Grassland and Savanna (Geldenhuys 1994b). Drought and fires lit in coastal grasslands may increase inflammability (Geldenhuys 1994b). Changes in substrate properties, between boulder screes on steep slopes in deep kloofs supporting afro-temperate forest and the surrounding vegetation, Fynbos, Savanna or Grassland may be a factorfor survival of forest patches in a fire prone landscape (Musina and Geldenhuys, 2011: 590).

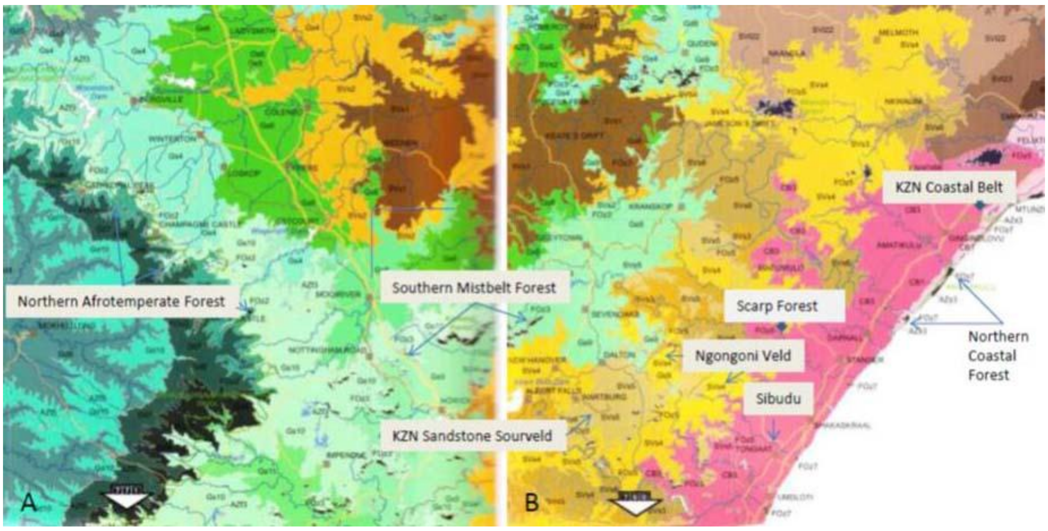

Figure 1.7: Vegetation map of the Forest and Savanna Biomes: A. Northern Afrotemperate Forest on the higher Drakensberg slopes and Southern Mistbelt Forest in the foothills. B. Closest to Sibudu, which is 15 km from the coastline, are the KZN Coastal Belt and Scarp Forests with Ngongoni Veld and Sandstone Sourveld Savanna. Note the grid 29° to 30°S and 30 to 32°E. Scale: 1 cm to 30 km. (Map: after Mucina and Rutherford 2011: 778–779).

Plants from the Afrotemperate and Southern Mistbelt Forests occur in the Montane, Subalpine and Alpine Belt vegetation of the Drakensberg (Boon 2010; Killick 1990; Mucina and Geldenhuys 2011). The Montane Belt vegetation from the valley floors to lowermost cliffs includes grassland, bracken-veld, scrub, *Protea* savanna and forest. The Subalpine Belt includes grasslands, bracken-veld, *Protea* savanna and stream-bank communities, outcrop vegetation and subalpine Fynbos. The Alpine Belt vegetation includes aquatic, hygrophilous vegetation, outcrop vegetation, alpine grassland and alpine heath (Killick, 1990). In the Montane Belt boulder bed scrub occurs in river-beds. Montane Belt Forest is limited, particularly in the colder and drier Southern Drakensberg. The Forest patches are triangular, and may join to form a longitudinal gorge on the southern, eastern or south-eastern aspect of slopes, where the conditions are moist, with adequate protection from wind and fire. Forests occur in streambanks in kloofs, gorges and on slopes and consist of a dominant tree layer (12-22 m high), a small tree layer (4-6m high), a shrub layer (up to 3m high), a field layer of herbs and ferns, a layer of mosses, epiphytes, climbers and bamboo (Killick, 1990: 30-31). The climbers may be showy, less showy or colourful and rare. The subalpine belt extends from the edge of the Little Berg to just below the summit of the Drakensberg where *Protea* are restricted to koppies and stony ridges, up to 2 135m, protected from fire affects density (Killick, 1990: 28).

The Scarp forest is an archipelago of forest patches which remain along the narrow steps of the Escarpment. It was formerly a continuous belt of forest in the warm-temperate biome. The forest patches are surrounded by various temperate biomes, such as the Savanna or Grassland (Mucina and Geldenhuys 2011: 587). The trees collect when dispersal corridors along mountain chains, escarpments and river valleys meet, which determines the variety of woody plants in the forest (Geldenhuys 1992a, 1997a). The Scarp Forest species diversity is high and there are a number of endemic rich Scarp Forests (Mucina and Geldenhuys 2011: 591). The KwaZulu-Natal Coastal Forests and Pondoland Scarp Forest have a high frequency of woody species (254-338 species)(Mucina and Geldenhuys, 2011: 589) and a high proportion of endemic plants (Van Wyk and Smith, 2001). There are endemic rich subtropical scarp forests on Msikaba sandstones in Umtumvuna River gorge near Port Edward (southern KwaZulu-Natal; Mucina and Rutherford, 2011). The Scarp Forest species diversity is high and there are a number of endemic rich Scarp Forests (Mucina and Geldenhuys, 2011: 591). The KwaZulu-Natal Coastal Forests and Pondoland Scarp Forest have a high frequency of woody species (254-338 species; Mucina Geldenhuys, 2011: 602).

The Indian Ocean Coastal Belt (IOCB) or Coastal Subtropical Forest Biome (Moll and White, 1978; Huntley, 1984) was probably dominated by a subtropical forest (Mucina and Geldenhuys, 2011: 587). The rainfall is even in the north, with higher summer rainfall in the south, 819-1272 mm. Maputaland-Pondoland is a global centre of vascular plant diversity. The Maputaland region was submerged ~ 10 Ma. The Maputaland Group started with Miocence-Pliocence beach and dune facies and terrigenous fossils are missing for this period as a regression followed during the Pliocene (Porat and Botha 2008). The submerged landmasses were uplifted during the Neogene (Mucina *et al.* 2011). Although erosion by the Agulhas current hampers studies of climate variations along the eastern and southern coast, Neumann and Bamford (2015) tentatively suggest that the warm current created a warm subtropical and humid climate at the coast of eastern South Africa similar to that of today.

Although *Acacia* spp. are presently considered to be characteristic of savanna bushveld in the northern part of the country, *Acacia robusta* occurs near Sibudu in the river valleys and wooded grassland (Appendix E; Boon 2010; Sievers 2013). *Acacia natalitia* and the biogeographically important taxon at the southern limit of its distribution, *Acacia nilotica* ssp. *kraussiana*, occur in the KZN Coastal Belt Forest (Boon 2010; Mucina *et al.* 2011: 578). There are three Acacia species - *A. natalitia, A. nilotica* and *A. sieberiana* – in the Savanna Ngongoni Veld (Mucina *et al.* 2011: 578). *A. ataxacantha, A. karoo, A. kraussiana* and *A. schweinfurthii* occur in nature reserves in the vicinity of Sibudu (Boon 2010; Sutherland 2014) and could possibly continue to grow near Sibudu, possibly lost to land disturbed by human influence. *A. kosiensis* and *A. kraussiana* occur in the Coastal Forest in the region and the distribution is not in the vicinity of Sibudu (Boon 2010). *Acacia* is typical of the bushveld and savanna in the northern part of the country (Mucina and Rutherford 2011; Scholes 1997). In response to the revision of the genus *Acacia* a group of South African plant taxonomists (Kyalangalilwa *et al.* 2013) have renamed most of the *Acacia* species with an African distribution. These include *Vachellia* (formerly in subgenus *Acacia*), *Senegalia* (formerly in subgenus *Aculeiferum*), *Acaciella* (formerly in subgenus *Aculeiferum* section Filicinae) and *Mariosousa* (formerly in the *A. coulteri* group). The results reinforced the inevitability of recognizing separate genera for *Acacia*. and new combinations for the African species in *Senegalia* and *Vachellia* were formalized. In this thesis the name *Acacia* has been retained. It is interesting to note that Robbertse *et al*. (1980) grouped the *Acacia* into two groups, subgenera *Acacia* and *Aculeiferum* according to the wood anatomy and that Neumann *et al.* (2000) utilise anatomical features including ray width in cell number, ray height and frequency as distinguishing features, which may be used to group the *Acacia* into Types.

The wood collectively known as *Podocarpus* spp. includes *Afrocarpus falcatus, Podocarpus elongatus, Podocarpus henkelii* and *Podocarpus latifolius* (Boon 2010; Van Wyk and Van Wyk 2013). *Afrocarpus falcatus*, *Podocarpus henkelii* and *Podocarpus latifolius* occur in the Northern Afrotemperate forest and in the Southern Mistbelt forest (Mucina and Geldenhuys 2011). *Podocarpus latifolius* is a tree of general importance in the Afrotemperate and Southern Mistbelt Forest and a tree of less general importance in the Coastal Forest and in the Ngongoni Veld (Mucina *et al*. 2011). *Podocarpus henkelii* is a tree of general importance in the Southern Mistbelt Forest and a rare tree in the Ngongoni veld (Rutherford *et al*. 2006). The wood anatomy is considered indistinguishable (Bamford and Stevenson 2002; Chalk *et al*. 1932; Chalk *et al*. 1935; Kaeiser 1954).

This study was done to learn more about the use of plants by people from 58 and 49 ka at Sibudu during the MSA. The interaction of people and plants has been studied to discover when people began to use medicines, and the use of poison is a point of departure. The context of this work is the discoveries of technology during the MSA which have shown the resourcefulness of people during the deep past (Wadley *et al*. 2013; Wadley *et al.* 2015). The influence of climate on vegetation and subsequent lifeways has been studied in the context of the discoveries of changes in the environment during the Quaternary (Allott 2006; Backwell *et al*. 2014; Bamford 2015 a, b; Cartwright 2013; Villa *et al*. 2012).

CHAPTER 2

MATERIAL AND METHODS

2.1 Material

2.1.1 Comparative reference collection

Prior to this new study, the pre-existing KwaZulu-Natal reference collection (Allott, 2005) consisted of 209 indigenous species of modern wood and charcoal held at the University of the Witwatersrand, Johannesburg, in the Department of Archaeology. This included a database of scanned electron microscope (SEM) images and anatomical features (Allott, 2005, 2006) and specimens are referred to as Allott when referred to in this thesis. This has now been extended by 98 species of indigenous trees collected from farms in Limpopo and KZN with permission from the landowners. In addition, a donation of 70 indigenous wood blocks from the South African Forestry Department, by the Larry Leach Herbarium, University of Limpopo, was included.

Wood samples (1 cm^3) were carbonised and studied as a comparative reference of anatomical features. Stereomicroscope images were created and anatomical features were recorded. The charcoal, wood and voucher herbarium specimens with locality co-ordinates are at the University of the Witwatersrand, in the Evolutionary Studies Institute Palaeobotany Herbarium**.** Reference wood blocks were charred in a LENTON 0861 muffle furnace, for 3.5 hours at 350 °C at the Palaeosciences Centre, University of the Witwatersrand. The specimens are labelled SJL and catalogued in the Appendix in this thesis.

2.1.2 Archaeological charcoal specimens

The deposit was excavated in 50 cm quadrants within each metre square: material from each quadrant is separately curated and is labelled, for example, B5a, B5b, B5c, B5d (the lower case letter is the name of the quadrant). Quadrant a is always the north and east facing corner of each square. A permanent datum line is painted on the shelter wall, 1.3 m above the ground surface. Some depth readings are “m below main datum” and the painted datum line is referred to in these instances (Wadley 2006: 4). Large pieces of charcoal were collected individually during excavation and the remaining charcoal fragments were extracted after dry-sieving the deposits through 2mm and 1 mm screens. The charcoal excavation (Allott 2005, 2006: 177; Wadley 2006) used standard methods in archaeobotany (Pearsall 2000; Popper and Hastorf 1988. The archaeological material is in the Sibudu collection, stored in the Evolutionary Studies Institute at the University of the Witwatersrand (Wadley and Whitelaw 2006).

In BYA2(i) and SPCA the charcoal was sorted into four groups of small, medium, medium- large and large sizes which were studied by means of simple random sampling (as in Drennan 2009: 85), removing the bias of only one size class of charcoal (as discussed by Allott 2005: 77-78). The whole sample from MOD was studied. The identified specimens are numbered according to the quadrant excavated as given in the data tables in Appendix B and C.

2.2 Methods

The methods used here have been adapted from those used in other anthracology studies. For example, archaeological charcoal has been studied referring to wood anatomy **(**Metcalfe and Chalk, 1950; Jane, 1970; Cutter, 1971; Carlquist, 1975; Desch and Dinwoodie, 1996; Evert and Esau, 2006). Classical anthracology studies which developed the methods include Leney and Casteel (1975), Barefoot and Hankins (1982) and Figueiral and Mosbrugger (2000). Updated methodologies include those by Gonçalves *et al*. (2012), Hubau and colleagues (2012, 2013, 2014) and Py and colleagues (2013). In South Africa, archaeological charcoal has been studied, for example, by Scholtz (1986), Tusenius (1986), Esterhuysen and Mitchell (1996), Cartwright and Parkington (1997), February (2000), Allott (2004, 2005,
2006) and Cartwright (2013).

Charcoal specimens were examined, photographed and identified according to standard methods (Allott 2005, 2006; Théry-Parisot *et al*. 2010 a, b; Chrzazvez *et al*. 2014; Gonçalves *et al*. 2012; Hubau *et al*. 2012, 2013, 2014; Py *et al*. 2013; Asouti and Kabukcu 2014). Charcoal blocks were viewed from three planes by means of an Olympus SZX16 stereomicroscope, magnified up to 115x and photographed by means of an OSIS USB digital camera and Olympus soft imaging solutions software. Characteristic anatomy was studied in more detail by means of an Olympus BX51 reflective, polarised light microscope magnified up to 500x and photographed by means of Olympus Stream Essentials ® image analysis software with Extended Focal Image (EFI) capability. The anatomical features of archaeological charcoal in SPCA were recorded according to the IAWA *List of Microscopic Features for Hardwood Identification* (Wheeler *et al*. 1986; Wheeler *et al.* 1989).

Archaeological charcoals were identified by a number of steps and cross-checked. Specimens were studied under the microscope and features recorded. A matching suite of at least four diagnostic features was sought, by means of a key (Marion Bamford pers.comm. 2011), for the KwaZulu-Natal Reference Collection (Allott 2005), to limit the number of taxa to check. Images of archaeological and reference charcoal were matched using all the preserved features. This process was repeated by means of the modern reference collection and key. Published references were consulted, such as southern African woods described by Kromhout (1975), the wood end-blocks and thin-sections of many woods of the world photographed by Ilic (1991), and the woods of the Sahara and the Sahel described by Neumann *et al*. (2000).

The online database InsideWood was consulted in two ways depending on whether or not a specimen was identified as described above. For identified specimens, these were confirmed by comparing them with the images and lists of features recorded for that species on InsideWood. If unavailable, then closely related southern African species were used as a guide. For unidentified specimens, numbers were allocated to anatomical characters according to the IAWA list. These were searched for on the InsideWood database in order to identify the species or to find the closest living relative. If woods could not be identified, then those with similar characteristics that did not completely match were investigated in order to find the family and, where possible, the genus. The Delta database, with comparative images and descriptions (Richter and Dallwitz, 2009), was consulted but this is a much smaller database and less applicable to the KwZulu Natal woods.

The anatomical features and images of the identified archaeological charcoal specimens were compared with each other, and with reference material, by means of an Excel spreadsheet. The features observed in many specimens form a data base of descriptions and images for confirming identifications. For more information on the comparative features used as a reference see Appendix A, B and C. Unique features were sought, where possible, such as the crystals and silica bodies which aid the distinction between *Spirostachys africana*, *Shirakiopsis elliptica* and *Sclerocroton integerrimus* (Lennox and Bamford, 2015).

After the archaeological samples had been identified the medicinal uses were recorded from the published literature and databases such as Delta and InsideWood (Richter and Dallwitz 2009; Wheeler 2011). The InsideWood database has been used in since it utilises the IAWA features and is most comprehensive (Wheeler 2011). Finally the distribution of taxa in the different layers and the various hearths has been used to interpret uses of plants by the occupants, and also palaeoenvironmental signatures.

As explained before (Chapter 1. Introduction, Section 3. History and status of the study), the abundance (number of pieces) of any particular taxon is not interpreted as the relative abundance of that species used by people because charcoal pieces fragment easily. Different species have different burning properties based on density (Venter and Venter 2001; Manalula and Meincken 2009) and hence variable preservation potential in this region of high biodiversity. Instead, the presence/absence of a species recorded in each separate quadrant was considered as meaningful. This is different to the approach taken in regions of lower biodiversity where fragmentation is the same for all species and where the final proportions of charcoal fragments represent the initial proportions of fuel wood burnt (Théry-Parisot et al. 2010b). The family names of woody taxa have been abbreviated according to Weber's three letter acronyms used in the World Checklist of Selected Plant Families (WCSP), facilitated by the Royal Botanic Gardens at Kew, London (Snow and Holton 2000; Weber, 1982; WCSP, 2015). Names are conferred (cf.) where anatomical features and of archaeological charcoal and reference material matched closely but not completely usually due to distortion of the charcoal by the carbonisation process. While the convention is to place cf. before the species as followed by Lucy Allott (2004, 2005 and 2006), in this thesis cf. is placed after the species in data tables for practical reasons.

The charcoal taxonomy is influenced by matching anatomical features and the availability of a full reference collection of species for each genus identified, to supplement tropical woods from Southern and Eastern Africa which are under-represented on the online databases, as described in several anthracological studies of Southern African archaeological charcoal (Allott 2006; Bamford 2015 a and b; Cartwright 2013; Chikumbirike 2014; Deacon *et al*. 1983; Esterhuysen 1996; Esterhuysen *et al.* 1999; February 2000; Hubau *et al*. 2012; Lennox *et al*. 2015; Prior and Gasson 1990; Scholtz 1986; Tusenius 1986; Vogelsang *et al*. 2010; Wadley *et al*. 1992).

CHAPTER 3

USE OF WOOD ANATOMY TO IDENTIFY POISONOUS PLANTS: CHARCOAL OF *SPIROSTACHYS AFRICANA*

The paper in this chapter presents the key finding of this thesis. The detailed anatomical study of very similar woods, *Spirostachys africana*, *Shirakiopsis elliptica* and *Sclerocroton integerrimus*, enabled the identification of *Spirostachys africana* in archaeological charcoal from 58 ka and 49 ka. This implies that wood from a poisonous plant had been collected by people who understood how to avoid being poisoned. The wood had been burnt, not for cooking, but probably for the insecticidal effect of the noxious smoke. This proved that the people understood how to make use of the poison without poisoning others. They understood how to use the poison sparingly. Since poison may be used as medicine in small quantities, it follows that the bark may have been used medicinally. The latex may have been used as arrow poison and the wood may have been used as an insect repellent. This adds to knowledge of the complex cognition of the people who produced this charcoal. The paper is published in the *South African Journal of Science* in 2015, volume 111 (3/4), pages 43–51.

Author contribution:
MKB helped with the research, *Spirostachys africana* NDO reference and writing the paper.

LW initiated the research and helped with writing the paper.

SJL identified *Spirostachys africana* and wrote the paper.

Use of wood anatomy to identify poisonous plants: Charcoal of *Spirostachys africana*

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Spirostachys africana Sond. (tamboti/tambotie) is a woodland tree that is often found near water. It has a poisonous and purgative latex. The archaeological site of Sibudu, a rock shelter in KwaZulu-Natal, has evidence, from well-preserved charcoal and seeds, of past environments and wood use from approximately 77–38 thousand years ago (ka). As their uses and environmental indicators are different, it is critical to confidently distinguish among the three anatomically similar woods of the Euphorbiaceae: *Spirostachys africana*, *Sclerocroton integerrimus* and *Shirakiopsis elliptica*. A detailed anatomical study of reference and archaeological charcoal shows that xylem vessel width increases proportionally as vessel frequency decreases, from *Spirostachys africana*, *Sclerocroton integerrimus* to *Shirakiopsis elliptica*. Crystals of calcium oxalate are present in ray cells of *Spirostachys africana*, whereas silica bodies are present in ray cells of *Sclerocroton integerrimus* and *Shirakiopsis elliptica*. Using these features, the presence of *Spirostachys africana* was confirmed amongst hearth charcoal of the Spotty Camel layer, with an age of approximately 58 ka and of the Mottled Deposit occupational layer, with an age of approximately 49 ka. The presence of this charcoal, collected from ancient fireplaces or sieved from surrounding sediments, implies that people at Sibudu understood and used this poisonous tree to their advantage. We are encouraged in this view by the presence of many *Cryptocarya woodii* leaves found on the surface of 77-ka sedge bedding at Sibudu (Wadley L et al., Science. 2011;334:1388–1391). *Cryptocarya woodii* has insecticidal and larvacidal properties and members of the Laurel family are well known for their medicinal properties.

Introduction

General introduction

Three indigenous woods – *Spirostachys africana* (tamboti), *Sclerocroton integerrimus* (duiker-berry) and *Shirakiopsis elliptica* (jumping-seed tree) – were tentatively identified from charcoal recovered from archaeological deposits at the rock shelter Sibudu. The anatomy of charcoal reference material was compared with that of the recovered charcoal in order to confidently identify these taxa in the archaeological charcoal. The identification of these woods in the Middle Stone Age at Sibudu is significant because *Spirostachys africana* is particularly poisonous. *Spirostachys africana* Sond., *Sclerocroton integerrimus* Hochst. (=*Sapium integerrimum* (Hochst.) J.Léonard) and *Shirakiopsis elliptica* (Hochst.) Esser (=*Sapium ellipticum* (Hochst.) Pax) are members of the family Euphorbiaceae, subfamily Euphorbioideae, tribe Hippomaneae A.Juss. ex Bartl. and subtribe Hippomaninae.[1]

Sibudu

Sibudu is situated on the uThongathi River, KwaZulu-Natal. It has a sequence of archaeological layers from the Middle Stone Age, dated by single-grain optically stimulated luminescence to approximately 77–38 ka.[2-6] Some of the evidence for the behaviour of the anatomically modern people who visited and lived at Sibudu includes stone tools, ochre, bone, perforated seashells and hearths[7-15], as well as evidence for the making and use of compound adhesives[16], and circumstantial evidence for snares[17] and bows and arrows[18]. There is evidence of the use of plant resources from pollen, phytoliths, seeds, nutlets, stems, charcoal and leaves excavated at Sibudu.[2,19-27]

The relevance of identifying *Spirostachys africana*

The presence of charcoal at Sibudu implies that people who visited and occupied the site burned wood.[2,4,5]

Spirostachys africana charcoal was tentatively identified from Sibudu in a previous study.[20,21] Nowadays, the wood from this tree is not used as fuel for cooking because the smoke and fumes are poisonous.[28] People who live in a particular environment for long periods develop knowledge about local resources[2,14,25,29] and the *Spirostachys africana* wood was almost certainly recognised for its toxic properties and utilised by ancient hunter–gatherers[14]. Therefore a secure identification of the archaeological charcoal is necessary in order to interpret behavioural strategies in the past.

Sclerocroton integerrimus wood anatomy is similar to that of *Spirostachys africana*.[1,20,30] Both were recorded as *Spirostachys*/*Sapium* in the scanning electron microscopy (SEM) study of charcoal from Sibudu,[20,21] so it is important to try to distinguish between the two taxa. *Shirakiopsis elliptica* wood anatomy is also similar.[1,31] As it was not in the original charcoal reference collection for Sibudu,[20] new fresh material was gathered, charred and studied.

Anthracology

Archaeological charcoal is identified by means of wood anatomy[32-35] to describe palaeoenvironments and palaeoclimate and to develop an understanding of past wood use[36-38]. Anatomical features of living or fresh woods, listed by the International Association of Wood Anatomists, accessed on InsideWood, an online database[39], can assist with charcoal identification[34,35,40] but charred reference material is more useful[41-43]. Woody taxa have been identified from charcoal assemblages from many sites elsewhere in southern Africa; a few examples are Diepkloof Rock Shelter[44] and Elands Bay Cave in the Western Cape[45] and from sites in Lesotho[46,47].

Habits, habitats and uses of the three woods

Spirostachys africana is a medium-sized, hardwood, deciduous tree, 10–18 m tall, and grows in woodland and valley bushveld. Often found in dense stands; in warm, dry areas along rivers and drainage lines; in poorly drained brackish and clay soils; or near underground water, tambotie is distributed from KwaZulu-Natal to Tanzania.[48] *Sclerocroton integerrimus* is a small- to medium-sized, hardwood, deciduous tree, 2–10 m tall, and grows in coastal thicket, on forest margins and in wooded grassland.[48] *Shirakiopsis elliptica* is a medium to tall, softwood, deciduous tree, 12–20 m tall. It grows in wooded ravines and is common at the canopy edge of evergreen forests and as a canopy tree in swamp forests.[48] The timber of the three trees is similar.[49]

The bark, wood, stems and leaves of *Spirostachys africana* contain poisonous milky latex[28] which is used as a purgative in small doses[50]. This fish and arrow poison causes conjunctivitis when in contact with the eyes[28] and urticaria and blistering when in contact with the skin[28]. A triterpenoid (C_{30}) isolated from the bark showed significant inhibition of the bacteria *Staphylococcus aureus, Salmonella typhi, Vibrio cholera, Escherichia coli* and *Shigella dysenteriae*, explaining the traditional use in several African countries against diarrhoea and dysentery.[50-55] Cytotoxic and genotoxic activities have been reported.[28,52]

The cytotoxins in latex are phorbol esters, which are terpenoids.[28,54] *Spirostachys africana* is classified as an extremely hazardous Class IA cellular poison according to the four toxicity classes recognised by the World Health Organization. This measure of poisoning is based on an LD_{50} determination in rats, that is, less than 5 mg of plant material ingested per kilogram body mass killed 50% of the population.[28] (Poisons kill in minute amounts, toxins are less toxic than poisons and toxicants are toxic in high concentrations only.[50]) Phorbol esters affect mucous membranes in the skin and the alimentary tract.[28] The latex and bark have antimicrobial, anthelminthic and larvacidal properties and are effective against ailments of the digestive tract, skin, reproductive system and respiratory tract.[50-55]

Spirostachys africana wood is hard and heavy with a beautiful close grain coppery brown colour, impervious to insect attack and weathering.[48] When burned, the wood gives off a sweet odour, which can cause headaches, nausea and diarrhoea.[28,55] The Venda use *Spirostachys africana* smoke to fumigate their huts against wood-boring and other insects (Anonymous reviewer, 2014, written communication of personal observation, July 03).

Sclerocroton integerrimus has clear latex which is suspected of being poisonous and is used as a mouthwash to relieve toothache and coughs.[56] Fruit is used to make ink and as a source of tannin. Fallen fruit and leaves are eaten by antelope and stock animals.[48]

Shirakiopsis elliptica is considered very poisonous and is used as a drastic purgative in West Africa.[57] The rough bark has sparse, scattered depressions and clear latex. Bark latex is added to arrow poison, *ouabain*, from the East African *Acokanthera schimperi* and is used as bird lime and for body markings.[57] *Acokanthera oppositifolia* (Bushman's poison), distributed along eastern and northern parts of South Africa, is amongst the *Acokanthera* species which are known to be sources of extremely toxic arrow poisons.[28] Various parts of the *Shirakiopsis elliptica* tree are used in folk medicine in Africa, in dermatology and gastroenterology, particularly as an anthelminthic.[57]

Wood anatomy

A detailed study of the wood anatomy of *Spirostachys africana*, *Sclerocroton integerrimus* and *Shirakiopsis elliptica* has been done to distinguish among these taxa and to clearly identify *Spirostachys africana* in charcoal from Sibudu. Modern reference material was collected specifically for this project, charred in a furnace and supplemented with data from InsideWood and the literature. As outlined below, the three woods share similar features but there are several useful distinguishing characteristics.

Methods

Material

Comparative reference collection

A wood sample of *Spirostachys africana* from a Southern African Forestry Department woodblock stored in the Department of Archaeology, University of the Witwatersrand, was carbonised and studied as a reference of anatomical features (SJL 103; Table 1, Figure 1a–c). Inferred archaeological *Spirostachys africana* charcoal from Ndondondwane Iron Age site[58] in KwaZulu-Natal was used as intermediate reference material (NDO; Table 1, Figure 1d). Reference wood samples and voucher herbarium specimens of *Sclerocroton integerrimus* (SJL 88, Figure 1e) and *Shirakiopsis elliptica* (SJL 67, Figure 1f) were identified by local botanists and were collected *ex hort* in Durban and on a farm near Port Edward, KwaZulu-Natal (coordinates 31.04615°S, 30.16886°E) for a study of anatomical features (Table 1).

Archaeological specimens

Sibudu archaeological charcoal was examined from squares of occupational layer Spotty Camel (SPCA), which has not been dated but lies between layers with ages of 61.3 ± 2.0 ka and 56.2 ±1.9 ka, and from Mottled Deposit (MOD) at approximately 49.7 ± 1.8 ka.[1,3-6] These layers were chosen because *Spirostachys*/*Sapium* charcoal was previously recorded from them by Allott[20,21].

Methods

Reference woodblocks were charred in a LENTON 0861 muffle furnace (Lenton, Hope, UK) for 3.5 h at 350 °C at the Palaeosciences Centre, University of the Witwatersrand. Archaeological charcoal was identified by comparing it with reference material, using standard techniques.[20,21,41-43] Charcoal blocks were viewed from three planes by means of stereomicroscopy (Olympus SZX16, Münster, Germany) and reflective and polarised light microscopy (Olympus BX51) at magnifications of 100x, 200x and 500x. Characteristic anatomy was digitally photographed using Olympus Stream Essentials® image analysis software with extended focal image capability. Anatomical features according to the International Association of Wood Anatomists' list[35,39] were recorded for the comparative reference material and archaeological specimens. Identifications were also confirmed against published reference material.[1,32,33,39,49]

Useful distinguishing features

Prismatic crystals occur in *Spirostachys africana* ray and parenchyma cells, whereas silica bodies are absent in this species.[1,30,59] Silica bodies occur in *Sclerocroton integerrimus*[2,60] and *Shirakiopsis elliptica*[1,31] ray cells, whereas crystals are absent from ray cells[40]. Crystals are occasionally visible in the parenchyma cells of *Sclerocroton* and *Shirakiopsis.*[2]

Prismatic crystals are not common in wood anatomy and their occurrence may be sporadic.[35] Features such as crystals and silica bodies are therefore useful attributes and are listed as an anatomical feature when commonly observed. Prismatic crystals are solitary, rhombohedral or octahedral crystals of calcium oxalate which are birefringent (produce a rainbow effect) under polarised light[35] and appear shiny in charcoal specimens.

Silica bodies are spheroidal or irregularly shaped particles of silicon dioxide which are non-birefringent (do not produce a rainbow effect) under polarised light[35] and appear opaque. Silica is present in ray cells in African *Sapium* species in aggregates, which often fill the entire cell lumen, or as grains or small dark dots in Asian *Sapium* species such as

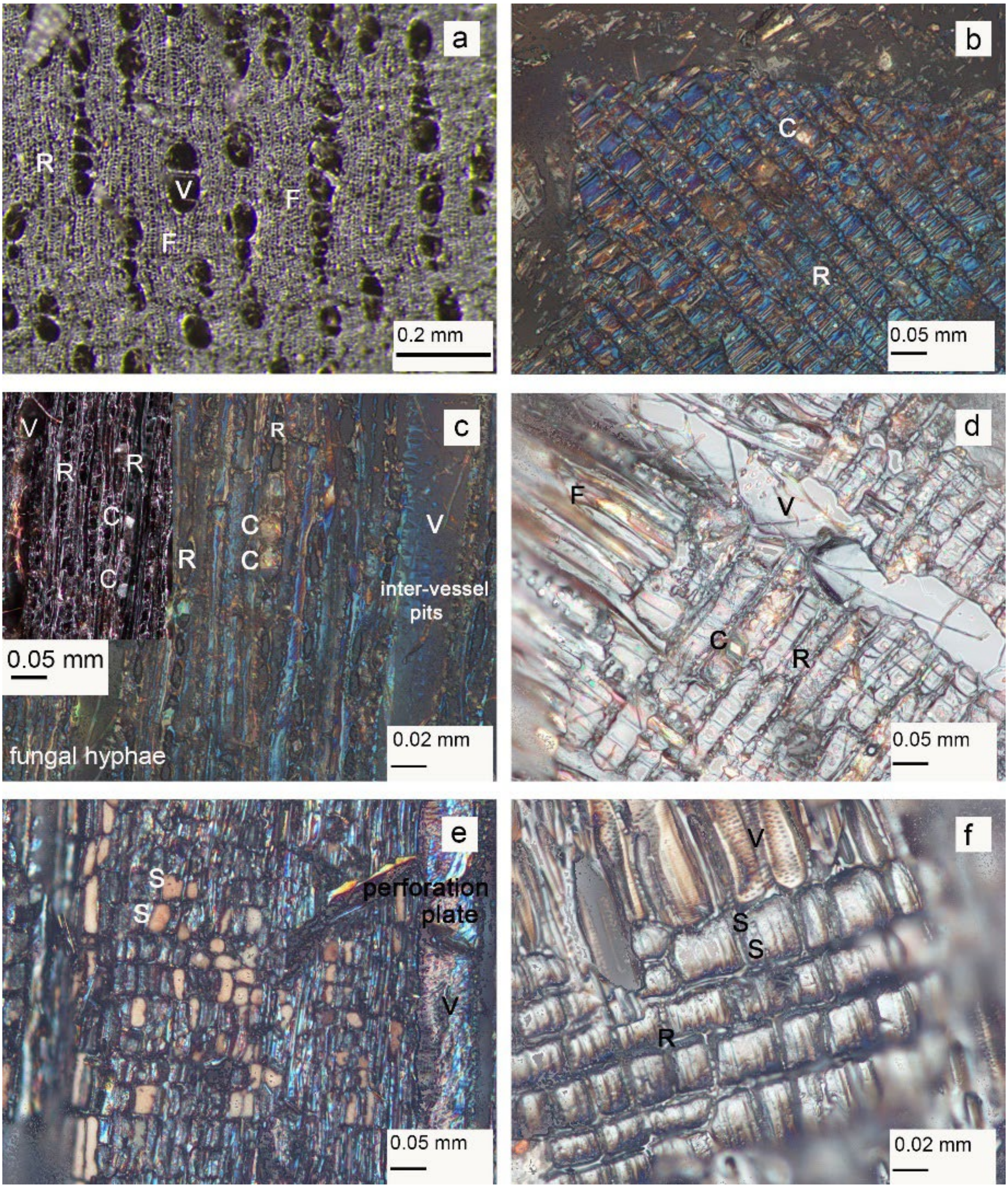

Figure 1: Diagnostic characteristics of charcoal reference material: (a–c) *Spirostachys africana* (SJL 103), (d) *Spirostachys africana* (NDO), (e) S*clerocroton integerrimus* (SJL 88) and (f) *Shirakiopsis elliptica* (SJL 67). (a) In transverse section, *Spirostachys africana* has many small vessels (V) in long lines. Vessels are occasionally in pairs. The shiny cell contents may be resin[2] or gum[30]. These fibres (F) are thin-walled and regular. (b) The radial longitudinal section has crystals labelled (C) in the ray cells, which shine under polarised light. Ray cells (R) are mixed; the procumbent cells are as high as the square cells and occasionally there are upright cells in the margins. The rays are low. (c) The tangential longitudinal section has frequent, uniseriate rays. The prismatic crystals of calcium oxalate in ray cells which distinguish *Spirostachys* shine under polarised light. Vessels with alternate inter-vessel pits occur and the vessel walls are birefringent under polarised light. The insert shows these ray crystals at a lower magnification. (d) Inferred *Spirostachys africana* reference material from Ndondondwane, KwaZulu-Natal (NDO) has prismatic, rhombic, crystals in the ray cells which shine under non-polarised light, in radial longitudinal section. (e) In S*clerocroton integerrimus* reference material*,* SJL 88, there are silica bodies labelled (S) in the ray cells. These are spheroidal or irregularly shaped particles which are opaque under polarised light. The ray cells are heterocellular, mixed procumbent, square and upright in radial longitudinal section. The cell walls of the vessels, rays and fibres are birefringent in polarised light. (f) In *Shirakiopsis elliptica* reference material, SJL 67, the silica bodies (S) in ray cells are granular, dark spots. Rays are heterocellular with upright and square cells seen in radial longitudinal section. These inter-vessel pits are alternate.

Sapium luzonicum.[40] The arrangement (aggregated, irregularly shaped or globular) or surface (smooth or verrucose) may be diagnostic in certain groups and needs to be recorded in a description.[35]

Results and discussion

Figure 1 illustrates reference charcoal of the three taxa. Figure 1d, *Spirostachys africana* (NDO), is of archaeological charcoal and is therefore an interpreted identification. Figure 2 illustrates the identified archaeological charcoal from Sibudu. Table 1 summarises the charcoal anatomy of the modern reference and archaeological material. Table 2 lists the most useful diagnostic features for identifying the three species, the environmental conditions required by the trees and the medicinal and other uses for their wood.

Table 1: The anatomical features of modern and archaeological charcoal specimens of *Spirostachys africana, Sclerocroton integerrimus* and *Shirakiopsis elliptica*

Plant species	Charcoal specimen	Vessel radials	Vessel diameter	Vessel frequency	Ray width in cells	Heterocellular ray body cells	Ray marginal cells	Parenchyma	Ray crystals or silica bodies
Spirostachys africana	SJL 103	l	s	a	1	p,s,u	–	da	c
	NDO	l	s	a	1	p,s,u	–	da	c
	MOD C6a 39	l	s	a	1	p,s,u	(s)	d	c
	SPCA D5c 51	l	s	a	1	p,s,u	(s)	d	c
	SPCA B4b 62	l	s	m	1	p,s,u	–	d	c
	SPCA B4b 67	l	s	m	1	p,s,u	–	d	c
Sclerocroton integerrimus	SJL 88	s	m	m	1	p,s,u	–	da	s
	MOD E3d 08	s	m	m	1	p,s	(u)	d	s
	SPCA B4b 65	l	m	m	1	p,s	–	d	s
	SPCA B4b 66	l	m	m	1	p,s,u	–	d	s
	SPCA B4c 07	l	m	m	1	s,u	–	d	s
	SPCA B4c 14	l	m	m	1(–2)	s,u	–	d	s
	SPCA D5a 27	l	m	m	1	s,u	–	d	s
Shirakiopsis elliptica	SJL 67	s	l	f	1(–2)	s,u	–	d	s
	MOD C6a 46	s	m	m	1(–2)	p,s	u	dc	s
	SPCA B4c 45	s	m	m	1(–2)	p,s	u	d	s

Notes:

Vessel radials: short (s), 1–3 vessels; or long (l), >4 vessels
Vessel diameter: small (s), <50 µm; medium (m), 50–100 µm; large (l), 100–200 µm
Vessel frequency: few (f), 5–20 per mm²; medium (m), 20–40 per mm²; abundant (a), 40–100 per mm²
Heterocellular ray body cells: procumbent (p); square (s); upright (u)
Ray marginal cells: square (s); upright (u); (bracketed = occasional)
Parenchyma: diffuse (d) or diffuse-in-aggregate (da); crystals (c)
Ray crystals (c) or silica bodies (s)

Attributes common to Spirostachys*,* Sclerocroton *and* Shirakiopsis

Vessels are commonly arranged in long, radial multiples ($\geq$4). Perforation plates are simple. Inter-vessel pits are alternate and polygonal; medium (8–10 μm) in *Spirostachys africana* [1,30,49], medium to large (8–10 μm to 11–16 μm) in *Sclerocroton integerrimus*[60] and large (11–16 μm) in *Shirakiopsis elliptica*[31]. Vessel-ray pits are bordered and similar to inter-vessel pits in size and shape in *Spirostachys africana* and *Shirakiopsis elliptica;* rounded or angular, with much reduced borders, in *Sclerocroton integerrimus*. Fibres are non-septate, with simple to minutely bordered pits. Fibres are short in *Spirostachys africana*; in *Sclerocroton integerrimus,* they are medium length and regularly arranged. *Shirakiopsis elliptica* fibre length varies from short to long (Figure 1).

Diffuse parenchyma occurs in *Spirostachys africana.* Parenchyma which is diffuse-in-aggregate (SJL 103, Figure 1a), or in narrow bands or lines which are up to three cells wide, may be observed as a variation.[1,30,49] Parenchyma which is diffuse or diffuse-in-aggregate is difficult to see. In *Sclerocroton integerrimus* parenchyma is diffuse-in-aggregate and/or there are narrow bands or lines up to three cells wide.[60] *Shirakiopsis elliptica* parenchyma is diffuse and/or diffuse-in-aggregate, with the variation of occasionally occurring in narrow bands or lines up to three cells wide.[31] Axial parenchyma strand length is either 4 or 8 cells per parenchyma strand in all three woody taxa.

Rays are exclusively uniseriate, commonly heterocellular, with procumbent, square and upright cells mixed throughout the ray (SJL88, Figure 1e), although this pattern varies within and between the three woody taxa (Table 1; SJL 103, Figures 1a–c; NDO, Figure 1d). *Shirakiopsis elliptica* reference charcoal ray cells are upright and square (SJL 67, Figure 1f). Very long rays occasionally occur in *Shirakiopsis elliptica* where two rays meet end to end, and are visible in both reference material (SJL 67) and archaeological material (SPCA B4c 45).[1,31,40]

Rays are frequent, with up to 12 observed per millimetre. Laticifers – thin, radial tubes carrying latex which occasionally occur in Euphorbiaceae wood – were absent from the charcoal examined.[1,35]

Distinguishing attributes of reference material

The charcoal of the three species differs in vessel size and frequency as well as in the presence or absence of crystals or silica bodies in ray cells. The differences in vessel size and pattern among the wood of the three species are recorded in a photographic study of endgrain woodblocks of Euphorbiaceae.[49]

Spirostachys africana has several to many, small to medium vessels in long radial lines.[1,30,49] Charcoal reference, SJL 103, (Figure 1) and interpreted reference material, NDO, vessels are narrow (30–50 μm), at a frequency of between 40–100 vessels per mm^2 (an average of 80/mm^2) and vessels are arranged in long radial lines (radial multiples $\geq$ 4). The prismatic crystals in ray cells are birefringent, appearing shiny under reflected polarised light. Shape may vary in different material, from clearly rhombic in the archaeological specimen – which is an interpreted reference for *Spirostachys africana* (NDO in Figure 1d) – to irregular but shiny in the modern wood forestry block reference material (SJL 103 in Figure 1b and 1c). Crystals are visible in the SEM images recorded by Allott[20]. Silica bodies are absent from ray cells. The vessel inclusions are either resin[1] or gum[30]. Resin occurs in the heartwood.[1] Similar comparative images of *Spirostachys africana* have been recorded by Allott[20], Ilic[32] and Kromhout[33].

Sclerocroton integerrimus has few, medium to large vessels in radial lines.[1,60] Charcoal reference material, SJL 88, vessels are narrower than 100 μm, at a frequency of 20–40 vessels per mm^2, and are arranged in short radial lines of two to four vessels. The silica bodies are non-birefringent and opaque under polarised light (SJL 88, Figure 1e).[35] The silica bodies present in ray cells are spheroidal, irregularly shaped particles[35] arranged in aggregates which often fill the entire cell lumen[40]. These silica bodies are visible in the SEM images recorded by Allott[20]. Prismatic crystals are absent from ray cells.

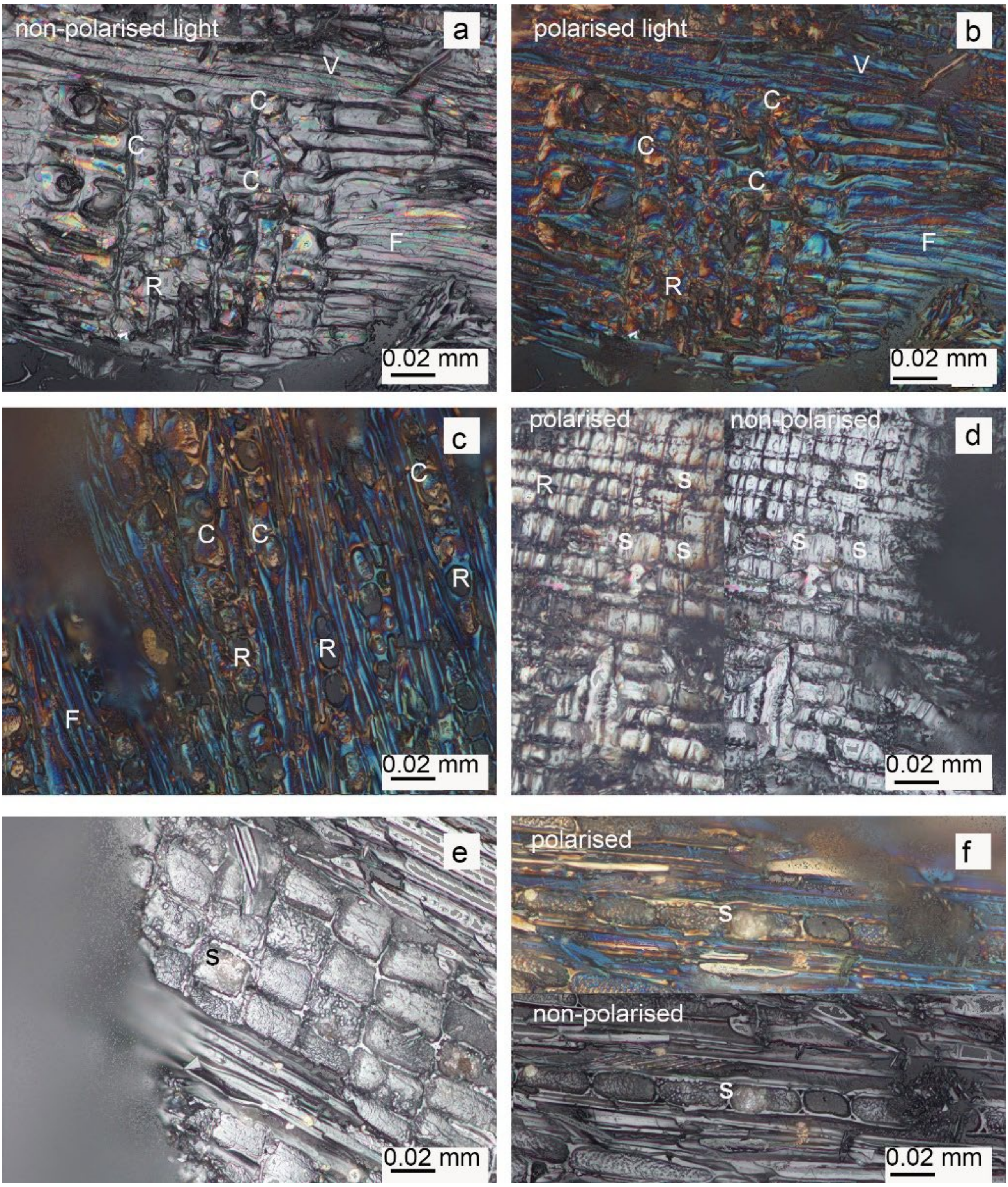

Figure 2: Diagnostic characteristics of archaeological charcoal: (a–c) *Spirostachys africana,* (d) *Shirakiopsis elliptica* and (e,f) *Sclerocroton integerrimus.* (a) In *Spirostachys africana*, SPCA B4b 62, there are prismatic crystals (C) in the procumbent ray cells (R), under non-polarised light. (b) These appear shiny under polarised light in radial longitudinal section, matching those of the *Spirostachys africana* SJL 103 reference material. The vessel (V), fibre (F) and ray cell (R) walls are also birefringent under polarised light. (c) In *Spirostachys africana,* SPCA D5c 51, tangential longitudinal section, the ray cell walls are cut away and the crystals underneath are present and shiny, matching those of the *Spirostachys africana* SJL 103 reference material when magnified 500x. (d) In *Shirakiopsis elliptica* archaeological material, MOD C6a 46, silica bodies (S) are present as grains and dots in ray cells and appear opaque under both polarised and non-polarised light. Rays are heterocellular, with mixed upright, square and procumbent cells, in radial longitudinal section. (e) In *Sclerocroton integerrimus* archaeological charcoal, SPCA B4b 66, the silica bodies in the ray cells are spheroidal or irregularly shaped and opaque in non-polarised light in radial longitudinal section and in both polarised (f) and non-polarised light in tangential longitudinal section.

Shirakiopsis elliptica has very few, large to very large vessels in radial lines.[1,31] Charcoal reference material, SJL 67, (Figure 1f) vessels are wider than 100 μm, at a frequency of fewer than 10 vessels per mm^2, and are arranged in short radial lines. Silica bodies occur as grains or small dark dots in Asian *Sapium* species.[41] In our reference material, the silica bodies are inconspicuous, prismatic crystals are absent from ray cells with occasional crystals observed in the parenchyma and tyloses commonly occurring in vessels.[1,31]

Spirostachys *and* Sclerocroton *archaeological charcoal*

Spirostachys africana was identified in charcoal from Sibudu from MOD square C6a and from SPCA squares B4b and D5c. Specimens MOD C6a 39 and SPCA 62 have as many as 110 vessels per mm^2, small (20–30 μm) to medium (50–100 μm) in size and arranged in radial multiples $\geq$4 (long radial lines); rays are uniseriate, frequent and heterocellular, with mixed procumbent, square, upright cells. Prismatic crystals occur in ray cells and shine under polarised light (Figure 2a–c).

Sclerocroton integerrimus charcoal was identified from MOD square E3d and from SPCA squares B4b, B4c and D5a. Few (30–50 vessels per mm^2), medium-sized (50–100 μm) vessels occur in radial multiples $\geq$4. Silica bodies occur as aggregates which partially fill the ray cell lumen and are opaque under both non-polarised as well as polarised light (SPCA B4b 66; Figure 2e). Variation was observed in vessel arrangement and ray cell pattern (Table 1).[1,60]

Shirakiopsis elliptica charcoal was identified from MOD square C6a. Specimen MOD C6a 46 has many (40 vessels per mm^2), medium ($\pm$50 μm) vessels in radial lines. Specimen SPCA B4c 45 has as many as 50 large (100-μm) vessels per mm^2. Occasionally two uniseriate rays meet, forming rays which are jointly longer than 1 mm. Silica bodies in ray cells appear as inconspicuous grains or small, dark dots (MOD C6a 46; Figure 2). The diffuse parenchyma occasionally contains crystals.[1]

Summary of the characteristic diagnostic features of each species

The detailed anatomical study of reference material enables the identification of these taxa based on the occurrence of crystals in *Spirostachys africana* and silica bodies in *Sclerocroton integerrimus* and *Shirakiopsis elliptica* ray cells[1] as well as on vessel size classes and frequency of vessels. These diagnostic characteristics are compared in Table 2.

The vessel size of *Spirostachys, Sclerocroton* and *Shirakiopsis* increases proportionally as vessel frequency decreases, from *Spirostachys africana*, with the smallest and most numerous vessels, to *Sclerocroton integerrimus*, then to *Shirakiopsis elliptica* with the largest and fewest vessels.

A comparison of anatomical features

No clear differentiation in anatomical features among these three taxa under investigation could be found, thus necessitating this study. There is some variation in vessel width and frequency, ray cell type, the absence or presence of tyloses in vessels, of laticifers in rays and of gum or resin deposits in vessels among different published accounts.[1,30,31,33,49,59]

Relative abundance of crystals may vary. As wood is inherently variable, some features are well defined in some samples, but poorly defined or absent in other samples of the same species.[35] There are no quantitative criteria for 'common' in the list of the International Association of Wood Anatomists. Comments on relative frequency are therefore added to descriptions.[35]

The crystals of calcium oxalate are birefringent under polarised light; however, some cell walls, especially lignified cell walls, are also birefringent (Anonymous reviewer, 2014, personal observation, written communication, July 03). Structures such as xylem vessels with birefringent cell walls have a rainbow sheen in the reference material (SJL 103) and in the inferred reference material (NDO). Birefringent crystals are visible in *Spirostachys africana* reference material in the

Table 2: Comparing the wood anatomy, environment and uses of *Spirostachys, Sclerocroton and Shirakiopsis* (Euphorbiaceae)

	Spirostachys africana[2,30,59]	***Sclerocroton integerrimus***[2,60]	***Shirakiopsis elliptica***[2,31]
Wood anatomy: vessel size and frequency, cell inclusions	Small to medium vessels, 50–100 μm wide Several (20–40/mm^2) to many (40–100/mm^2) vessels	Medium (50–100 μm wide) to large (100–200 μm wide) vessels Few vessels, 5–20/mm^2	Large (100–200 μm wide) to very large ($\geq$200 μm wide) vessels Very few vessels, $<$5/mm^2
	Prismatic crystals are present in ray cells. Parenchyma may contain prismatic crystals.	Silica bodies are present in ray cells. Parenchyma may contain prismatic crystals.	Silica bodies are present in ray cells. Parenchyma may contain prismatic crystals.
Timber	The hard, heavy wood has contrasting light sap wood and dark heartwood, with an attractive lustre when polished and has therefore been used as a replacement for sandalwood. It is used in furniture, for staves, beads and bangles and in construction as rafters. The sawdust is poisonous, as is the wood if burnt for fuel, causing conjunctivitis, nausea and food poisoning.[28,55]	The hard, durable wood is used as timber for general purposes, in construction and for furniture.[56]	The tough, soft, light, white wood is used to make instruments, burnt as firewood and charcoal, but not used as rafters when used in construction as it is susceptible to insects.[57]
Phytochemistry and uses	Phorbol esters (terpenoids) classify latex in bark, wood, stems and leaves as an extremely hazardous, Class 1a, cellular poison (LD_{50} = 5 mg/kg).[28,50,61] Isolated terpenoids have antibacterial properties.[28] A very drastic purgative, the bark and milky latex are used to treat alimentary tract infections. Latex is used to treat tooth decay and eye infections. Used as fish and arrow poison, latex causes conjunctivitis, or a severe contact dermatitis. Bark is used for skin ailments, and headaches. The fragrant woodblocks are an insect repellent.[62] Smoke is inhaled for treatment of respiratory infections.[28,55]	Toxic tetracyclic triterpenic cucurbitacins have been extracted from root bark of *Sclerocroton cornutus* from West and Central Africa.[56] Suspected of being poisonous, the clear latex is used as an antiseptic against toothache and coughs. The fruits were formerly used to make a black ink and are used for tanning.[56]	Tannins and alkaloids have been extracted from the whole plant. Bark extracts have moderate antimicrobial activity against *Campylobacter jejuni* which causes food poisoning.[57] Considered very poisonous and a very drastic purgative, the clear latex is added to arrow poison and used as bird lime.[57]

tangential longitudinal section in which the cell walls are cut away. The outline of these crystals is visible, differentiating these crystals from ray cell walls in the radial longitudinal section. Under non-polarised light, the crystals in the inferred reference material match those seen in SJL 103 and those usually seen in wood[35] and charcoal[44]. The crystals seen in archaeological specimens of *Spirostachys africana* match those found in reference material SJL 103 ray cells observed in radial and tangential longitudinal sections at high magnification.

The *Spirostachys africana* crystals are magnified to 500x the original size and they are clearly visible. In SEM studies of charcoal, energy dispersive x-ray spectrometry analysis capabilities may be used to distinguish between crystals of calcium oxalate and silica, such as the crystals found in *Searsia undulata* (Namaqua kuni-bush), *Cassine peragua* (spoon-wood) and *Gymnosporia buxifolia* (spike-thorn) from archaeological charcoal at Diepkloof Rock Shelter.[44]

The variation in anatomical features between the charcoal and fresh wood or between charcoal made from modern wood and archaeological charcoal are because of the natural variation occurring in biological material affected by the sample origin (twig or trunk) or habitat.[49] Quantitative variation may be a result of the shrinkage and distortion which occurs during the formation of charcoal.[36,38]

We have supplemented the charcoal wood anatomy descriptions with those from fresh woods from the InsideWood database as more detail usually is visible in fresh wood. Comparative sizes rather than measurements are used in anthracology because the anatomy may be distorted by shrinkage, vitrification, diagenesis, and fragmentation and powdering.[36,38,41]

Conclusion

The charcoal anatomy of *Spirostachys africana, Sclerocroton integerrimus* and *Shirakiopsis elliptica* enables these species to be distinguished by vessel arrangement, size and frequency, as well as by the presence or absence of crystals or silica bodies in ray cells.

Spirostachys africana has narrow, frequent vessels; prismatic crystals are present in ray cells. *Sclerocroton integerrimus* has wider, less frequent vessels. Of the three species under comparison, *Shirakiopsis elliptica* has the widest and least frequent vessels. Silica bodies are present in ray cells of *Sclerocroton integerrimus* and in *Shirakiopsis elliptica* as small grains and dots while prismatic crystals are absent from ray cells*.* The silica bodies of *Sclerocroton integerrimus* are aggregates of irregularly shaped silicon dioxide particles which often fill the entire cell lumen and appear opaque under polarised light. The silica bodies of *Shirakiopsis elliptica* appear as grains or small, dark dots.

Spirostachys africana was identified amongst hearth charcoal of the SPCA layer in squares B4b and D5c, with an age of approximately 58 ka; and in charcoal of the MOD layer in square C6a, with an age of approximately 49 ka. This find confirmed the use of *Spirostachys africana* wood at Sibudu rock shelter. *Sclerocroton integerrimus* charcoal occurred in SPCA in squares B4b, B4c and D5a and in MOD in square E3d. *Shirakiopsis elliptica* charcoal was found in SPCA B4c and in MOD in square C6a.

Sclerocroton integerrimus, Shirakiopsis elliptica and poisonous *Spirostachys africana* wood was deliberately burned by people at Sibudu who utilised natural resources. *Sclerocroton integerrimus* timber is a hard, heavy, durable wood. *Shirakiopsis elliptica* timber is soft, light, and suitable for making implements. *Spirostachys africana* wood is a hard, durable wood, with poisonous properties.

Many of the present day uses of these woods were not applicable during the Middle Stone Age, but these species may have been selected for making wooden implements and for firewood. *Spirostachys africana* wood is a skin irritant and it seems unlikely that this wood would have been worked by hand to make implements. Nor does it seem likely that the poisonous wood was used for domestic fires to cook food. It seems more likely that *Spirostachys* was deliberately selected for its toxic or insecticidal properties, perhaps so that its smoke would fumigate insects from the camp in Sibudu.

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Authors' contributions

S.J.L. was responsible for the experimental work and wrote the manuscript; M.K.B. supervised the research, helped with charcoal identification and assisted with writing the manuscript.

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CHAPTER 4

CHARCOAL IDENTIFICATION IN SOME SOUTH AFRICAN SPECIES OF ASTERACEAE

The charcoal of the large woody shrub, *Tarchonanthus parvicapitulatus* P.P.J. Herman (syn. *Tarchonanthus camphoratus*) Herman (2002) has been studied as the smoke is known to have various medicinal properties. Since the wood anatomy of this shrub is very similar to *Brachylaena discolor* DC, another woody member of the Asteraceae, every effort has been made to study modern reference charcoal to confidently distinguish the species.

4.1 General introduction

Interest in Asteraceae was stimulated by their putative identification amongst charcoal specimens from Sibudu, a rock shelter in KwaZulu Natal. Charcoals from Sibudu, studied by Allott (2005, 2006) include some specimens thought to be from *Brachylaena* and others from unspecified Asteraceae. Members of the Asteraceae are predominantly herbs, with a few woody members occurring in southern Africa and other parts of the world. In Southern Africa there are 246 genera and 2 300 species and the woody taxa consist of 34 species in 14 genera (www.plantzafrica.com; Coates-Palgrave 2002). In all there are 1 500 Asteraceae genera worldwide (www.kew.org).

Brachylaena sp. was identified in layers GS, GR2, GR from > 60ka, Eb from ~60ka and Bu from ~ 37ka (Allott, 2006). Some members of the Asteraceae family, for example *Tarchonanthus parvicapitulatus* (Beentje 1999; Braithwaite *et al*. 2008; Matasyoh *et al*. 2007; Omolo *et al*. 2004, 2005) and *Tarchonanthus parvicapitulatus* (syn. *Tarchonanthus camphoratus*) are reported to have medicinal properties (Abimola 2010) and this further prompted interest in securely identifying the Sibudu specimens. *Tarchonanthus parvicapitulatus* (narrowly defined) has foliage with a grey-green appearance, the leaves are narrowly oblong to eliptic, with a strong smell of camphor when crushed (Van Wyk and Van Wyk 2013: 124). On the contrary, in *T. parvicapitulatus* (= *T. camphoratus*, in part) the leaves are usually oblanceolate, dark green, with a strong smell of camphor when crushed (Van Wyk and Van Wyk 2013). It is *T. parvicapitulatus* which occurs near Sibudu rock shelter.

Since several members of the Asteraceae family could occur in the Sibudu charcoal, it is important to be able to distinguish the taxa confidently, based on their wood anatomy. The identifications of Asteraceae were not possible solely from modern charcoal/wood anatomy descriptions that are already published (Allott 2005; Carlquist 1961, 1966, 2001; Cartwright 2013; Gao *et al*. 2010; Kromhout 1975) or from more general texts (Carlquist 1975, 2010, 2012;

InsideWood 2004; Metcalfe and Chalk 1950). It was therefore necessary to create a modern reference collection of selected charred woods and to create our own data base of anatomical attributes after detailed microscopy. Charcoal must be used for the comparative collection because the available literature on modern woods is based on fresh material. Woody tissues shrink and fragment on charring (Bamford and Henderson 2003; Chrzazvez *et al*. 2014; Gonçalves *et al*. 2012) so the quantitative features of charcoals will differ from those of fresh woods (Hubau 2012, 2013, 2014). However, vessel diameter and frequency can be affected by climatic conditions and the position of the branch or stem within the plant, thus qualitative characteristics are probably more reliable than absolute sizes (Wheeler *et al*. 1989).

Table 4.1: Selected woody Asteraceae which occur in KwaZulu-Natal and have a stem diameter greater than 2 cm, *Brachylaena* and *Tarchonanthus* are shaded.

Scientific name	Author	Common name
Artemisia afra	Jacq. ex Willd.	wildeals
Brachylaena discolor	DC.	coastal silver-oak,
B. elliptica	(Thunb.) DC.	bitter leaf silver-oak
B. glabra	(L.f.) Druce	Malabar silver-oak
B. huillensis	O. Hoffm.	Lowveld silver-oak
B. ilicifolia	(Lam.) E.Phillips & Schweick.	small-leaf silver-oak
B. neriifolia	(L.) R.Br.	Cape silver-oak
B. rotundata	S. Moore	mountain silver-oak
B. transvaalensis	E. Philips & Schweick	forest silver-oak
B. uniflora	Harv.	tall silver-oak
Chrysanthemoides monilifera	(L.) T.Norl.	bush tick-berry
Gymnanthemum coloratum	(Willd.) H.Rob. & B.Kahn sens.lat	Lowveld bitter-tea
Gymnanthemum myrianthum	(Hook.f.) H.Rob.	blue bitter-tea
Lopholaena platyphylla	Benth.	broad-leaved fluff bush
Metalasia densa	(L.) D. Don	bristle-bush
Stoebe vulgaris (syn *Seriphium plumosum)*	(L.) Thunb	zig-zag bush
Tarchonanthus camphoratus	L.	camphor bush
T. littoralis	P.P.J.Herman	coast camphor bush
T. minor	Less.	-
T. obovatus	DC.	-
T. parvicapitulatus	P.P.J.Herman	small-head camphor bush
T. trilobus var. *galpinii*	(Hutch. & E.Phillips) Paiva	broad-leaf camphor bush
T. trilobus var. *trilobus*	DC.	trident camphor bush

4.2 Identifying *Tarchonanthus* in the archaeological charcoal by direct comparisons with modern charcoal anatomy

A selection of woody Asteraceae from KZN was made for the study of their wood anatomy, *Artemisia afra* which is widely used as traditional medicine (Van Wyk 2009), *Brachylaena discolor, B. huillensis, B. rotundata, B. transvaalensis* and *B. uniflora*, *Tarchonanthus parvicapitulatus* (syn. *T. camphoratus*) and *Chrysanthemoides monilifera* (L.) T.Norl. which is a low shrub or small tree (Boon 2010; Coates-Palgrave 2002). The criterion for choosing these Asteraceae is stem diameter (Table 4.1).

A representative sample of between one and three species of each genus, of *Artemisia*, *Brachylaena*, *Chrysanthemoides* and *Tarchonanthus* was studied and the carbonised wood is housed in the Palaeobotany Herbarium, Evolutionary Studies Institute (ESI) at the University of the Witwatersrand (WITS). As shown in Table 4.2, each sample has a voucher specimen, collected by S.J. Lennox (SJL). The wood stem diameters were 2 cm, length 20 cm.

Table 4.2: The anatomical features of the charcoal of *Artemisia*, *Brachylaena, Chrysanthemoides* and *Tarchonanthus* The abbreviations are *rm* radial multiples, *vasi*- vasicentric, *pro*- procumbent, *sq*.- square, *upr*.- upright and brackets show variations

Plant Species **Source of information**	**Vessel bands / radials**	**Vessel diameter (µm)**	**Vessel frequency (#/mm)**	**Parenchyma paratracheal**	**Parenchyma apotracheal**	**Ray width in cells**	**Ray body cells**	**Ray marginal cells**	**Fibres walls, Storied rays.**
Artemisia afra SJL 90	growth rings	50	40-100	-	narrow bands	1-3	mix	upr, sq	med- thick
Brachylaena discolor SJL 56 & Allott 26	1-3 rm	50	40-100	vasi-	-	1-3	pro.	upr, sq	med-thick, R ± storied
	1-3, ≥ 4 rm	50	40-100	vasi- (confl.)	-	1-2	pro.	-	thick, R ± storied
Brachylaena huilensis SJL 41 & Inside Wood	≥ 4 rm	50	≥ 100	scanty	diffuse	(1)-3	pro.	upr / sq	thick, R ± storied
	≥ 4 rm	50, 50-100	≥ 100	scanty	diffuse (bands)	(1)-3	pro.	upr / sq	thick, R storied
Brachylaena rotundata Allott 28	1-3, ≥ 4 rm	50	40-100	(vasi-)	diffuse	1-3-5	pro.	-	thick, R ± storied

Plant Species Source of information	Vessel bands / radials	Vessel diameter (µm)	Vessel frequency (#/mm)	Parenchyma paratracheal	Parenchyma apotracheal	Ray width in cells	Ray body cells	Ray marginal cells	Fibres walls, Storied rays.
Brachylaena transvaalensis Allott 27	≥ 4 rm	50-100	20-40	vasi-(confl.)	-	2-3-6	pro.	-	thick, R storied
Brachylaena uniflora SJL 61	solitary	50-100	40-100	scanty	-	1-2-3	pro.	upr	med-thick/ thick
Chrysanthemoides monilifera Allott 29	1-3, > 4 rm	50-100	20-40	scanty	wide bands	1-3	upr	-	thick
Tarchonanthus parvicapitulatus SJL 92	1-3 rm	50	≥ 100	scanty	-	1-2	pro, (sq)	(sq, upr)	med- thick
Tarchonanthus trilobus Kromhout 163	≥ 4 rm	50-100	40-100	diffuse	-	1-2-3	pro.	-	thick
B. discolor MOD C6a 32	≥ 4 rm	50	40-100	scanty, vasi-	-	1-4	pro.	sq	thick, R + storied
B. discolor SPCA B4c 11	≥ 4 rm	50	20-40	scanty	diffuse	1-3	pro.	upr	thick, R + storied
B. discolor SPCA B4c 18	≥ 4 rm	50	20-40	scanty	diffuse	1-4	pro.	upr	med-thick, R + storied
B. discolor SPCA B4c 32	≥ 4 rm	50	40-100	scanty, vasi-	-	1-4	pro.	-	med-thick, R ± storied
T. parvicapitulatus SPCA B4b 08	1-3 rm	50	≥ 100	scanty	-	1-2	pro, (sq.)	(sq)	med- thick
T. parvicapitulatus SPCA B4b 22	1-3 rm	50	≥ 100	scanty	-	1-2	pro, (sq)	(sq)	thin
T. parvicapitulatus SPCA B4c 27	1-3 rm	50	≥ 100	scanty	-	1-2	pro, (sq)	(sq)	thin

Anatomical features of living/fresh woods in the Allott (2005) charcoal (SEM) reference collection and on the InsideWood database (2004) as well as specialised literature (Carlquist, 1961, 1966 and 2001; Kromhout 1975) were used for comparative identification (Bamford 2011). The reference material studied included *Brachylaena discolor* (Allott 26), *B. transvaalensis* (Allott 27), *B. rotundata* (Allott 28), *Chrysanthemoides monilifera* (Allott 29) and *Tarchonanthus trilobus* (Kromhout 163).

Charcoal specimens from layers Spotty Camel (SPCA) and Mottled Deposit (MOD) were studied. SPCA has not been dated, but lies between layers with ages of approximately 61 300 and 56 000 years ago. MOD has an age of approximately 49.1 ± 2.1 ka (Jacobs *et al.* 2008a and b; Wadley 2015: 165). The ages of occupational floors were previously obtained by OSL dating.

4.3 Descriptions of the modern reference material

Artemisia afra. Material studied: SJL 90 (Fig. 4.1)

The distinct growth rings are traced by axial parenchyma in narrow bands of less than three cells. Vessels are mostly in clusters and occasionally solitary. Some vessels are angular in outline. Vessels are small with a mean tangential diameter of less than 50 µm and are abundant with between 40–100 vessels/mm^2. Perforation plates are simple and horizontal. Inter-vessel pits and vessel-ray pits are alternate and small, ~6 µm or between 4 and 7 µm wide. Shiny deposits occur in the vessels. A pith of regular hexagonal cells occurs. The pith has a diameter of ~ 3 mm, which is approximately a half of the stem diameter of ~6 mm. Fibres are septate. The fibre walls are thin to thick (medium thick) with fibre lumina less than three times the double wall thickness and distinctly open (Wheeler et al. 1989). Simple pits occur in both tangential and radial walls. Rays are triseriate and heterocellular with procumbent, square and upright body cells and with one to two rows of marginal upright cells.

Brachylaena spp. Material studied: *B. discolor* SJL 56 (Fig. 4.2), *B. huilensis* SJL 41 (Fig. 4.4), *B. uniflora* SJL 61 (Fig. 4.5).

4.3.1 Common characteristics of the genus *Brachylaena*

In *Brachylaeana* according to Carlquist (1961), the wood porosity is diffuse-porous. Vessels are round and arranged in a diagonal pattern, with a low degree of grouping. Vessel diameters are small, $\leq$ 50 µm, but may be medium $\geq$ 50 µm. Perforation plates are simple and oblique. Intervessel pits and vessel-ray pits are alternate, minute, 2-4 µm and polygonal in shape with distinct borders. There may be grooves alongside the pits. Axial parenchyma is variable, for example, scanty paratracheal or vasicentric or apotracheal diff use. There may be paratracheal confluent or apotracheal banded axial parenchyma. Fibres are longer than vessels, thick walled and there are radially flattened fibres. Fibres are septate with simple to minutely bordered pits in both tangential and radial walls. Rays are frequently uniseriate and short, < 200 µm. Rays are frequent, ≥ 12 rays/mm. Ray cells are procumbent with square cells. Tyloses are absent.

4.3.2 Characteristics particular to *Brachylaena* species

Brachyaena discolor SJL 56. Vessels are arranged in short radials of two to four, vessel diameters are small to medium between 50 – 100 µm and abundant between 40-100/mm^2 Axial parenchyma is vasicentric. Rays are 1-3 (-6) cells wide. Rays are heterocellular with procumbent body cells and one row of marginal square cells. Rays are stacked in a pattern which tends towards being storied although these are not as regular as storied rays. Fibre walls are thin to thick (medium thick). Vessels are wider than the fibres, in a ratio of ~5:1. The mineral inclusions are prismatic crystals which rarely occur and which fill the ray cells (Fig. 4.2).

B. huilensis SJL 41. Vessels are arranged in radial multiples of four or more, small and dense ≥ 100 vessels/mm^2. The helical thickenings reported in B.huilensis vessels by Essien *et al*. (2012) were not visible in this material. Axial parenchyma is diffuse or scanty. Rays are triseriate, occasionally uniseriate. Ray body cells are procumbent, occasionally with one r ow of upright and/or square marginal cells. Fibre walls are thin to thick (medium thick), but some have thick walls as a variation where the fibre lumina are almost completely closed (Wheeler *et al*. 1989). A shiny deposit is visible in the vessels (Fig. 4.3).

B. rotundata Allott 28 (2005). Vessels are arranged in short radial multiples of one to three, with the variation of having long radial multiples of more than four, vessels are small, approximately 50 µm and abundant between 40 and 100/ mm^2. Axial parenchyma is diffuse, occasionally vasicentric. Rays are one to three to five cells wide. Ray cells are procumbent. Rays tend to storied. Fibre walls are thick.

B. uniflora SJL 61. Vessels are arranged in short radials of one to three, many are solitary, small or medium, 50–100 µm and abundant. Axial parenchyma is scanty. Rays are 1-2-3 cells wide. Rays are heterocellular, procumbent body cells with one row of marginal square cells. Rays tend to storied. Fibre walls are thin to thick (medium thick), to very thick as the fibre lumina is almost completely closed. Fibres are septate with simple pits in both tangential and radial walls. Mineral inclusions are present as prismatic crystals occur in procumbent ray cells (Fig. 4.4).

4.3.3 Distinction between *Brachylaena* species

There are some differences between the very similar *Brachylaena* species. *B. discolor, B. huilensis* and *B. uniflora* rays are narrow, triseriate and the arrangement is heterocellular consisting of procumbent body cells, with one row of square marginal cells. On the contrary, *B. transvaalensis* and *B. rotundata* rays are widest with up to 5-6 cells and the arrangement is homocellular consisting of procumbent body cells.

Tarchonanthus parvicapitulatus Material studied: SJL 92 (Fig. 4.5).

Tarchonanthus parvicapitulatus wood is diffuse-porous. Vessels are in low radial lines of one to three to five cells, small, ~29 µm wide, round and dense, $\geq$100 vessels/mm^2 . Perforation plates are simple and oblique. Inter-vessel pits are alternate and minute, $\leq$ 2 µm. Vessel- ray pits and inter-vessel pits are alternate, minute, < 2µm and with distinct borders. Axial parenchyma is scanty. Rays are narrow, uni- to biseriate, low and frequent, $\geq$12/mm. The rays are heterocellular, with long and short procumbent cells and rare, square cells which infrequently distributed within each ray. Fibres are septate, fibre walls are thin to thick (medium thick). Shiny deposits are present in the vessels and central pith cells, it is possibly gum and is abundant in the pith where all the cells are filled.

4.3.4 Distinction between *Tarchonanthus parvicapitulatus* and *T. trilobus*

Tarchonanthus parvicapitulatus rays are heterocellular consisting of procumbent body cells and rare intermittent square cells, whereas *T. trilobus* (Kromhout 1975) rays are homocellular consisting of procumbent cells.

Chrysanthemoides monilifera Allott 29 (Table 4.2).

Growth rings are distinct and consist of parenchyma and fibres. The vessels are arranged in short radial multiples of 1-3 cells; some are in long radial multiples of $\geq$ 4 cells. Vessels are medium in diameter $\leq$ 100 µm and abundant $\geq$ 40/mm^2. The perforation plates are simple and the inter-vessel pits are alternate and small $\geq$ 3 µm. Parenchyma is apotracheal banded
and paratracheal scanty. Fibres are thick walled and $\leq$ 1 mm in length. Rays are homocellular with upright cells and there are $\geq$ 12 /mm.

4.4 Characteristics useful for distinguishing between *Artemisia*, *Brachylaena, Chrysanthemoides* and *Tarchonanthus* genera.

The following characteristics of the Asteraceae were observed in this material, vessels are arranged in radial lines, occasionally in clusters; vessels are small, 50 µm to medium, 50-100 µm and abundant, 40-100/mm^2 ; vessel plates are simple, horizontal or oblique; axial parenchyma is sparse, for example scanty or diffuse; inter-vessel pits are alternate and minute; the vessel-ray pits are equal in size and shape; the fibre pits are small and simple; the rays wide, occasionally uniseriate and occasionally storied; rays are composed of heterocellular, irregular, mixed procumbent and upright cells, crystals are rare and there are various types including prismatic (Metcalfe and Chalk 1950).

4.4.1 Differences between *Artemisia* and *Chrysanthemoides*

The *Artemisia afra* SJL 90 charcoal specimens are distinguished from the *Chrysanthemoides monilifera* Allott 29 charcoal samples in the Allott reference collection (2005) by the banded parenchyma and ray cell arrangement. *A. afra* parenchyma is arranged in narrow bands of less than three cells and the rays are heterocellular consisting of mixed procumbent, square and upright cells with marginal upright cells. On the contrary, *C. monilifera* parenchyma is arranged in wide bands of greater than three cells and the rays are homocellular consisting of upright cells.

4.4.2 Differences between *Brachylaena* and *Tarchonanthus* genera

B. discolor, SJL 56 vessel diameter, 50 µm is greater than *T. parvicapitulatus*, SJL 92, 30 µm. *B. discolor* vessel density, 40–100 vessels/mm^2 is greater than *T. camphoratus*, $\geq$ 100 vessels/mm^2. Axial parenchyma is scarce, in *B. discolor*, the arrangement is vasicentric and in *T.camphoratus* parenchyma is scanty. In *Brachylaena* the ray width is 1-6 cells: *B. rotundata* 1-3-5 (Allott 28, 2005) and *B. transvaalensis* 2-3-6 (Allott 27, 2005). In *Tarchonanthus* the width is 1-3: *T. parvicapitulatus* 1-2 and *T. trilobus* 1-3 (Kromhout 163, 1975). *B. discolor* rays are either homocellular with procumbent cells or heterocellular with procumbent body cells or one row of marginal square cells. *T. parvicapitulatus* rays are heterocellular, procumbent, long and short body cells, with rare square cells. Rays tend to be storied in *Brachylaena* but not in *Tarchonanthus*. Fibres of *B. discolor* with diameters of 10 µm are narrower than *T. parvicapitulatus* with diameters of 20 µm. In *B. discolor* the vessels are wider than the fibres, but similar in *T. parvicapitulatus*. The vessel to fibre diameter ratio is high in *B. discolor* with 50/10 µm or 5:1 and low in *T. parvicapitulatus* with 30/20 µm or 1.5:1.

Over all, *Brachylaena* vessel density is 40-100/mm^2 and vessels tend to be medium, 50-100 µm. *Brachylaena* has wide rays 1-3(-6) cells and rays tend to be storied. The ratio between vessel and fibre diameters in *B. discolor* is pronounced, ˜5:1. *Tarchonanthus* vessel density is 100 vessels/mm^2 and vessels tend to be small, $\leq$ 50 µm. *Tarchonanthus* rays tend to be narrower, 1-2 cells and rays tend not to be storied in *Tarchonanthus*. The ratio between the vessel and fibre diameter is even, ˜1.5:1.

In an early comparative study of woody Asteraceae which included *Brachylaena discolor* and *Trachonanthus camphoratus* (formerly in the Tribe Inuleae; Carquist 1961) the features which distinguish *Brachylaena* from *Tarchonanthus* are that *Brachylaena discolor* vessels are generally larger, $\geq$ 50 µm, vessels are less grouped, fibres are radially flattened and the parenchyma is diffuse and aliform (Carlquist 1961). On the contrary, *Tarchonanthus parvicapitulatus* vessels are generally narrower, < 50 µm, vessels are more grouped, fibres are both long and short which is termed dimorphic and parenchyma is scanty (Carlquist 1961). In contrast, *Brachyleana discolor* rays were not storied and *Tarchonanthus parvicapitulatus* presented storied structure (Carlquist 1961). In this study, the similarities between the species examined and those described by Carlquist are that the rays are frequently uniseriate and generally short, $\leq$ 200 µm, ray cells are procumbent and square, fibres are very long and generally longer than vessels fibre walls are exceptionally thick. These characteristics of *Brachylaena* and *Tarchonanthus* are in contrast to other Asteraceae where rays are generally multiseriate and mostly upright (Carlquist 1961). The characteristics of *Brachylaena discolor* and *Tarchonanthus parvicapitulatus* similar to other Asteraceae are narrow vessels, $\leq$ 50 µm, small inter vessel pits, ~ 5 µm, vessels arranged in groups and thin walled fibres.

4.5 Identification of *Tarchonanthus parvicapitulatus* and *Brachylaena* cf. *discolor* in archaeological charcoal from Sibudu

Brachylaena cf*. discolor.* Material studied: MOD C6a 32, SPCA B4c 32, SPCA B4c 11 and 18 (Fig.4.6, Table 4.2).

In the described specimen, MOD C6a 32, the vessels are in long radial multiples of four or more, vessels are small, 20 – 50 µm to medium, 50– 100 µm in diameter and abundant, 50 – 70 vessels/mm^2 . The inter-vessel and vessel-ray pits are alternate and minute, $\leq$ 4 µm. The axial parenchyma is vasicentric. Rays are one to four cells wide, low and frequent, 12 vessels per mm, tending to storied. Rays consist of nine rows of procumbent cells marginal square cells. The fibre walls are thin-thick. Vessels are wider than the fibres, in a ratio of ~5:1. Charcoal specimens SPCA B4a 06, SPCA B4a 17 and MOD E4a 54 are conferred *B. discolor* since features are distorted (Fig. 4.6).

Tarchonanthus parvicapitulatus. Material studied: SPCA B4b 22, SPCA B4c 27 and B4b 08 (Fig. 4.7, Table 4.2).

In the described specimen, SPCA B4b 22, the vessels are in short radial lines of 1-3-5, vessels are small, 20-50 µm and dense, 120-150 vessels/mm^2. The inter-vessel pits and the vessel- ray pits are alternate and minute, $\leq$ 4 µm. The axial parenchyma is scanty. The rays are narrow, biseriate, low and frequent, 12 vessels/mm, with absent storied structure. Rays consist of procumbent cells and occasionally these are short cells, with rare square cells. Fibre walls are thin with lumina diameter more than three times the width of the walls of two adjacent fibres (Wheeler *et al*. 1989). Vessels and fibres are similar in diameter, in a ratio of ~1.5:1.

4.6 Conclusion .

From the detailed anatomical study of modern reference material and other sources it is possible to distinguish between the selected woody Asteraceae. *Artemisia afra* and *Chrysanthemoides monilifera* are distinguished by means of banded parenchyma and ray composition. *Artemisia afra* rays are heterocellular, mixed cells with marginal upright cells and *Chrysanthemoides monilifera* rays are homocellular, upright cells.

Tarchonanthus parvicapitulatus vessel density is higher than that of *Brachylaena discolor*. There is less difference between vessel and fibre diameters in *Tarchonanthus parvicapitulatus* than in *Brachylaena discolor*. *Tarchonanthus parvicapitulatus* rays are narrower than the *Brachylaena discolor* rays which tend to storied. *Tarchonanthus parvicapitulatus* ray cells are procumbent, occasionally square. *Brachylaena discolor* ray cells are procumbent with marginal square cells.

Woody taxa in charcoal from hearths from SPCA, ~58ka and from MOD, ~49ka are *Brachylaena discolo*r SPCA B4c 18 and MOD C6a 32. On the contrary, *Tarchonanthus parvicapitulatus* charcoal specimens SPCA B4c 27 and SPCA B4b 22 are only from SPCA ~58ka. *Brachylaena discolor* is common in coastal forest and adjacent woodland *Tarchonanthus parvicapitulatus* occurs in forest and bushveld, mostly inland to 1 850m.

Brachylaena discolor may simply have been collected as useful firewood. It seems likely that *Tarchonanthus parvicapitulatus* was deliberately selected for its medicinal properties, due to aromatic oils in the leaves, and perhaps its smoke repelled insects from the camp in Sibudu cave. Insecticidal and larvicidal leaves of *Cryptocarya woodii* have been recovered from bedding in the 77 ka layers of Sibudu Cave (Wadley et al., 2011) and the charcoals of poisonous wood *Spirostachys africana* were found in hearths of BYA2(i), SPCA and MOD layers (Chapters 5 and 6; Lennox and Bamford, 2015). The confirmed presence of *T. parvicapitulatus* in one hearth from SPCA layer is another addition to the likely medicinal repertoire at Sibudu in KwaZulu Natal.

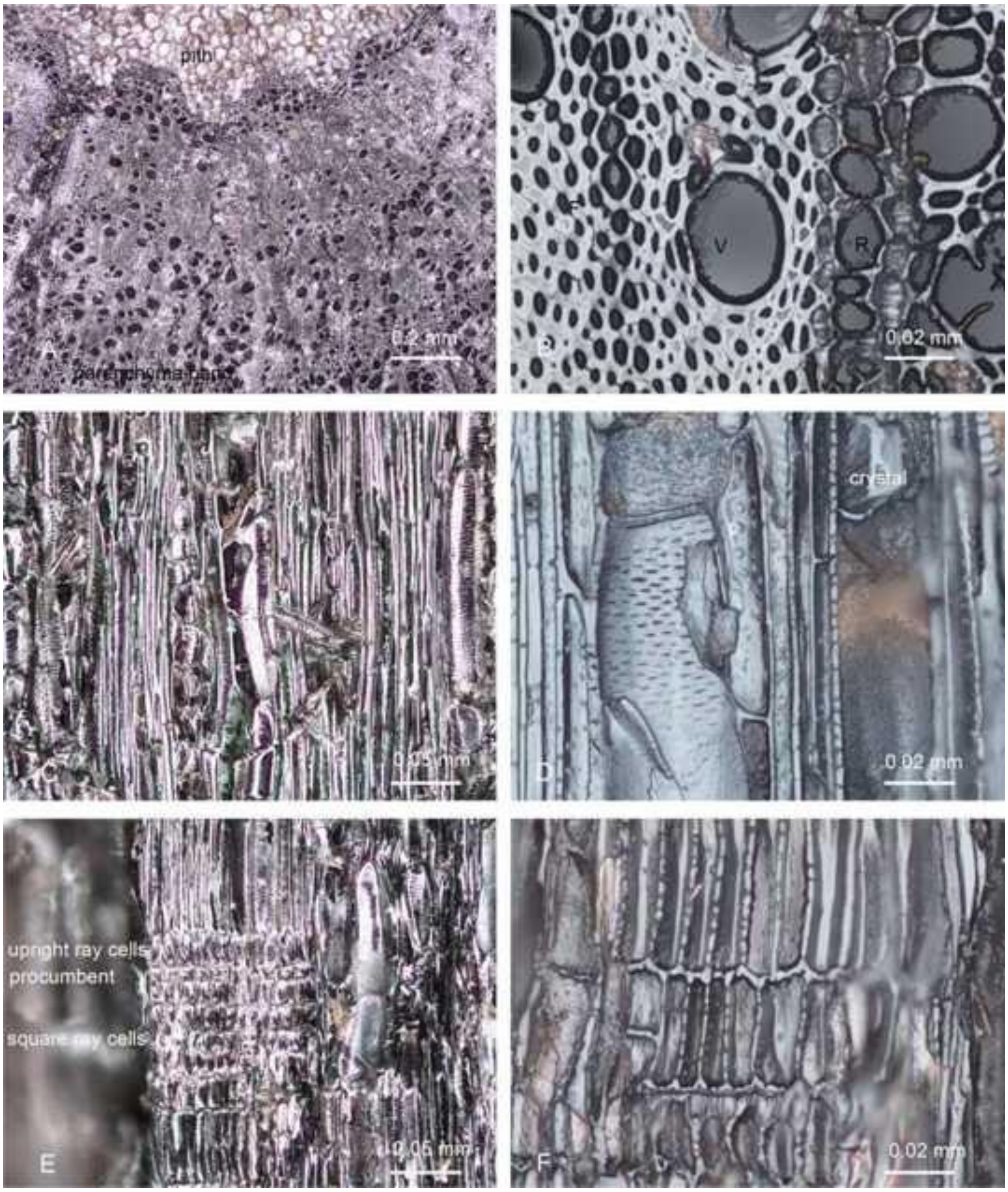


Figure 4.1: Microphotographs at x200 and x500 of *Artemisia afra,* SJL 90. (A) TS (transverse section) of growth rings traced by thin parenchyma bands, with central pith approximately half the width of the stem. (B) TS thin-thick walled fibres. (C) TLS (tangential longitudinal section) of triseriate rays. (D) TLS of inter-vessel pits, perforation plates and parenchyma (p). (E) RLS (radial longitudinal section) of rays with procumbent, square and upright cells. (F) RLS of marginal upright ray cells.

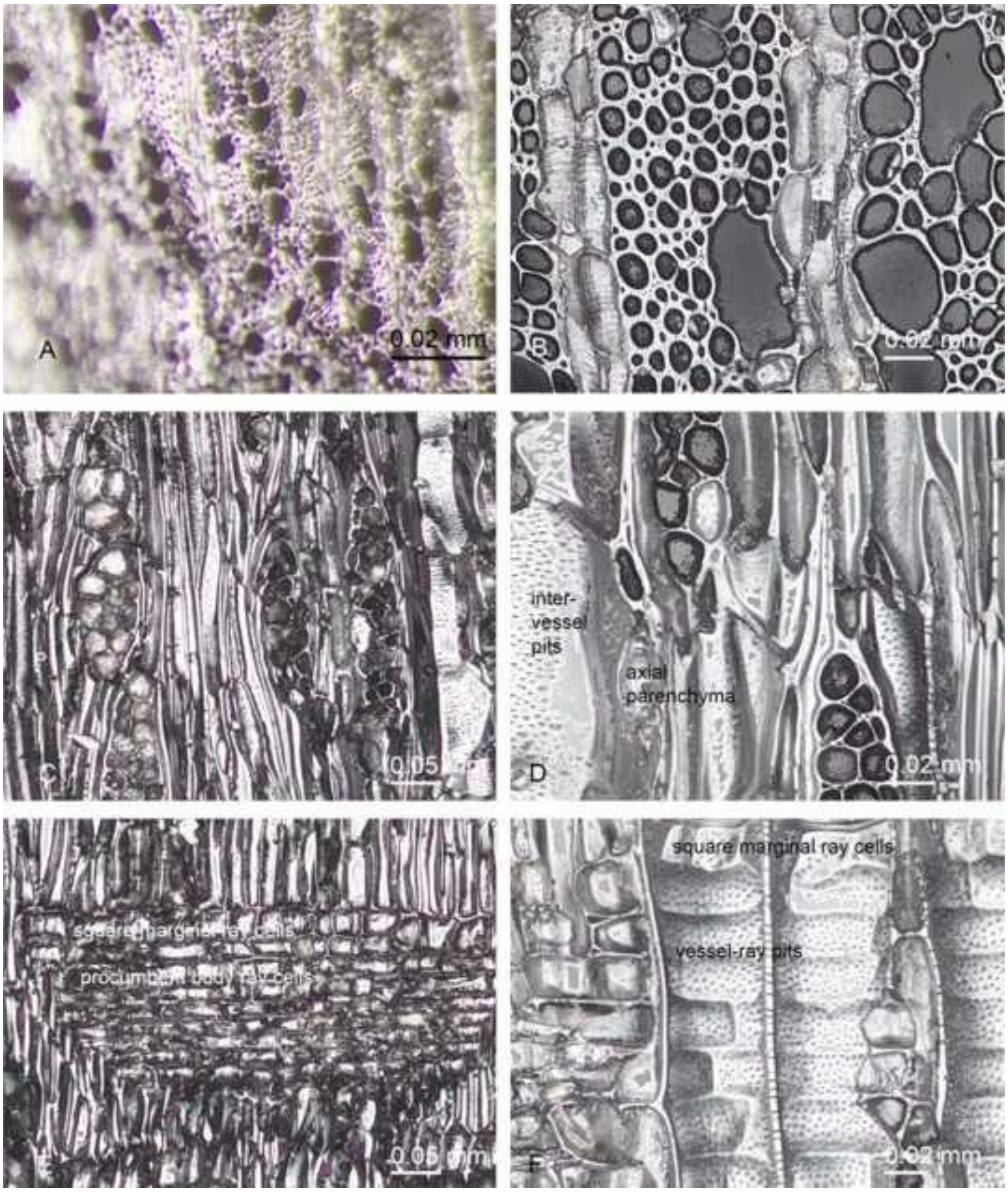


Figure 4.2: Microphotographs of *Brachylaena discolor,* SJL 56. (A) TS of vessels in short radials of two to four, vessels are small to medium and abundant. (B) TS of fibres with thin-thick walls and narrower than vessels. (C) TLS of triseriate rays which tend to storied, with crystals. (D) TLS of intervessel pits and vasicentric parenchyma. (E) RLS of rays with procumbent cells and one row of marginal square cells, (F) RLS of vessel-ray pits equal in size and shape to inter-vessel pits.

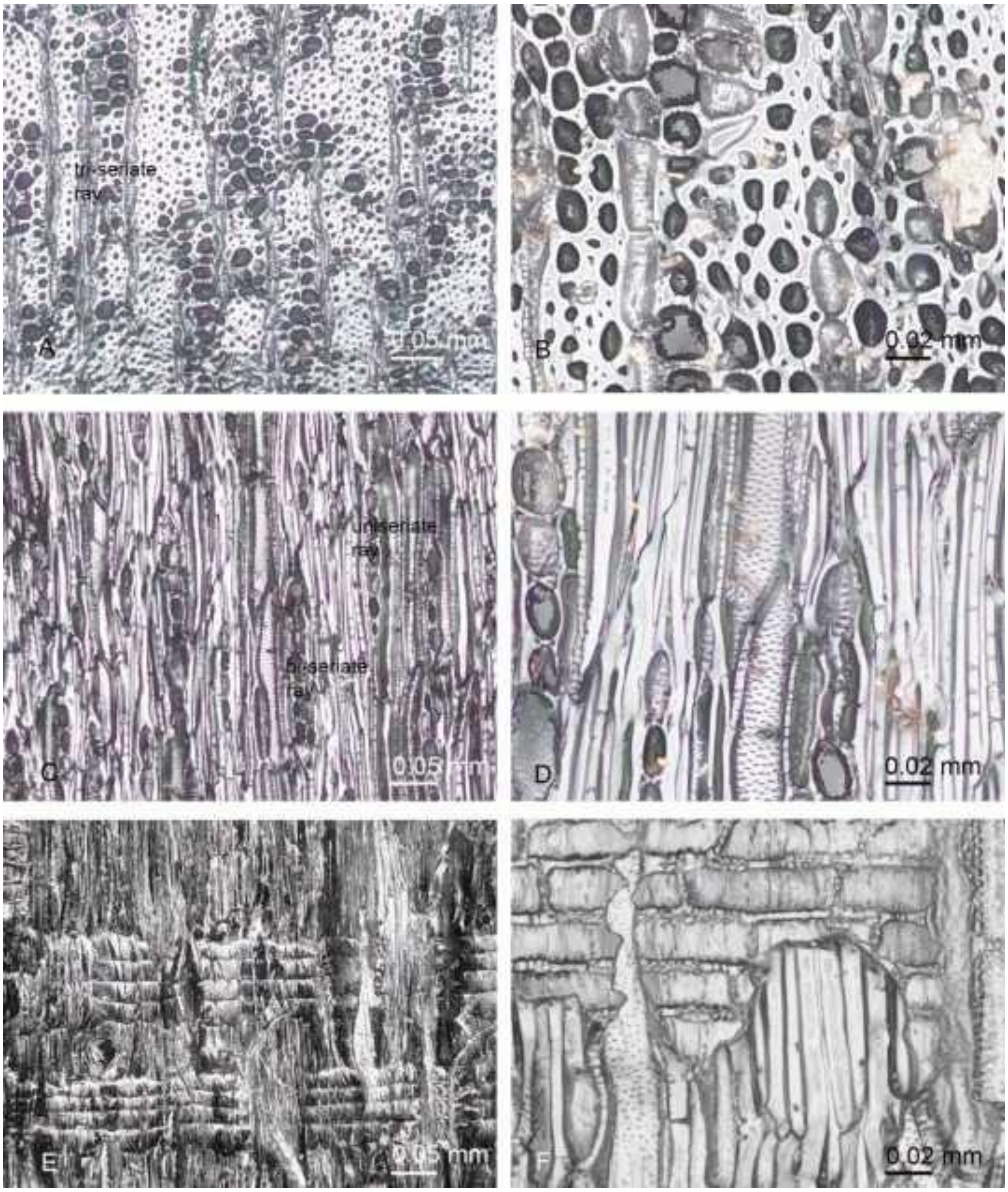


Figure 4.3: Microphotographs of *Brachylaena huilensis*, SJL 41. (A) TS of vessels in long radial multiples with scanty parenchyma. (B) TS of very thick fibre walls. (C) TLS of uniseriate and triseriate rays. (D) TLS pf perforation plates, intervessel pits distinctly bordered and septate fibres. (E) RLS of procumbent rays. (F) RLS of vessel-ray pits equal to intervessel pits.

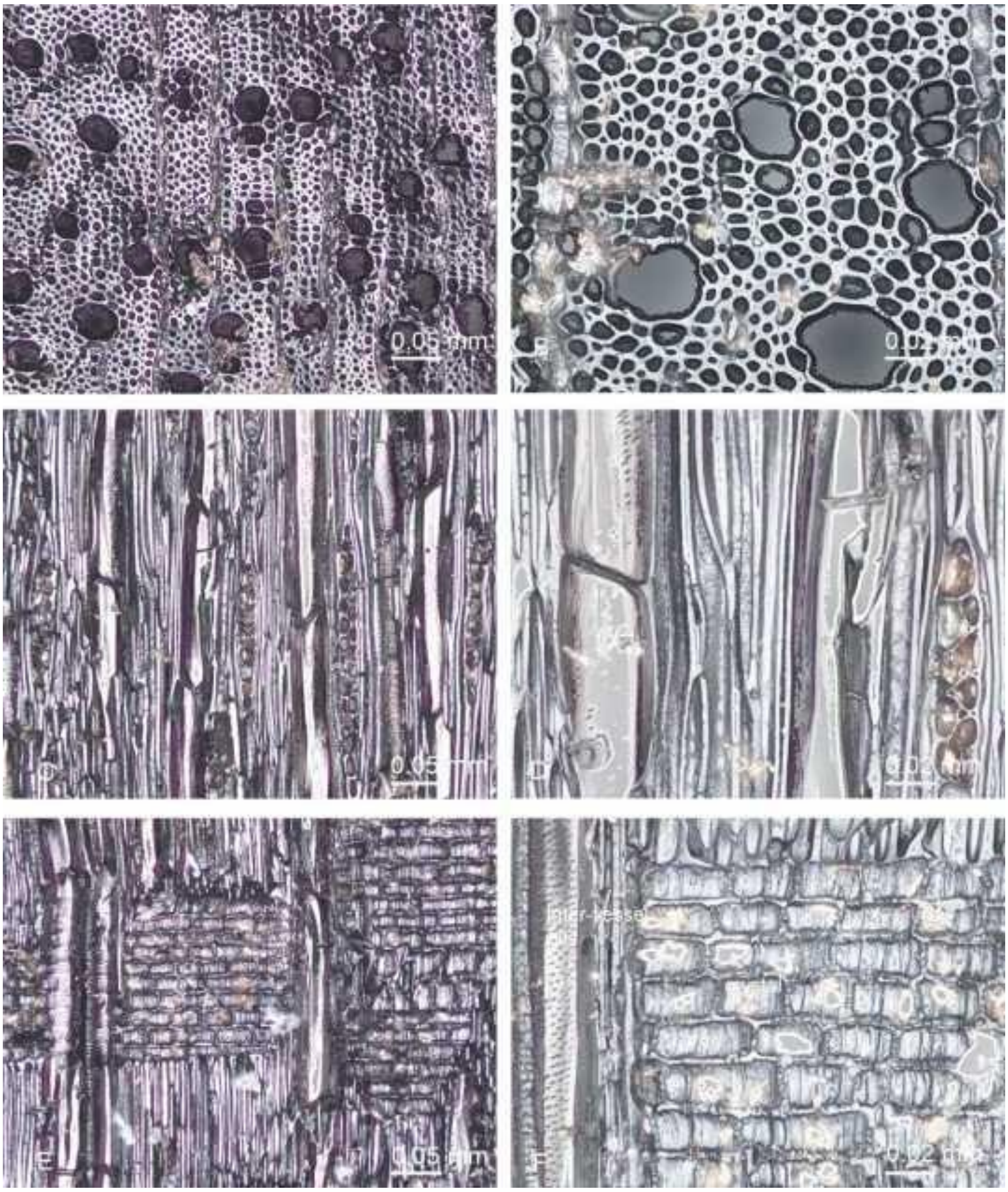


Figure 4.4: Microphotographs of *Brachylaena uniflora*, SJL 61. (A) TS of vessels in short radials, occasionally solitary and abundant. The axial parenchyma is scanty. (B) TS of thin-thick walled fibres. (C) TLS of bi- to triseriate rays. (D) TLS of crystals in ray cells and of intervessel- pits. (E) RLS of procumbent ray cells (F) TLS of prismatic crystals and of vessel-ray pits similar in size and shape to inter-vessel pits.

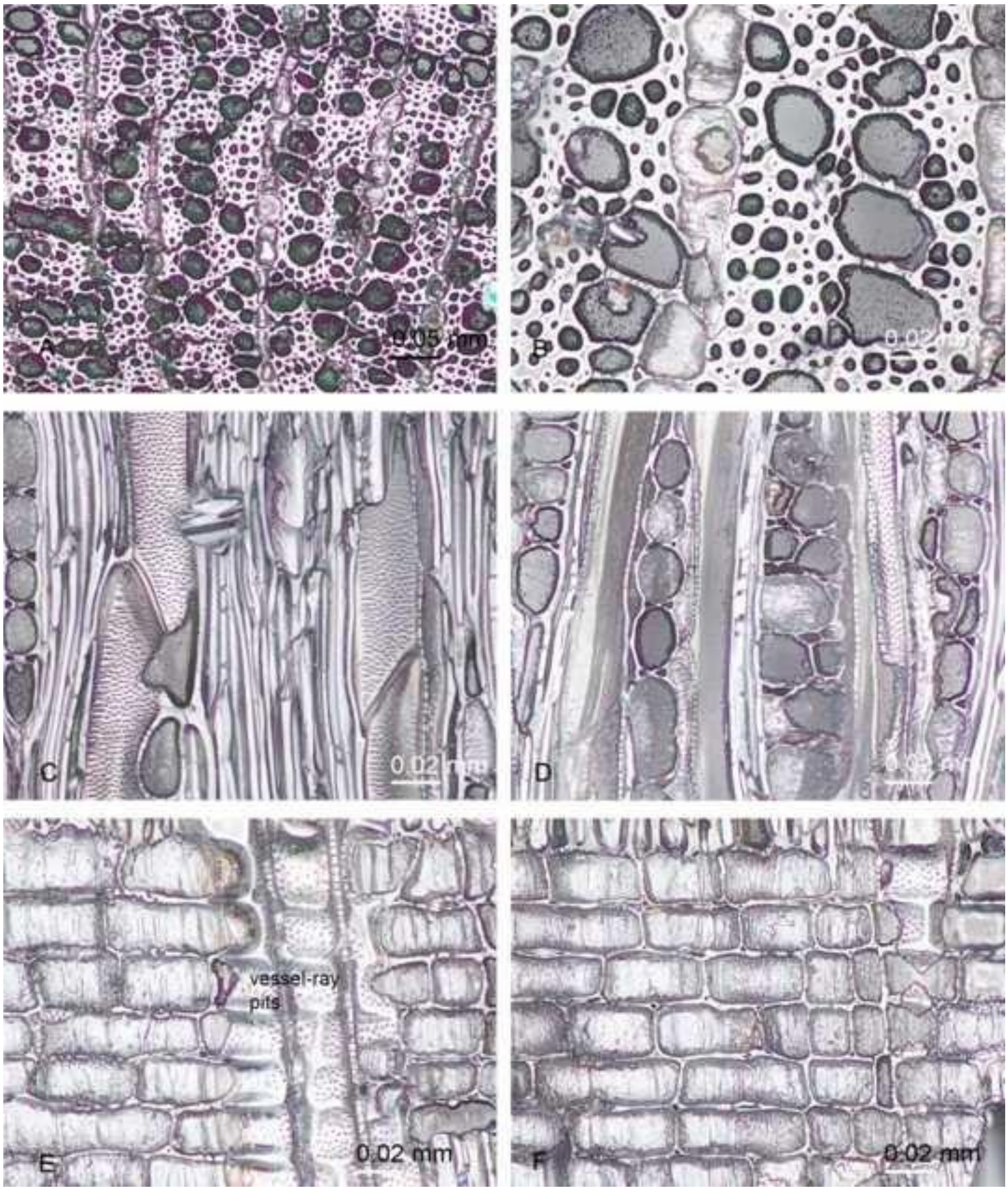


Figure 4.5: Microphotographs of *Tarchonanthus parvicapitulatus*, SJL 92. (A) TS of vessels in short radials of 1-3-5 cells, vessels are small and dense. Vessels are similar to fibres in diameter. (B) TS of scanty parenchyma and fibres with thin-thick walls. (C) TLS of perforation plates and inter-vessel pits (D) TLS of biseriate rays (E) RLS of vessel ray pits equal to inter- vessel pits. (F) RLS rays of procumbent cells with rare square cells.

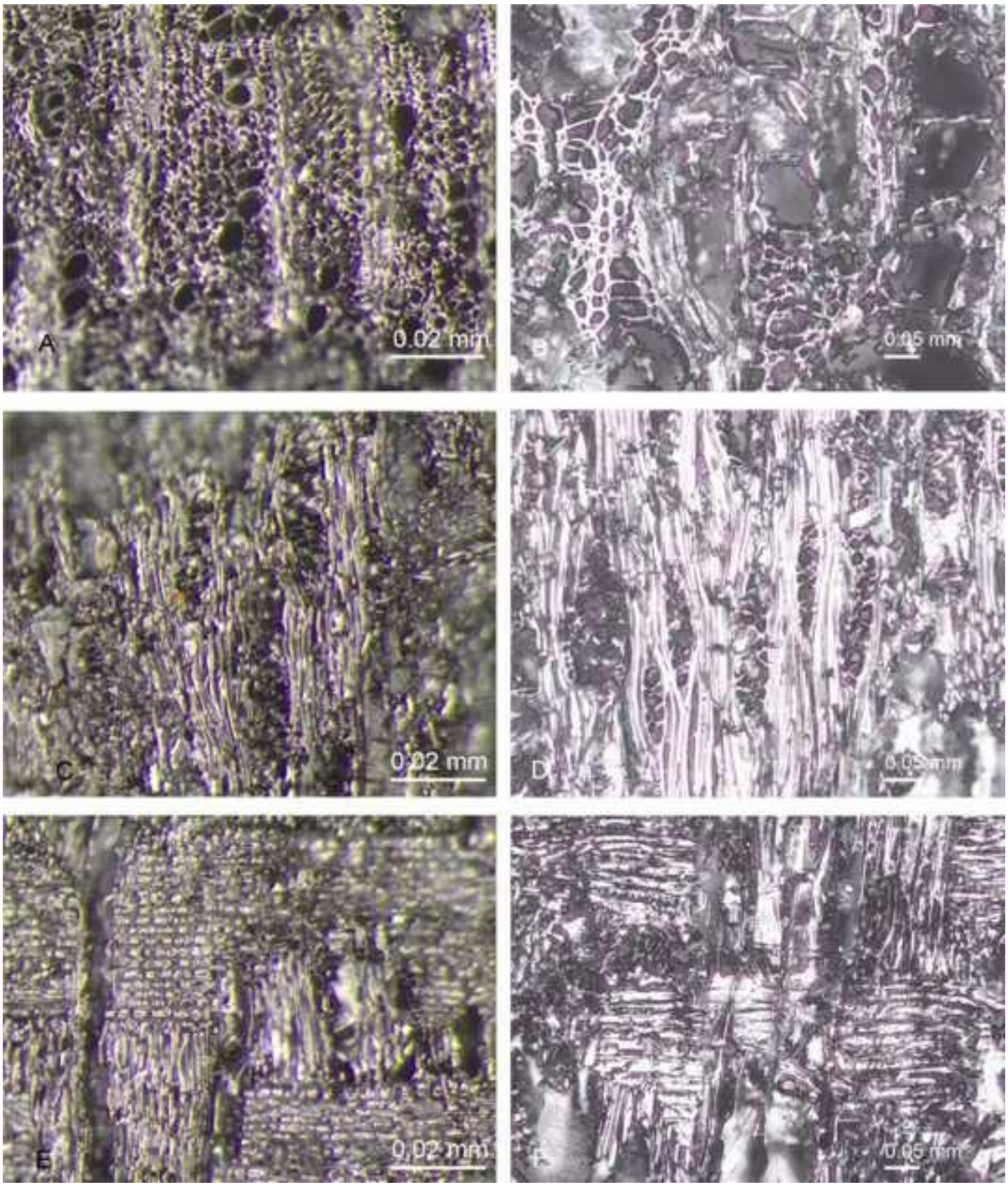


Figure 4.6: Microphotographs of *Brachylaena* cf*. discolor* in the archaeological charcoal, MOD C6a 32and SPCA B4c 32. MOD C6a 32 (A,C,E) (A) TS of small and abundant vessels, fibres with thin-thick walls, where vessles are wider than fibres. (C) TLS of wide rays which tend to storied. (E) RLS of rays of procumbent cells with marginal square cells. SPCA B4c 32 (B,D,F): (B) TS of small and abundant vessels, and thin-thick fibre walls (D) TLS of wide rays which tend to storied. (F) RLS of procumbent ray cells. The distortion is due to the nature of the archaeological charcoal.

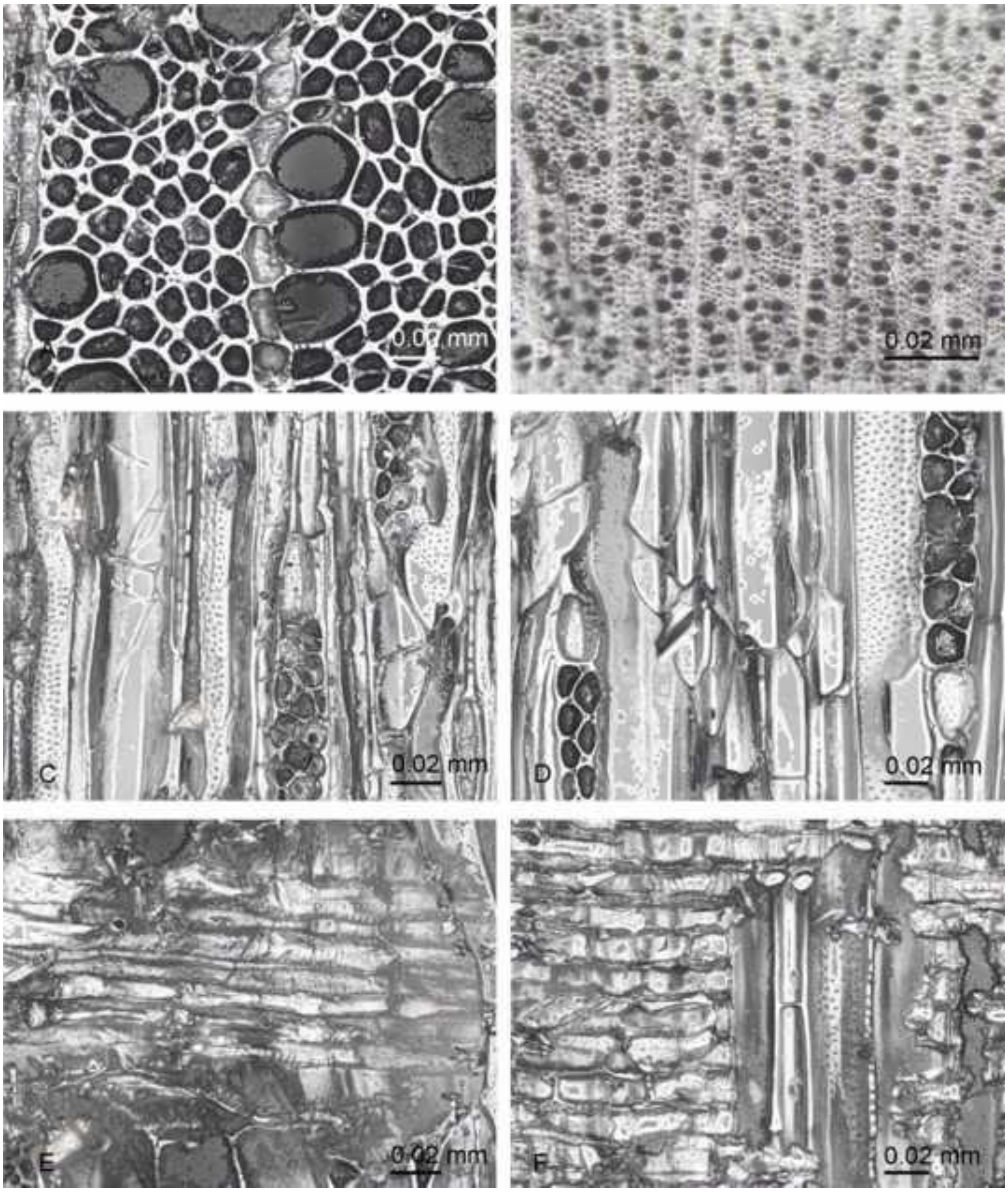


Figure 4.7: Microphotographs of *Tarchonanthus parvicapitulatus* in the archaeological charcoal, SPCA B4b 22 and SPCA B4c 27. SPCA B4b 22 (A,C,E): (A) TS of vessels in short radials of 1-3-5 cells, vessels are small and dense. Fibre walls are thin. Vessels and fibres are similar in diameter. Parenchyma is scanty; (C) TLS of biseriate rays and irregular cells. Inter-vessel pits are alternate and minute (E) RLS of procumbent ray cells. SPCA B4c 27 (B,D,F): (B) TS of vessels in 1-3-5 radial multiples, vessels are small and dense. Fibre walls are thin. (D) TLS of biseriate rays biseriate. Inter-vessel pits are alternate and minute. (F) RLS of rays of procumbent, occasionally short cells.

CHAPTER 5

CHARCOAL ANALYSIS FROM 58 000 YEAR OLD HEARTHS IN BYA2(i) AT SIBUDU: IMPLICATIONS FOR AN UNDERSTANDING OF WOOD USES AND FOR THE ENVIRONMENT

5.1 Introduction

The layer BYA2(i) was selected because it has three hearths that were not previously studied except for a small charcoal sample from Hearth 1 from BYA2(i) analysed by Lucy Allott for Silje Bentsen (2014b). The identified taxa suggested that this layer was worth further investigation.

5.2 Materials and methods

Seven hundred charcoal pieces from the BYA2(i) collection of charcoal made by Lyn Wadley and colleagues, were analysed and identified using the criteria presented in chapter 2. Charcoal was studied from eight quadrants in two squares, B4 and C4. One large hearth, two small ones and two putative ash dumps are present in these two squares. The layer and the hearths have been described in Chapter 1 in Section 2 and in Figures 1. 3 to 1.6. Hearth 1 in BYA2(i) contains charcoal placed into packets labelled Hearth 1 base (B4a,b,C4a-d), Hearth 1 light base (C4b), Hearth 1 middle (B4a,b,d,C4a), Hearth 1 top and bottom (B4d), Hearth 1 top (B4d), Hearth 1 (C4a- d), Hearth 1 ash dump (C4a,b), Hearth 1 ash heap (B4a) and charcoal adjacent to Hearth 1 (B4d). Hearth 2 charcoal is in packets labelled Hearth 2 (C4d), Hearth 2 base (B4a), Hearth 2 orange base (B4c) and Hearth 2 top (B4b). Hearth 3 contains charcoal from B4a and C4b (Fig.2). Organic preservation is good in BYA2(i) and the charcoal fragments collected from the layer are $\leq$ 2mm to $\geq$ 4.76 mm, and well-preserved. This observation was also made by Allott (2006) for charcoal from similarly aged layers Eb (Ebony), SPCA and BSp (Brown Speckled). Microphotographs of a selection of woody taxa are shown in Appendix A. Species lists and the IAWA features of each charcoal specimen with matching comparative reference material and a comparative summary are listed in Appendix B. In order to interpret the diversity of woods in each hearth from the published literature on modern plants the main uses of the woods have been assimilated (Appendix D) and are presented in Table 5.1 and Fig. 5.1 with captions in Table 5.2. These uses have been simplified into five categories: fuel, tinder, firesticks, poison and medicine, as previously discussed (Chapter 1, Section 3). Many plants have more than one use but the interpreted major use has been listed here. The line of reasoning adopted in Chapter 1 Section 3 for multiple uses is that most woods can be burned as fuel but most would not be used as medicine, for example for aromatic smoke. Nonetheless, the suggested use of aromatic smoke is only a possibility except for the *Spirostachys africana*.

5.3 Results

5.3.1 The taxonomic composition of the charcoal assemblage

In all, 69 woody taxa were distinguished when 598/700 charcoal fragments were identified. This includes 39 families and 55 genera (Table 5.1). One new family, Apocynaceae, *Tabernaemontana ventricosa* cf. and 28 new genera have been added to the charcoal record. Four of the new charcoal genera are already in the archaeological seed record, namely *Canthium* sp. from layers OMOD and MOD (~49 ka*), Cordia* cf. *caffra* from Su–Mi and Or–SPCA (~58 ka), in addition to YSp–RSp (~49 ka), *Harpephyllum caffrum* from BMOD–OMOD2, OMOD and MOD (~49 ka) and *Pavetta* spp. from YA2–G1, Or–SPCA (~58 ka), YSp–RSp, BMOD–OMOD2, OMOD and MOD (~49 ka)(Sievers 2006; Jacobs *et al.* 2008 a, b; Wadley 2015: 165).

5.3.2 Relative frequency of the occurrence of woody taxa from BYA2(i)

Many woods are restricted to one hearth, for example *Spirostachys africana* charcoal occurs only in the base of Hearth 1 (Fig 5.1 with details in the captions given in Table 5.2; Fig. 5.2). A few woods occur in more than one hearth. Charcoal representing *Afrocarpus/Podocarpus* spp., *Buxus macowanii* and *Vangueria randii* occurs in Hearths 1 and 2 and *Mystroxylon aethiopicum* occurs in Hearth 1 and 3. *Protea caffra* occurs in all three hearths. It is possible that the wood was used for a similar purpose in the different hearths. There are two heaps of ashes from Hearth 1, the ash heap and the ash dump. The ash dump is evidence of sweeping out ash to clean a fireplace (Bentsen 2014b; Wadley *et al*. 2011). There are ten woody taxa in Hearth 1 ash dump and five in Hearth 1 ash heap. Three pieces of *Spirostachys africana* were identified according to Lennox and Bamford (2015), namely *S. africana* C4d 66 (Fig. 5.2) and charcoals *S. africana* C4d 15 and *S. africana* cf. C4a 57 were identified in Hearth 1 base. *Acacia* spp. charcoal occurs in Hearth 1 base and in sediment. *Acacia* spp. charcoals in this study have been divided into types according to the ray width measured in cell number according to Lennox *et al.* (2015) and in chapter 7. Type 1 rays are 1-2 cells wide (B4a 42, B4a 121), Type 3 rays are 1-5 cells wide (B4d 23, B4a 21, B4a 39), Type 4 rays are 4-10 cells wide (B4b 31, B4b 32). Type 2 *Acacia* spp, are absent. In this thesis the name *Acacia* is used for all the African *Acacia* species. Charcoal fragments of *Afrocarpus/Podocarpus* spp. which according to Bamford and Stevenson (2002) are indistinguishable from the wood anatomy, occur in Hearth 1 base, middle and top and in Hearth 2 top and bottom.

5.3.3 The distribution of fuel and medicinal wood in hearths from BYA2(i)

The charcoal fragments are interpreted as explained before (Chapter 1 Introduction, Section 3. History and status of the study; Chapter 2. Material and Methods, Section 2.2. Methods). The abundance (number of pieces) of any particular taxon are not interpreted as the relative abundance of that species. Instead the presence/absence of a species and the number of species in each separate quadrant is recorded.

The wood use categories based on literature (Appendix D) have been described before (Chapter 1 Introduction, Section 3. History and status of the study). Wood which may be used as firesticks, fuel or tinder is collectively regarded as "fuel wood", whereas wood from plants with medicinal or poisonous qualities, is collectively regarded as "medicinal wood" (Appendix D). The ratio of fuel to medicinal wood species was compared within the BYA2(i) hearths and between the hearths (Table 5.3). Overall more fuel than medicinal wood has been used. All hearths contain fuel wood, to start and maintain fires. It is noteworthy that *Afrocarpus/ Podocarpus spp., Buxus macowanii, Protea caffra, Mystroxylon aethiopicum* and *Vangueria randii* are found in several of Sibudu's features, for example, affirming what seems to be commonly used tinder and fuel woods. *Protea caffra* occurs in three hearths, and *Mystroxylon aethiopicum* in two hearths.

Table 5.1: The distribution of 69 woody taxa in BYA2i, in a study of 598/700 identified charcoal fragments. There are 55 genera and 39 families. Shaded taxa are new identifications (36 plants), not in previous lists of charcoal (Allott, 2006). An asterisk indicates 12 woody taxa previously represented in lists of identified seeds from Sibudu (Sievers, 2006, 2013). Names conferred are denoted cf. this means that the anatomical features and micrograph matched closely but not completely, usually due to distortion of the charcoal by the carbonisation process. The primary use of woody taxa as fire-sticks (fs), fuel (f), medicine (m), poison (p) and/or tinder (t) are recorded. Hearths and combustion features are shaded columns.

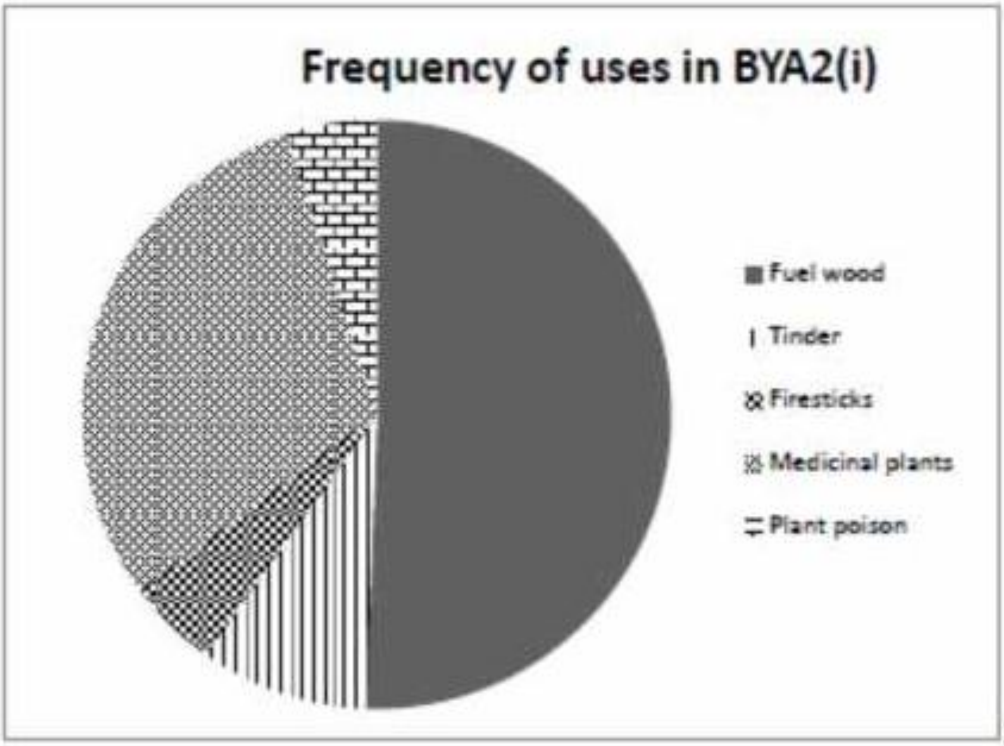
Scientific names	**Plant Families**	**Primary use**	**Hearth 1 base**	**Hearth 1 light base**	**Hearth 1 middle**	**Hearth 1 top**	**H1 top and bottom**	**H1 ash dump**	**H1 ash heap**	**adjacent to Hearth 1**	**H2 base**	**H2 orange base**	**H2 top & bottom**	**H2 top**	**H3 top**	**Sediments B4a,b,d**	**Total no. fragments**	**Distribution**
*Acacia**sp.type	MIM	f	4													2	6	2
Afrocarpus/ Podocarpus sp.	PDC	f	8		11	7							1	3		36	66	6
Allophylus dregeanus cf.	SAP	f	1										2				3	2
Brachylaena discolor cf.	AST	f	2		1								3		2	14	23	5
Buxus macowanii cf.	BUX	f	21		9	7		3					1			1	42	6
*Calodendrum capense**	RUT	m				1											1	1
Canthium mundianum* cf.	RUB	f	14		2											17	33	3
*Canthium** sp.	RUB	f	6		25												31	2
Canthium spinosum* cf.	RUB	f	1		1												2	2
Canthium suberosum* cf.	RUB	f	4					3									7	2
Celtis africana	CLT	f			3												3	1
*Volkameria glabra**	LAM	t	1		1	1			1								4	4
Cliffortia repens	ROS	t									1				6		7	2

Scientific names	Plant Families	Primary use	Hearth 1 base	Hearth 1 light base	Hearth 1 middle	Hearth 1 top	H1 top and bottom	H1 ash dump	H1 ash heap	adjacent to Hearth 1	H2 base	H2 orange base	H2 top & bottom	H2 top	H3 top	Sediments B4a,b,d	Total no. fragments	Distribution
Cola natalensis cf.	STR	f			2												2	1
Commiphora marlothii	BRS	m														3	3	1
*Cordia caffra** cf.	BOR	fs	3														3	1
Croton sylvaticus cf.	EUP	p				1											1	1
Cryptocarya liebertiana cf.	LAU	m	5														5	1
Cryptocarya woodii cf.	LAU	m	2		1											1	4	3
Cryptocarya wyliei	LAU	f	2		5											3	10	3
Cunonia capensis	CUN	m	5	3													8	2
Curtisia dentata	COR	m			5												5	1
Diospyros austro-africana*	EBN	fs			7												7	1
Dombeya rotundata	STR	m			1												1	1
Dovyalis rhamnoides cf.	FLC	f	1		1	1											3	3
Ekebergia capensis	MEL	m	1		1												2	2
Erica caffra	ERI	t	38		2			6									45	3
Faurea saligna cf.	PRT	f			1											1	2	2
Ficus lutea	MOR	f	2														2	1
Gardenia volkensii	RUB	m	2		4												6	2

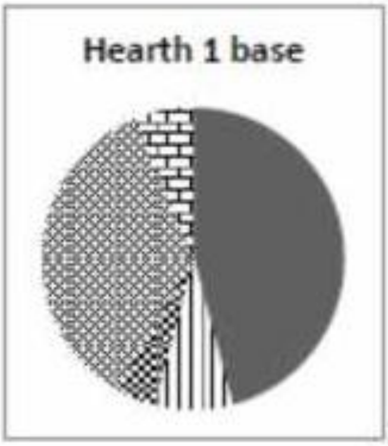
Scientific names	Plant Families	Primary use	Hearth 1 base	Hearth 1 light base	Hearth 1 middle	Hearth 1 top	H1 top and bottom	H1 ash dump	H1 ash heap	adjacent to Hearth 1	H2 base	H2 orange base	H2 top & bottom	H2 top	H3 top	Sediments B4a,b,d	Total no. fragments	Distribution
Halleria lucida	SCR	fs				1					2						3	2
*Harpephyllum caffrum** cf.	ANA	f	1			1				3							5	3
Hippobromus pauciflorus cf.	SAP	p	1		2	1	4										8	4
Indeterminate Asteraceae cf.	AST	t						2									2	1
Indeterminate Fabaceae cf.	FAB	f	1													1	2	2
Leucosidea sericea	ROS	f	1			1		3								17	22	4
Mimusops obovata cf.	SPT	m		2		1											3	2
Morella pilulifera	MYR	t							2						6		8	2
Mystroxylon aethiopicum	CEL	f	11		2	1		2		1					3	4	24	7
Nuxia floribunda	BUD	m							1						1		2	2
Ochna sp. cf.	OCH	f	1														1	1
Olea europaea* ssp. *africana*	OLE	f	2			1											3	2
*Pappea capensis**	SAP	m	3		3	3									1		10	4
Pavetta eylesii*	RUB	t	6														6	1

Scientific names	Plant Families	Primary use	Hearth 1 base	Hearth 1 light base	Hearth 1 middle	Hearth 1 top	H1 top and bottom	H1 ash dump	H1 ash heap	adjacent to Hearth 1	H2 base	H2 orange base	H2 top & bottom	H2 top	H3 top	Sediments B4a,b,d	Total no. fragments	Distribution
Pittosporum viridiflorum cf.	PIT	m	1		2	1						3					7	4
Protea caffra	PRT	f	5	1	4	2		1	2				1		2	2	20	9
Protea spp.	PRT	f	2		1												3	2
Psydrax obovata cf. (syn. *Canthium* obovatum*)	RUB	f														2	2	1
Ptaeroxylon obliquum cf.	PTX	m	4			1		2								3	10	4
*Rapanea melanophloeos**	MRS	m											1				1	1
Rhamnus prinoides	RHM	m	1														1	1
Rothmannia capensis cf.	RUB	f											2				2	1
Sclerocroton integerrimus	EUP	m	5	4													9	2
*Searsia *chirindensis* cf.	ANA	m	4		6											5	15	3
Searsia burchellii* cf.	ANA	t	3			7										5	15	3
Searsia dentata* cf.	ANA	f	6	1											4		11	3
Searsia erosa* cf.	ANA	m								1							1	1
Searsia leptodictya* cf.	ANA	f	5		11	2			3							4	25	5
*Searsia** sp. cf.	ANA	f	2			2		1									5	3

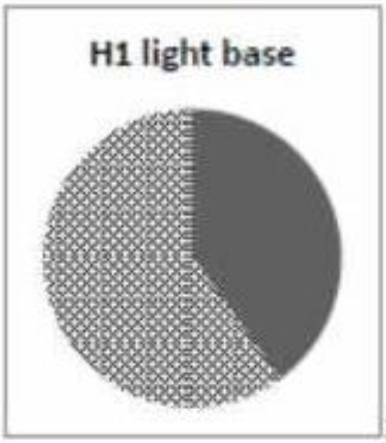
Scientific names	Plant Families	Primary use	Hearth 1 base	Hearth 1 light base	Hearth 1 middle	Hearth 1 top	H1 top and bottom	H1 ash dump	H1 ash heap	adjacent to Hearth 1	H2 base	H2 orange base	H2 top & bottom	H2 top	H3 top	Sediments B4a,b,d	Total no. fragments	Distribution
Shirakiopsis elliptica cf.	EUP	f	2														2	1
Spirostachys africana	EUP	p	3														3	1
Tabernaemonta na ventricosa cf.	APO	m	1														1	1
Trema orientalis cf.	CLT	m	1		1	1											3	3
Vangueria madagascarensis cf.	RUB	f			2												2	1
Vangueria randii cf.	RUB	p	2		1	1		1		6		2					76	6
Vitex rehmannii cf.	LAM	m	1		1									4			6	3
Ximenia caffra cf.	OLC	m	1			2											3	2
*Ziziphus mucronata** cf.	RHM	m	2														2	1
Total identified			201	11	119	47	4	24	9	11	3	5	11	7	25	121	598	
Total unidentifiable: crystallised, fibrous, vitrified, powdered			36			3					2			19	3		63	
Total unidentified			13		5	12			0	1	2	1	5				39	
Total studied			250	11	124	62	4	24	9	12	7	6	16	26	28	121	700	
Total woody taxa (n=69)			48	5	31	23	1	10	5	4	2	2	7	2	8	18		14


Frequency of uses in BYA2(i)
Fuel wood
Tinder
Firesticks
Medicinal plants
Plant poison

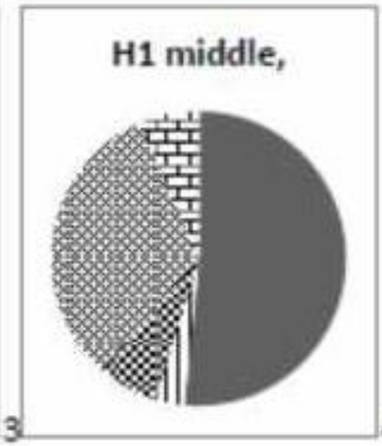
1


Hearth 1 base

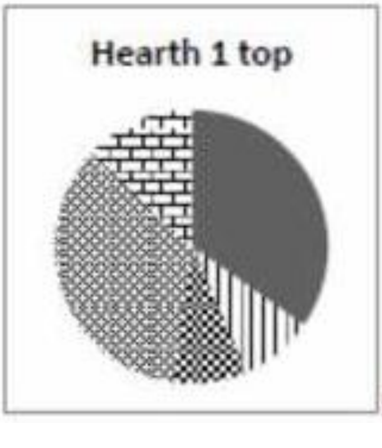
2


H1 light base

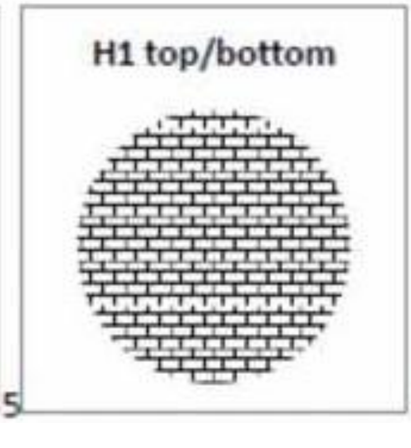
3


H1 middle,

4


Hearth 1 top

5


H1 top/bottom

6


H1 ash dump

7

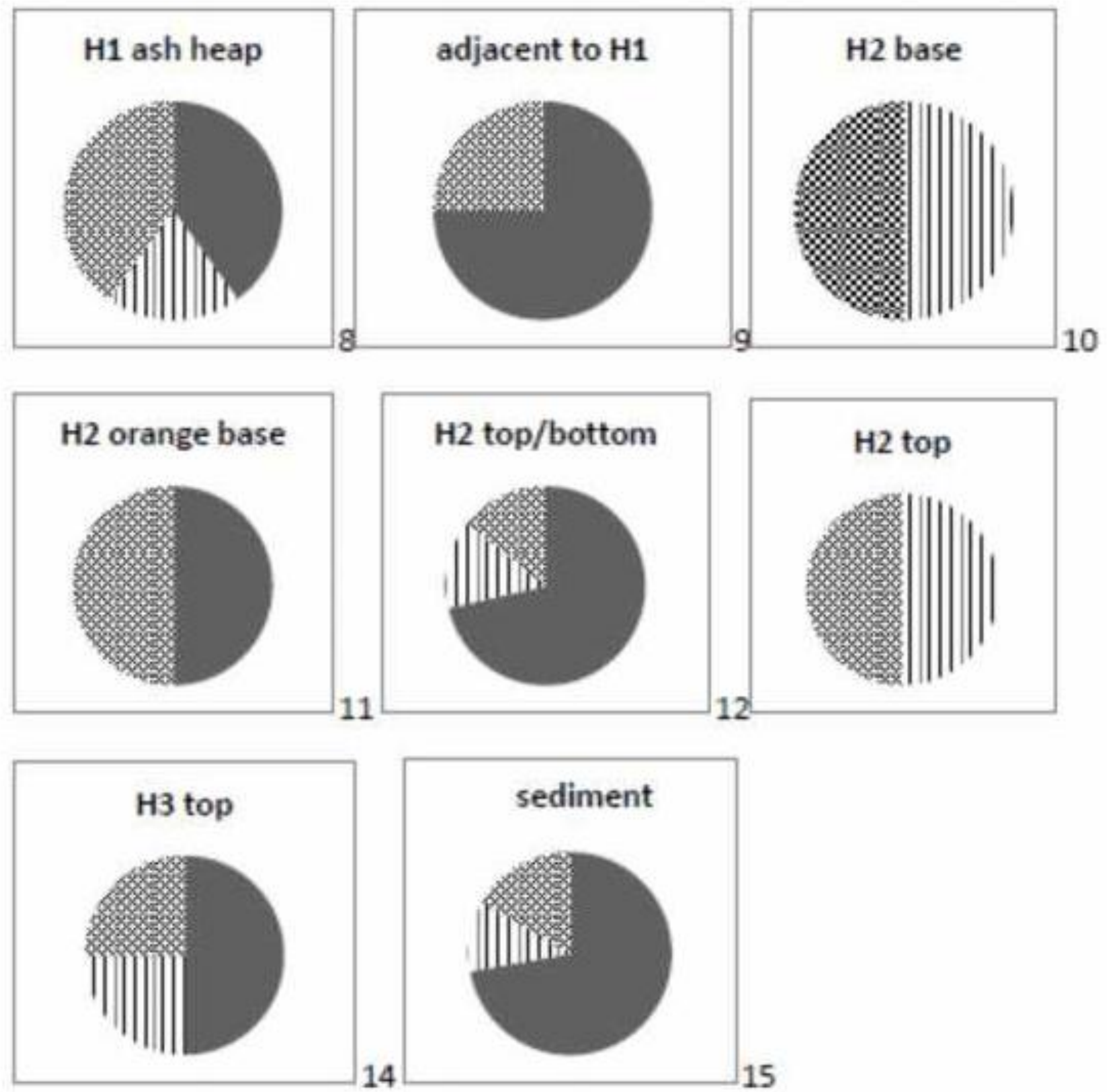


Figure 5.1: Percentage frequencies of the primary uses of wood in layer BYA2(i). The first pie chart is the combined sample from all squares, sediment and features (n of taxa = 69).

Table 5.2: The list of species identified from the charcoal samples in five use categories for each of the hearths studied from layer BYA2(i), Sibudu rock shelter and providing captions for Fig. 5.1. Note: "cf." after the species name means the identification is not as confident as for those names without "cf". The underlined woody taxa are restricted to one of the strata in one of three hearths.

1. BYA2(i) sediments and features, all squares	**List of species identified from the charcoal**
Fuel n=31	*Acacia sp., Allophylus dregeanus* cf.*, Brachylaena discolor* cf.*, Buxus macowanii, Canthium mundianum, Canthium sp. , Canthium spinosum, Canthium suberosum, Celtis africana* cf.*, Cola natalensis* cf.*, Cryptocarya wyliei, Dovyalis rhamnoides, Fabaceae* cf.*, Faurea saligna* cf.*, Ficus lutea, Harpephyllum caffrum* cf.*, Leucosidea sericea, Mystroxylon aethiopicum, Ochna sp.* cf.*, Olea europaea subsp. africana, Protea caffra, , Protea spp., Psydrax obovata* cf. *, Rothmannia capensis* cf.*, Searsia dentata* cf. *,Searsia leptodictya, Searsia* sp. cf.*, Shirakiopsis elliptica* cf.*, Vangueria madagascarensis* cf.*, Vangueria randii*
Tinder n=8	*Asteraceae* cf.*, Volkameria glabra, Cliffortia repens, Erica caffra, Morella pilulifera, Pavetta eylesii, Podocarpus sp., Searsia burchellii* type.
Firesticks n=3	*Cordia caffra* cf.*, Diospyros austro-africana, Halleria lucida*
Medicine n=24	*Calodendrum capense, Commiphora marlothii, Cryptocarya liebertiana* cf.*, Cryptocarya woodii, Cunonia capensis, Curtisia dentata, Dombeya rotundifolia, Ekebergia capensis, Gardenia volkensii , Mimusops obovata* cf. *, Nuxia floribunda, Pappea capensis, Pittosporum viridiflorum, Ptaeroxylon obliquum, Rapanea melanophloeos* cf.*, Rhamnus prinoides, Sclerocroton integerrimus, Searsia chirindensis, Searsia erosa* type*, Tabernaemontana ventricosa* cf.*, Trema orientalis* cf.*, Vitex rehmannii* cf.*, Ximenia caffra, Ziziphus mucronata* cf.
Poison n=3	*Croton sylvaticus* cf.*, Hippobromus pauciflorus* cf.*, Spirostachys africana*
2. Hearth 1 base (n=48)	**List of species identified from the charcoal**
Fuel	*Acacia sp. , Allophylus dregeanus* cf.*, Brachylaena discolor* cf.*, Buxus macowanii, Canthium mundianum, Canthium sp. , Canthium spinosum, Canthium suberosum, Cryptocarya wyliei, Dovyalis rhamnoides, Fabaceae* cf.*, <u>Ficus lutea</u>, Harpephyllum caffrum* cf.*, Leucosidea sericea, Mystroxylon aethiopicum, <u>Ochna</u> sp.* cf.*, Olea europaea subsp. africana, Protea caffra, <u>Protea sp,</u> Searsia dentata* cf. *, Searsia leptodictya, Searsia sp.* cf.*, <u>Shirakiopsis elliptica</u>* cf.*, Vangueria randii.*
Tinder	*Volkameria glabra, Erica caffra, <u>Pavetta eylesii</u>, Podocarpus sp., Searsia burchellii* type.
Fire-sticks	*<u>Cordia caffra</u>* cf.

Medicine	*Cryptocarya liebertiana* cf., *Cryptocarya woodii, Cunonia capensis , Ekebergia capensis, Gardenia volkensii , Pappea capensis, Pittosporum viridiflorum, Ptaeroxylon obliquum, Rhamnus prinoides, Sclerocroton integerrimus, Searsia chirindensis, Tabernaemontana ventricosa* cf., *Trema orientalis* cf., *Vitex rehmannii* cf., *Ximenia caffra, Ziziphus mucronata* cf.
Poison	*Spirostachys africana, Hippobromus pauciflorus* cf.
3. Hearth 1 light base (n=5)	**List of species identified from the charcoal**
Fuel	*Protea caffra, Searsia dentata* cf.
Medicine	*Cunonia capensis, Mimusops obovata* cf. , *Sclerocroton integerrimus*
4. Hearth 1 middle (n=31)	**List of species identified from the charcoal**
Fuel	*Brachylaena discolor* cf., *Buxus macowanii, Canthium mundianum, Canthium sp. , Canthium spinosum, Celtis africana* cf., *Cola natalensis* cf., *Cryptocarya wyliei, Dovyalis rhamnoides, Faurea saligna* cf., *Mystroxylon aethiopicum, Protea caffra, Protea sp., Searsia leptodictya, Vangueria madagascarensis* cf. , *Vangueria randii*
Fire-sticks	*Diospyros austro-africana*
Medicine:	*Cryptocarya woodii, Curtisia dentata, Dombeya rotundifolia, Ekebergia capensis, Gardenia volkensii , Pappea capensis, Pittosporum viridiflorum, Searsia chirindensis, Trema orientalis* cf., *Vitex rehmannii* cf.
Poison	*Hippobromus pauciflorus* cf.
Tinder	*Volkameria glabra , Erica caffra, Podocarpus* sp.
5. Hearth 1 top (n=23)	**List of species identified from the charcoal**
Fuel	*Buxus macowanii, Dovyalis rhamnoides, Harpephyllum caffrum* cf., *Leucosidea sericea, Mystroxylon aethiopicum, Olea europaea subsp. africana, Protea caffra, Searsia leptodictya, Searsia sp.* cf., *Vangueria randii*
Fire-sticks	*Halleria lucida*
Medicine	*Calodendrum capense, Mimusops obovata* cf. , *Pappea capensis, Pittosporum viridiflorum, Ptaeroxylon obliquum, Trema orientalis* cf., *Ximenia caffra*
Poison	*Croton sylvaticus* cf., *Hippobromus pauciflorus* cf
Tinder	*Volkameria glabra, Podocarpus sp., Searsia burchellii* type
6. H1 top and bottom (n=1)	**List of species identified from the charcoal**

Poison	*Hippobromus pauciflorus* cf.
7. H1 ash dump (n=10)	**List of species identified from the charcoal**
Fuel	*Buxus macowanii, Canthium suberosum, Leucosidea sericea, Mystroxylon aethiopicum, Protea caffra, Searsia sp.* cf. , *Vangueria randii*
Medicine	*Ptaeroxylon obliquum*
Tinder	*Asteraceae* cf.*, Erica caffra*
8. H1 ash heap (n=5)	**List of species identified from the charcoal**
Fuel	*Protea caffra, Searsia leptodictya*
Tinder	*Volkameria glabra*
Medicine	*Nuxia floribunda, Morella pilulifera*
9. adjacent to Hearth 1 (n=4)	**List of species identified from the charcoal**
Fuel	*Harpephyllum caffrum* cf. , *Mystroxylon aethiopicum, Vangueria randii*
Medicine	*Searsia erosa* type
10. H2 base (n=2)	**List of species identified from the charcoal**
Fire-sticks	*Halleria lucida*
Tinder	*Cliffortia repens*
11. H2 orange base (n=2)	**List of species identified from the charcoal**
Medicine	*Pittosporum viridiflorum*
Fuel	*Vangueria randii*
12. H2 top & bottom (n=7)	**List of species identified from the charcoal**
Fuel	*Allophylus dregeanus* cf.*, Brachylaena discolor* cf.*, Buxus macowanii, Protea caffra, Rothmannia capensis* cf.
Tinder	*Podocarpus* sp.
Medicine	*Rapanea melanophloeos* cf.
13. H2 top (n=2)	**List of species identified from the charcoal**
Tinder	*Podocarpus* sp.
Medicine	*Vitex rehmannii* cf.
14. H3 top (n=8)	**List of species identified from the charcoal**
Fuel	*Brachylaena discolor* cf.*, Mystroxylon aethiopicum, Protea caffra, Searsia dentata* cf.
Medicine	*Nuxia floribunda, Pappea capensis*

Tinder	*Cliffortia repens, Morella pilulifera*
15. Sediment BYA2(i) (n=18)	**List of species identified from the charcoal**
Fuel	*Acacia sp., Brachylaena discolor* cf.*, Buxus macowanii, Canthium mundianum, Cryptocarya wyliei, Fabaceae* cf.*, Faurea saligna* cf.*, Leucosidea sericea, Mystroxylon aethiopicum, Protea caffra, Psydrax obovata* cf.*, Searsia leptodictya*
Medicine	*Commiphora marlothii, Cryptocarya woodii, Ptaeroxylon obliquum, Searsia chirindensis*
Tinder	*Podocarpus sp., Searsia burchellii* type

5.4 Discussion

5.4.1 Overview of hearths

In Hearth 1, the ratios are almost equal with slightly more fuel than putative medicinal wood being used. In Hearths 2 and 3, more fuel than medicinal wood was used (Table 5.3).

When assessing the ratios within the hearth, for Hearth 1 more fuel wood than medicinal wood occurs in the base, middle and top and more medicinal wood occurs in the layer labelled light base. This hearth also has evidence of burned bedding (Bentsen 2014b). Tinder wood occurs in all sublayers and in the adjacent ash dump there is more fuel wood than in the ash heap. In Hearth 2 most fuel wood occurs in the top layer whereas the potential medicinal wood occurs in the orange base and in the top. Charcoal fragments from Hearth 2 were most abundant in the top sublayer. It seems that Hearth 2 had a succession of fires with a small fraction of medicinal woods. In Hearth 3 the fire also consisted of fuel and tinder with a small fraction of medicinal wood (Table 5.3).

Hearth 1 has firesticks, tinder and fuel in the base, middle and top and also a considerable amount of charcoal from medicinal plants, including charcoal from the three plants with poisonous properties, *Hippobromus pauciflorus* (in three of the layers), *Spirostachys africana* in the base only and *Croton sylvaticus* in the top only. In the base of Hearth 1, 48 woody taxa were identified from 250 charcoal specimens studied of which 49 remain unidentified. In Hearth 1 base *Afrocarpus/Podocarpus* spp. tinder and *Buxus macowanii, Protea caffra* and *Vangueria randii* are good fuel woods, and were probably collected for this purpose. They occur more than five times in BYA2(i). In this predominantly fuel wood fire, there are 16 potential medicinal plants which are represented by charcoal: *Spirostachys africana, Cryptocarya liebertiana, Tabernaemontana ventricosa, Shirakiopsis elliptica, Ziziphus mucronata and Rhamnus prinoides.* In Hearth 1 light base there are three woods; none is unique. In Hearth 1 middle, *Curtisia dentata* and *Dombeya rotundifolia* are present. In Hearth 1 top, *Calodendrum capense* and *Croton sylvaticus* occur. Here, *Ptaeroxylon obliquum* is common.

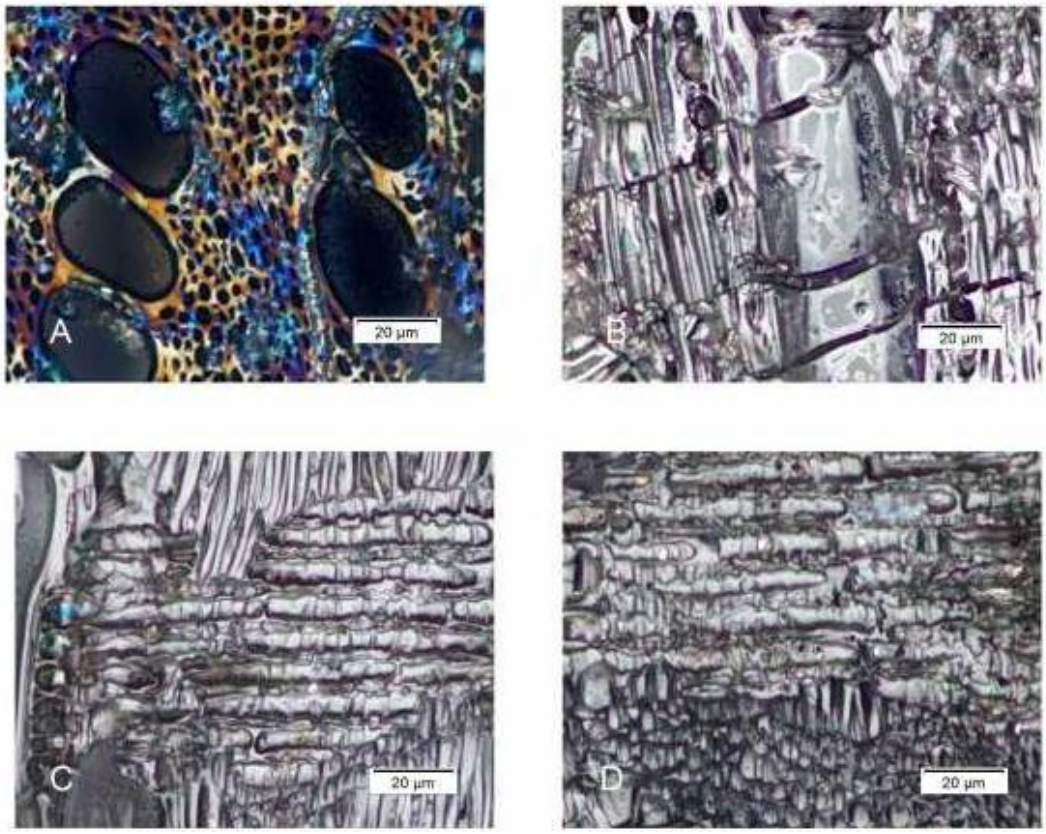


Figure 5.2: Microphotographs of *Spirostachys africana* C4d 66 in Hearth 1 BYA2(i). The reference material is SJL 103 and NDO. (A) TS, vessels are arranged in long radial multiples, with vessel diameter 40 µm and vessel density 100/mm^2. The parenchyma arrangement is apotracheal diffuse. (B) TLS, rays are uniseriate and 12/mm. (C) RLS, rays are heterocellular and low, with procumbent cells as high as the square cells and occasionally with upright cells in the margins. (D). RLS, the prismatic crystals in the ray cells are birefringent under polarised light.

Hearth 1 seems more complex than was realised when it was excavated. This large combustion feature seems to comprise both burnt bedding and several generations of hearth use. These diverse features are intertwined in a way that could not be distinguished during excavation. The patch of burnt culms at the base of Hearth 1 in square C4 and the micromorphological block revealing stratified, burnt phytoliths certainly supports the interpretation of at least part of the feature known as Hearth 1 (probably much of its base) as burnt bedding. Having said this, the presence of large amounts of fuel wood and tinder in the base of the feature seems less consistent with an interpretation of bedding, and more consistent with an interpretation of at least part of this feature as a hearth or overlapping hearths from various episodes of fire production (Bentsen 2014b; Sievers 2013; Wadley 2012a).

Table 5.3: The distribution of woods from BYA2(i) according to the primary uses. Medicinal information is shaded. The calculations are fuel: phytomedicine= (fuel+ tinder+ firesticks): (phytomedicine+ phyto-poison/medicine) and the phytomedicine is shaded.

Primary uses	H1 base	H1 light base	H1 middle	H1 top	H1 top and bottom	H1 ash dump	H1 ash heap	adjacent to Hearth 1	H2 base	H2 orange base	H2 top & bottom	H2 top	H3 top	sediment : B4a,b,d	BYA2(i)
fuel	24	2	16	10	0	7	2	3	0	1	5	0	4	13	31
tinder	5	0	3	3	0	2	1	0	1	0	1	1	2	2	8
firesticks	1	0	1	1	0	0	0	0	1	0	0	0	0	0	3
medicine	16	3	10	7	0	1	2	1	0	1	1	1	2	3	24
poison	2	0	1	2	1	0	0	0	0	0	0	0	0	0	3
No. taxa (n)	48	5	31	23	1	10	5	4	2	2	7	2	8	18	69
No. identified specimens	201	11	119	47	4	24	9	11	3	5	11	7	25	121	598
No. studied	250	11	124	62	4	24	9	12	7	6	16	26	28	121	700
Total fuel	30	2	20	14	0	9	3	3	2	1	6	1	6	15	42
Total medicine	18	3	11	9	1	1	2	1	0	1	1	1	2	3	27
Ratio fuel: medicine	1:1.6	1:0.7	1:1.8	1:1.6	m	9:1	1:1.5	3:1	f	m	6:1	1:1	3:1	5:1	1.6:1
	f>m	f<m	f>m	f>m	m	f>m	f>m	f=m	f	m	f>m	f=m	f>m	f>m	f>m

5.4.2 Environmental implications from BYA2(i), ~58ka

In the charcoal flora there are five evergreen trees, at least 24 plants associated with water, at least 20 plants from open deciduous woodland and nine plants from drier, bushveld or savanna. Of the 57 taxa, 44 plants occur in the river valley today. The riverine environment, therefore, enabled a diversity of habitats and subsequent diversity of plants in the valley and associated high ground (Wadley 2006). The environmental requirements of the plants suggest that they grew in habitats where evergreen, riverine, woodland and bushveld (savanna) plants thrived, although several could inhabit a variety of habitats. In terms of vegetation units in the Forest and Savanna Biomes, a large proportion of plants from BYA2(i) presently occur in the KZN Coastal Belt, and an even larger proportion in the forest biome in the Scarp, Northern Coastal, Southern Mistbelt and Northern Afrotemperate Forest. A small proportion can be found today in the Savanna Ngongoni Veld and KZN Sandstone Sourveld, and an even smaller proportion in bushveld or Fynbos (Mucina and Rutherford 2011).

In the KZN Coastal Belt, evergreen *Cryptocarya liebertiana* occurs, *Allophylus dregeanus* is associated with water and *Ximenia caffra* represents bushveld on the higher ground. In the Scarp Forest, evergreen *Harpephyllum caffrum* occurs. *Erica caffra* occurs on cliffs, rocky outcrops, alongside streams and rivers from the coastal scarp to 2 500 m. *Cryptocarya wyliei* and *Ptaeroxylon obliquum* occur in open deciduous woodland.

In the Northern Afrotemperate Forest, *Leucosidea sericea*, *Morella pilulifera*, *Pittosporum viridiflorum* and *Rhamnus prinoides* are associated with water. *Diospyros austro-africana* is in open deciduous woodland, this shrub on rocky slopes occurs in scrub or in Fynbos at high altitude. *Leucosidea sericea* is a straggling, small tree and a pioneer at high altitude, which occurs near water in scrub forest and in grassland. *Morella pilulifera* is a shrub or small tree which occurs on forest edges and in grassland in rocky places, at high altitude. *Pittosporum viridiflorum* is a medium to tall tree on forest margins, rock outcrops and in bush clumps, to 1 800 m. *Rhamnus prinoides* is a scrambling tree in forest margins and on stream banks, in drier scrub understorey and at high altitude. In the Southern Mistbelt Forest, *Calodendrum capense, Curtisia dentata* and *Trimeria grandifolia* are associated with water and *Celtis africana* occurs in open woodland. *Olea europaea* ssp. africana occurs on stream banks and rocky hillsides in addition to termite mounds in the bushveld. *Cliffortia repens* is a multi- stemmed shrub on rocky outcrops and near water, which grows at high altitude - up to 1 900 m in the Montane Belt and to 2 250 m in the Drakensberg sub-alpine belt (Killick 1990: 36) - widely distributed from the Eastern Cape to Limpopo.

Thus, in the Drakensberg vegetation types of forest, Montane Belt river valleys and sub - alpine belt (Killick 1990: 23-43), these plants may be found in the Montane Belt forest (*Curtisia dentata*), forest margins (*Halleria lucida* – also in outcrop vegetation in the sub- alpine belt), forest margins or scrub (*Leucosidea sericea*), cliff scrub (*Morella pilulifera* and *Cliffortia repens*), *Protea* savanna (*Protea caffra*) and in *Leucosidea-Buddleja* scrub (forest- pioneers *Rhamnus prinoides* and *Searsia dentata*). The plants may be found in the sub- alpine belt stream bank scrub (*Diospyros austro-africana*, *Erica caffra*) and in the Montane belt scrub in sheltered situations such as stream-banks and deep gullies up to 2 440m (*Leucosidea sericea*), in outcrop vegetation amongst mosses and ferns (*Cliffortia repens*) on koppies up to 1 950 m.

In the KZN Sandstone Sourveld, Proteaceae, *Faurea saligna* and *Protea* spp. indicate sourveld. While *Acacia robusta* occurs near Sibudu today and a few *Acacia* spp. occur in the KZN Coastal Belt (*Acacia natalitia* and *Acacia nilotica* ssp.

kraussiana) and in the Savanna Ngongoni Veld (*A. natalitia, A. nilotica* and *A. sieberiana*), most are characteristic of the savanna bushveld. In Savanna *Commiphora marlothii* occurs on rocky outcrops or slopes and sometimes in woodland in northern South Africa, *Gardenia volkensii* occurs in open woodland and bushveld widespread from northern KZN to tropical Africa and *Pavetta eylesii* occurs in woodland, rocky outcrops or in the understorey of bush clumps in northern South Africa.

In summary, a mixture of evergreen and deciduous plants occur in BYA2(i). The people who lived at Sibudu collected wood in the MSA from plants representing forest and savanna. The charcoals originate from a collection of forest types in the river valley and in the region, within reach of Sibudu. The riverine environment enabled a diversity of habitats and plants in the valley and associated high ground. The environment near Sibudu thus represented a vegetation mosaic at 58 ka, as is the case today. However, the mosaic was somewhat different from that represented today and this was a time when the winters were colder and the summer rainfall was less than today (Bruch *et al.* 2012). The riverine forest and open woodland are strongly represented, from the KZN Coastal Belt, Southern Mistbelt and Northern Afrotemperate Forests. The riverine forest suggests water which is available most or all year round. Here, plants have access to moisture even if the environment is dry.

5.5 Conclusion

Charcoal from three hearths in BYA2(i) have been identified, with 69 woody taxa adding 28 new identifications for charcoal from Sibudu. A total of 700 charcoal specimens were studied and 598 were identified. Hearth 1 is large and complex, including layers of burnt sedge bedding. There is an ash dump and an ash heap.

Each BYA2(i) hearth contains taxa that could have been fuel and tinder woods. A third of the woods burnt in BYA2(i) are plants that, today, have medicinal uses for their wood, leaves or bark. Charcoal from the poisonous plant, *Spirostachys africana*, was only identified in the base of Hearth 1. Since the tambotie charcoal occurs in one place only, this suggests that this wood was used sparingly and burnt purposefully, possibly for aromatic, insecticidal smoke.

Vegetation at Sibudu ~58 ka ago seems to have had no modern correlate. Several trees and shrubs from BYA2(i) do not occur near Sibudu today. Amongst these are trees and shrubs which are common in the inland forests of the Southern Mistbelt Forest and the Northern Afromontane Forest. Here, *Afrocarpus/Podocarpus* spp. implies the presence of an evergreen forest that is no longer near Sibudu. *Leucosidea sericea* is a pioneer at high altitude in grassland, often near water in the scrub forest. Other woody plants seem to have been lost from the area due to anthropogenic factors such as habitat destruction and fuel collection. These plants are found in nearby nature reserves, river gorges and reserves, near the coast.

The uneven distribution of woody taxa between the BYA2(i) hearths implies that people discriminated between the wood types gathered around the Sibudu home range. If they had gathered wood indiscriminately, then all the hearths would have contained a similar range of taxa, Instead, the BYA2(i) woods come from a wide range of plant communities with different habitat requirements and which can be described as a vegetation mosaic near Sibudu.

CHAPTER 6

CHARCOAL ANALYSIS FROM 58 000 YEAR OLD HEARTHS IN SPCA AT SIBUDU: IMPLICATIONS FOR AN UNDERSTANDING OF WOOD USES AND FOR THE ENVIRONMENT

6.1 Introduction

The focus is on the charcoal analysis from Sibudu hearths in layer SPCA (Spotty Camel) which has an age estimated from the adjacent layers, between 59.6 ± 2.3 ka (SS: Speckled Sunrise) and 57.6 ± 2.1 ka (BSp: Brown Speckled) and based on single grain Optically Stimulated Luminescence (OSL) (Jacobs *et al.* 2008a, b; Wadley 2015: 165). The cultural association of SPCA is the post- Howiesons Poort (Wadley *et al*. 2011). The five hearths and one combustion feature were selected to examine the possibility that firewood was preferentially selected for certain tasks. The hypothesis is that woods found only rarely in single hearths were chosen for their specific properties.

A previous Sibudu charcoal analysis by Lucy Allott included 120 fragments from squares B5 and B6 of layer SPCA. (Allott 2006: 193). The woody plants identified during Allott's analysis are included here (Table 6.1). Allott's conclusions were interesting and prompted the need for further work on SPCA charcoal. First, she identified *Erica caffra, Leucosidea sericea* and *Afrocarpus/Podocarpus* spp. which do not occur near the site today (Allott 2006). Secondly, Allott (2005, 2006) cautiously suggested that one charcoal specimen might be *Spirostachys africana*/*Sapium*. The possible identification of *Spirostachys africana* is a noteworthy finding because, as mentioned before, the wood is poisonous and cannot be used for cooking fires (Van Wyk *et al*. 2002; Wink and Van Wyk 2008). In addition to this, one charcoal specimen of *Cryptocarya* sp. was recorded by Allott (2005, 2006) which is of interest since these insecticidal leaves (*C. woodii*), found layered on sedge bedding, are the first known record of the use of herbal medicine from ~77 ka at Sibudu (Wadley *et al.* 2011). Charcoals from unspecified Asteraceae, and from *Brachylaena* spp. were also recorded in SPCA by Allott (2005, 2006). Distinguishing *Brachylaena* spp. from *Tarchonanthus parvicapitulatus* is significant as camphor smoke has insecticidal properties (chapter 4).

Charcoal fragments were excavated from five hearths, one black feature and from sediment from quadrants (50 x 50 cm) within metre squares B4, C4, C6, D4, D5 and D6 of occupation layer SPCA (Fig. 6.1) (Wadley *et al*. 2011; Wadley and Jacobs, 2006). Hearth 1 (B4c) and the black feature, BF (D5c) are small features, surrounded by sediment in squares B4 and D5. The black feature may have been a fire, an ash dump or an ash heap. The other hearths are Hearth 2 (C6a), Hearth 3 (C6b), Hearth 4 (D6a) and Hearth 5 (D6b). SPCA sediment occupies all the areas where there are no features. Samples were analysed from the SPCA sediment matrix of these six squares and from the six features. Organic preservation is good in SPCA and the charcoal fragments collected from the layer are between 1–4mm, and well-preserved. This observation was also made by Allott (2005, 2006). The good preservation of the charcoal means that some of the challenges often faced by anthracologists, such as shrinkage (Bamford and Henderson, 2003; Gonçalves *et al*. 2012), powdering and vitrification (Wheeler *et al*. 1989), are ameliorated in SPCA.

A				
B6	B5	B4c B4a **Hearth 1** B4d B4b		
C C6a **Hearth 2** C6b **Hearth 3**		C4c C4a C4d C4b		
D6c D6a **Hearth 4** D D6b **Hearth 5**	D5c D5a **Black Feature** D5d D5b	D4b		
E6	5	4	3	2

Figure 6.1: The excavation grid at Sibudu (after Wadley and Jacobs, 2006), showing where SPCA features are located. The charcoal analysed was excavated from five hearths, from a black feature (BF) and from SPCA sediment. Each square is $1m^2$.

6.2 Material and methods

A sample of 544 charcoal specimens was studied and dozens of unidentified specimens remain. The charcoal was sorted into size classes and studied by means of simple random sampling (as in Drennan 2009: 85). An average of 8.4 specimens was studied from each of the packets (Table 6.1). Charcoal specimens were examined, photographed and identified according to standard methods (previously described, chapter 2). Unique features were sought, where possible, such as the crystals and silica bodies which aid the distinction between

Spirostachys africana and *Sclerocroton integerrimus* (Lennox and Bamford 2015). Closely related *Tarchonanthus parvicapitulatus* and *Brachylaena discolor* charcoal is distinguished by ray width, ray structure, vessel density and the variation in vessel to fibre diameter ratio (chapter 4). The presence and locality of each woody taxon was recorded. A charcoal fragment in the site is defined as the presence of a species, as previously described (Chapter 1 and 2)

6.3 Results

6.3.1 The taxonomic composition of the charcoal assemblage

In all, 110 woody taxa were distinguished, including those identified by Lucy Allott (2006), and 516/544 charcoal fragments studied were identified (Table 6.1). Eleven families (Bignoniaceae, Chrysobalanaceae, Clusiaceae, Combretaceae, Heteropyxidaceae, Icacinaceae, Melianthaceae, Pittosporaceae, Scrophulariaceae, Strychnaceae, Sterculiaceae) and 42 genera have been added to those in previous lists of charcoal (Allott 2006) and seeds (Sievers 2006, 2013). The plant family names are according to Weber's three letter acronyms (Snow and Holton 2000; Weber 1982; WCSP 2015). *Psydrax obovata* (syn. *Canthium obovatum*) charcoal has been identified, adding to the list of seeds from *Canthium* spp. Microphotographs which illustrate the identified charcoal are in Appendix A. A summary of the IAWA features of identified plants in comparison with the reference material are listed in Appendix C.

6.3.2 Relative frequency of the occurrence of woody taxa in SPCA

Several woods are restricted to one of the five hearths, either in charcoal which occurs in one hearth and nowhere else or in charcoal which occurs in one hearth and in sediment. A few woods occur in several hearths. Several woods are restricted to sediment B4, C4, D5 and D6 and to the black feature (Fig 6.2 with details in the captions given in Table 6.2). Charcoal representing *Shirakiopsis elliptica* is present only in Hearth 1, *Cussonia spicata* is only in Hearth 3 and *Maytenus albata*, *Diospyros austro-africana* and *Vitex rehmannii* are only in Hearth 4. *Acacia* sp., *Cryptocarya wyliei* cf., *Hippobromus pauciformis* cf., *Sclerocroton integerrimus* cf., *Spirostachys africana* and *Tarchonanthus parvicapitulatus* charcoal are restricted to Hearth 1 and adjacent sediment. *Chionanthus foveolatus* and *Syzigium cordatum* cf. occur in only Hearth 3 and adjacent sediment. *Volkameria glabra, Commiphora harveyi, Commiphora marlothii, Diospyros natalensis*, *Mystroxylon aethiopicum*, *Olea africana* and *Rapanea melanophloeos* occur in only Hearth 4 and adjacent sediment. *Morella pilulifera* and *Parinari curatellifolia* cf. occur in only Hearth 5 and adjacent sediment. The type of wood and its possible use was examined. The few woody taxa which were identified in several hearths in SPCA include charcoal representing *Brachylaena discolor* (Hearth 1, 2 and 3) and *Erica caffra* (Hearth 2, 4 and 5) occur in three hearths and sediment. *Leucosidea sericea* occurs in three hearths (Hearth 2, 3 and 4), the black feature and in sediment. Charcoals from *Commiphora schimperi* (Hearth 4 and 5), *Cussonia paniculata* (Hearth 1 and 2) and *Protea roupelliae* (Hearth 2 and 3) occur in two hearths and sediment. *Cryptocarya woodii* cf. is only in Hearth 5, the black feature and in sediment. *Brachylaena discolor*, *Erica caffra*, *Leucosidea sericea*, *Cussonia paniculata* and *Protea roupelliae* were identified in two or more hearths (Fig. 6.2 with details in the captions given in Table 6.2) and the significance of the distribution is discussed below. The charcoals in hearths are remnants of one or more fires.

Spirostachys africana fragments occur in Hearth 1 and in sediment from square B4 and D5 (B4b 62 and 67; D5c 51) identified according to Lennox and Bamford (2015). *Sclerocroton integerrimus* fragments occur in Hearth 1 and sediment from B4 and D6 (B4c 07 and 14; B4b 65 and 66). *Shirakiopsis elliptica* only occurs in Hearth 1 (B4c 45). *Brachylaena discolor* cf. occurs in Hearths 1, 2 and 3 (B4c 11, 18 and 32) and in sediment. *Tarchonanthus parvicapitulatus* occurs in Hearth 1 and sediment in B4b (08, 22, and 27). Only *Commiphora marlothii* cf. charcoal is present in sediment in quadrant D4b, near the back wall of the rock shelter (Fig. 6.1). Charcoals from *Commiphora* spp. (*C. harveyi* cf., *C. marlothii* cf. and *C. schimperi* cf.) occur in six places in SPCA, including Hearth 4. The possible uses are discussed below (Appendix D).

Nuxia floribunda, *Trema orientalis* and *Ximenia caffra* occur in the black feature and in sediment. *Afrocarpus /Podocarpus* sp and *Ziziphus mucronata* are only found in SPCA sediment. The significance is discussed below.

Acacia spp. charcoal occurs in Hearth 1 and in sediment in squares B4, C4 and D5 and in quadrant D6c. Charcoal fragments of *Afrocarpus/Podocarpus* spp. occur in SPCA sediment in C4 and D5 (Table 6.1). *Afrocarpus falcatus* seed has been identified in layers from ~60 ka, Su to Mi (Sievers 2013: 207). The environmental requirements of *Afrocarpus/ Podocarpus* spp. and *Acacia* spp. in Appendix E are discussed below.

Table 6.1: The distribution of 110 woody taxa in SPCA, in a study of 516/544 identified charcoal fragments. The 76 woody taxa indicated by grey boxes are new identifications that were not previously listed by Allott (2006). The twelve taxa marked by an asterisk were previously identified in seeds by Sievers (2006, 2013). Names conferred are denoted cf. This means that the anatomical features and micrograph matched closely but not completely, usually due to distortion of the charcoal by the carbonisation process. Eleven of the 51 families indicated by grey boxes identified are new. The primary and possible use of woody taxa as fire-sticks (fs), fuel (f), medicine (m), poison (p) and/or tinder (t) are recorded. Shaded columns indicate the five hearths (H1-5) and one black feature (BF). The plant family names are given as Weber's three letter acronyms according to the world checklist of selected plant families (WCSP), Kew Gardens (Snow and Holton 2000; Weber, 1982; WCSP, 2015).

Scientific names	**Plant Families**	**Primary use**	**Alternative uses**	**SPCA sediment (B4a-d)**	**H1 (B4c)**	**SPCA sediment (C4a-d)**	**(B5 & 6) (Allott, 2006: 182-**	**H2 (C6a)**	**H3 (C6b)**	**SPCA sediment (D4b)**	**BF (D5c)**	**SPCA sediment (D5a-d)**	**H4 (D6a)**	**H5 (D6b)**	**SPCA sediment (D6c)**	**Total no. fragments**	**Distribution**
*Acacia**spp.	MIM	f	f	6	1	5						1			1	14	5
Afrocarpus sp.	PDC	f				2	2					3				7	3
Allophylus dregeanus cf.	SAP	f	f	4												4	1
Apodytes dimidiata cf.	ICC	m	f	1												1	1
Bersama lucens cf.	MTH	m	p			1						1				2	2
Brachylaena discolor cf.	AST	f	m	7	4	5		1	2							19	5
Burkea africana cf.	CSL	f	m,p	2		1						2				5	3
Calodendrum capense*	RUT	m	m	1			1									2	2
Canthium mundianum* cf.	RUB	f	fs,	1		1						1				3	3
Canthium spinosum* cf	RUB	f	f			1										1	1
*Canthium *suberosum* cf.	RUB	f		1								2				3	2
Carissa macrocarpa cf.	APO	t				1										1	1
Celtis africana	CLT	f	m			1	1									2	2
Chionanthus foveolatus	OLE	f	f	1		1			1							3	3
*Volkameria glabra**	LAM	t	fs,									1	1			2	2

Scientific names	Plant Families	Primary use	Alternative uses	SPCA sediment (B4a-d)	H1 (B4c)	SPCA sediment (C4a-d)	(B5 & 6) (Allott , 2006: 182-	H2 (C6a)	H3 (C6b)	SPCA sediment (D4b)	BF (D5c)	SPCA sediment (D5a-d)	H4 (D6a)	H5 (D6b)	SPCA sediment (D6c)	Total no. fragments	Distribution
Clusiaceae *Hypericum* sp.	CLU	f	f	1												1	1
Commiphora harveyi cf.	BRS	m	m									1	1			2	2
Commiphora marlothii cf.	BRS	m	m			5				19			5			29	3
Commiphora schimperi cf.	BRS	fs	m									1	1	2		4	3
Commiphora sp. cf.	BRS	m			1											1	1
Cordia caffra*	BOR	fs	m												1	1	1
Cryptocarya liebertiana	LAU	m	m	1												1	1
Cryptocarya woodii cf.	LAU	m	m								7	4		1		12	3
Cryptocarya wyliei cf.	LAU	f	f	1	1											2	2
Cryptocarya sp.	LAU	f			3											3	1
Curtisia dentata	COR	m	m	1												1	1
*Cussonia*paniculata* cf.	ARL	t	m	3	1	5		1								10	4
*Cussonia*spicata* cf.	ARL	t							2							2	1
*Cussonia*zuluensis* cf.	ARL	t		1												1	1
Deinbollia sp. soap-berry	SAP	f	m			4										4	1
Diospyros austro-africana*	EBN	fs	fs										1			1	1
Diospyros lycioides* cf.	EBN	f	f									2				2	1
Diospyros mespiliformis* cf.	EBN	m	m	1		1										2	2
Diospyros natalensis* cf.	EBN	f	f	1									1			2	2

Scientific names	Plant Families	Primary use	Alternative uses	SPCA sediment (B4a-d)	H1 (B4c)	SPCA sediment (C4a-d)	(B5 & 6) (Allott, 2006: 182-	H2 (C6a)	H3 (C6b)	SPCA sediment (D4b)	BF (D5c)	SPCA sediment (D5a-d)	H4 (D6a)	H5 (D6b)	SPCA sediment (D6c)	Total no. fragments	Distribution
Dombeya rotundifolia cf.	STR	m	m	2		1						1				4	3
Ekebergia capensis	MEL	m	m	1								1				2	2
Empogna lanceolata (syn. *Tricalysia lanceolata*)	RUB	f	f	1												1	1
Englerophytum natalense cf	SPT	f	f									1				1	1
Erica caffra	ERI	t	t	1		19	33	1				35	9	4	3	105	8
Erica sp.	ERI						3									3	1
Euclea crispa*	EBN	m	xf			1										1	1
Euclea natalensis* cf.	EBN	p	xf	1												1	1
Eugenia erythrophylla	MRT	f	f			1										1	1
Faurea saligna cf.	PRT	f	f	5		1						6				12	3
Ficus burkei (syn. *thonningii)*	MOR	f		2		1						1				4	3
Ficus ingens	MOR	p	p	1				1								2	2
Ficus lutea cf.	MOR	f		2												2	1
Ficus sp.	MOR						3									3	
Ficus sur (syn. *capensis)* cf.	MOR	fs	fs	3		1										4	2
Gardenia volkensii cf.	RUB	m	m			6										6	1
Grewia bicolor* cf.	TIL	m	m			1						8				9	2
Grewia flava*	TIL	fs	fs									1			2	3	2
Grewia flavescens* cf.	TIL	f	f	1		1										2	2
Halleria lucida cf.	SCR	fs	fs			1										1	1

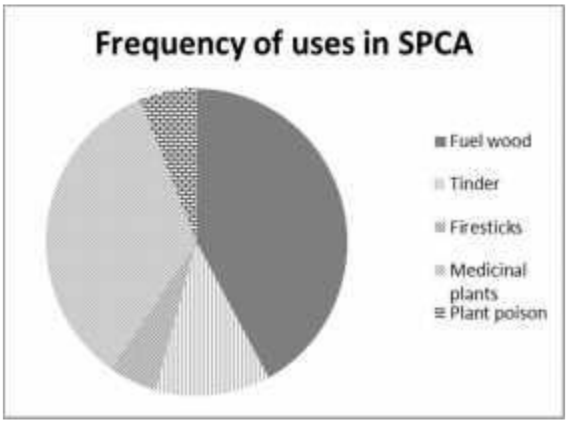
Scientific names	Plant Families	Primary use	Alternative uses	SPCA sediment (B4a-d)	H1 (B4c)	SPCA sediment (C4a-d)	(B5 & 6) (Allott, 2006: 182-	H2 (C6a)	H3 (C6b)	SPCA sediment (D4b)	BF (D5c)	SPCA sediment (D5a-d)	H4 (D6a)	H5 (D6b)	SPCA sediment (D6c)	Total no. fragments	Distribution
*Harpephyllum caffrum** cf.	ANA	f	f	6												6	1
Heteropyxis natalensis cf.	HET	m	m			2						7				9	2
Hippobromus pauciflorus cf.	SAP	p	p	1	1	2										4	3
Indeterminate Anacardiaceae/ Burseraceae	ANA						4									4	1
Indeterminate Annonaceae	ANN						1									1	1
Indeterminate Caesalpiniaceae / Fabaceae	CSL	f				2			1			3				6	3
Indeterminate Euphorbiaceae	EUP						1									1	1
Indeterminate Lauraceae	LAU						1									1	1
Indeterminate Rhamnaceae	RHM						2									2	1
Indeterminate Rubiaceae	RUB						3									3	1
Indeterminate Sapotaceae	SPT						2									2	1
Kigelia africana cf.	BIG	m	m	1		1										2	2
Kirkia acuminata cf.	SMR	f				2										2	1
Leucosidea sericea	ROS	f	t, m	3		9	1	2	1		1	11	4			32	8
Loxostylus alata cf.	ANA	m	m			2										2	1

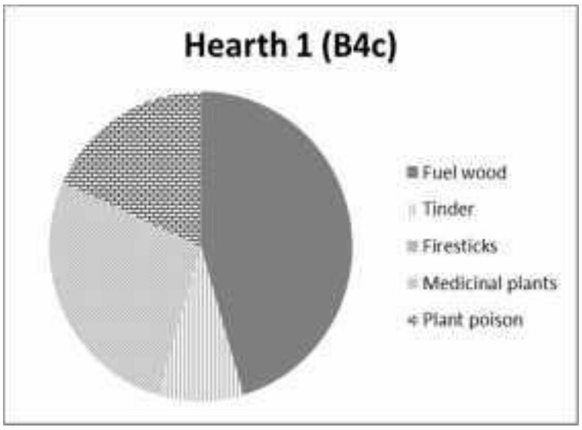
Scientific names	Plant Families	Primary use	Alternative uses	SPCA sediment (B4a-d)	H1 (B4c)	SPCA sediment (C4a-d)	(B5 & 6) (Allott, 2006: 182-	H2 (C6a)	H3 (C6b)	SPCA sediment (D4b)	BF (D5c)	SPCA sediment (D5a-d)	H4 (D6a)	H5 (D6b)	SPCA sediment (D6c)	Total no. fragments	Distribution
Maytenus albata cf.	CEL	f											1			1	1
Maytenus peduncularis cf.	CEL	f	f	1								2				3	2
Morella pilulifera cf.	MYR	t	m			3	3					2		3	4	15	5
Mystroxylon aethiopicum	CEL	f	m									3	1			4	3
Nuxia floribunda cf.	BUD	m	m	1		1					1	5				8	4
Nuxia sp.	BUD						1									1	1
Ochna serrulata	OCH	t		1												1	1
Olax dissitiflora cf.	OLC	t		1												1	1
Olea europaea* ssp. *africana*	OLE	f	m	1									4			5	2
Olinia ventosa (syn.cymosa) cf.	OLI	f	f	1												1	1
*Pappea capensis** cf.	SAP	m	m	5		2										7	2
Parinari curatellifolia cf.	CHB	m	m	1										1		1	2
Pavetta eylesii* cf.	RUB	t	t	2												2	1
Peltophorum africanum cf.	CSL	f				1										1	1
Pittosporum viridiflorum cf.	PIT	m	m	1												1	1
Protea caffra cf.	PRT	f	f	2		1										3	2
Protea sp	PRT	f	f			1										1	1
Protea roupelliae	PRT	f	f					1	1							2	2

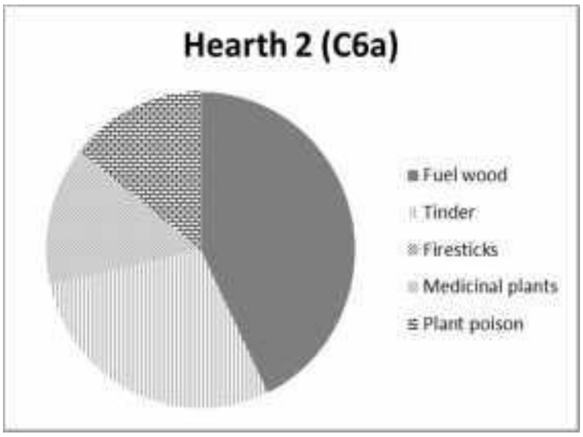
Scientific names	Plant Families	Primary use	Alternative uses	SPCA sediment (B4a-d)	H1 (B4c)	SPCA sediment (C4a-d)	(B5 & 6) (Allott, 2006: 182-	H2 (C6a)	H3 (C6b)	SPCA sediment (D4b)	BF (D5c)	SPCA sediment (D5a-d)	H4 (D6a)	H5 (D6b)	SPCA sediment (D6c)	Total no. fragments	Distribution
Protorhus longifolia*	ANA	p	m			1						1				2	2
Psydrax obovata cf. (syn. *Canthium* obovatum*)	RUB	f	f	1		1										2	2
Ptaeroxylon obliquum cf.	PTX	m	f			9		2				11				22	3
Rapanea melanophloeos	MRS	m	m				2						1			3	2
Rauvolfia caffra cf.	APO	m	m			1										1	1
Rhamnus prinoides cf.	RHM	m	m			1										1	1
Rhoicissus rhomboidea*	VIT	m	m			1										1	1
Sapium/ Spirostachys type	EUP						1									1	1
Sclerocroton integerrimus	EUP	m	p	8	4							1				13	3
Searsia burchelli* cf.	ANA	t	t	1												1	1
Searsia chirindensis* cf.	ANA	m	m			1										1	1
Searsia dentata* cf.	ANA	f	f	1												1	1
Searsia divaricata* cf.	ANA	m	m	1												1	1
Searsia erosa cf.*	ANA	m	m			1						1				2	2
Searsia leptodictya* cf.	ANA	f				2										2	1
*Searsia** sp.	ANA	f		1		1						2				4	3
Shirakiopsis elliptica	EUP	f	p		2											2	1
Sideroxylon inerme white milkwood	SPT	m	f				1									1	1

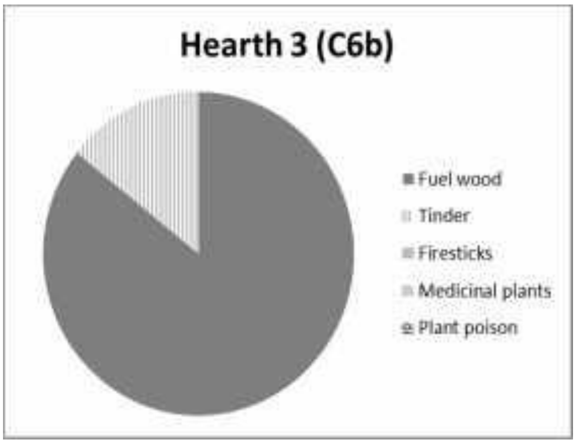
Scientific names	Plant Families	Primary use	Alternative uses	SPCA sediment (B4a-d)	H1 (B4c)	SPCA sediment (C4a-d)	(B5 & 6) (Allott, 2006: 182-	H2 (C6a)	H3 (C6b)	SPCA sediment (D4b)	BF (D5c)	SPCA sediment (D5a-d)	H4 (D6a)	H5 (D6b)	SPCA sediment (D6c)	Total no. fragments	Distribution
Sophora inhambanensis cf.	FAB	t		1												1	1
Spirostachys africana	EUP	p	p	5	2							1				8	3
Sterculia rogersii cf.	STR	f		4												4	1
Strychnos henningsii cf.	SRY	p	f,m			1										1	1
Syzygium cordatum	MRT	f	p	1					1							2	2
Syzygium sp.	MRT						1									1	1
Tarchonanthus parvicapitulatus	AST	m	p	2	2											4	2
Teclea gerrardii cf.	RUT	m	m			1						2				3	2
Terminalia phanerophlebia cf.	CMB	f	f			1										1	1
Trema orientalis cf.	CLT	m	m	2		1					1	1				5	4
Trichilia dregeana cf.	MEL	m	m			1										1	1
Trichilia emetica cf.	MEL	m	m	1		3									1	5	3
Trimeria grandifolia cf.	FLC	f	f	1												1	1
Vangueria madagascarensis cf.	RUB	f				1										1	1
Vangueria randii cf.	RUB	p	xf (p)	1								1				2	2
Virgilia type.	FAB	t	t	1												1	1
Vitex rehmannii	LAM	m	f										1			1	1
Vitex sp.	LAM						1									1	1
Ximenia caffra cf.	OLC	m	m			5					1	3				9	3

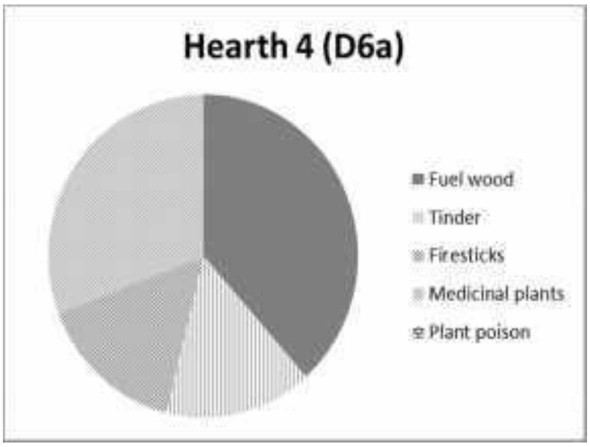
Scientific names	Plant Families	Primary use	Alternative uses	SPCA sediment (B4a-d)	H1 (B4c)	SPCA sediment (C4a-d)	(B5 & 6) (Allott, 2006: 182-	H2 (C6a)	H3 (C6b)	SPCA sediment (D4b)	BF (D5c)	SPCA sediment (D5a-d)	H4 (D6a)	H5 (D6b)	SPCA sediment (D6c)	Total no. fragments	Distribution
Zanthoxylum davyi cf.	RUT	f	f	2								1				3	2
Ziziphus mucronata cf.	RHM	m	f	3		4	1					7			1	16	5
Total identified specimens				119	22	134	69	9	9	19	11	138	31	11	13	585	
Total fragments assigned to types							20									20	
Total unidentifiable					2	1	31					1				35	
Total fragments abraded				4		2						1				7	3
Total unidentified				2	2	2			1			7				13	
Total studied				125	26	139	120	10	10	19	11	147	31	11	14	663	
Total identified woody taxa (n=110)				61	11	57	22	7	7	1	5	37	13	5	7	110	

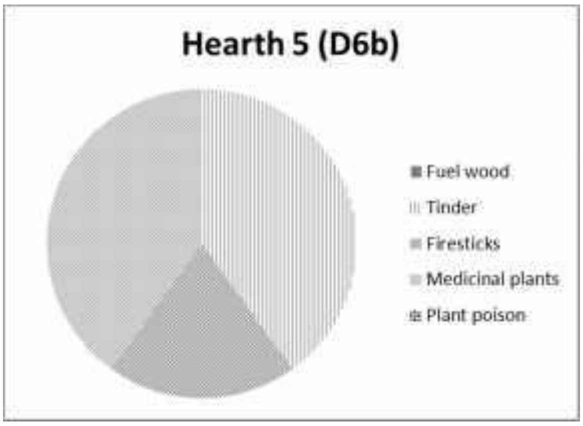

Frequency of uses in SPCA
Fuel wood
Tinder
Firesticks
Medicinal plants
Plant poison

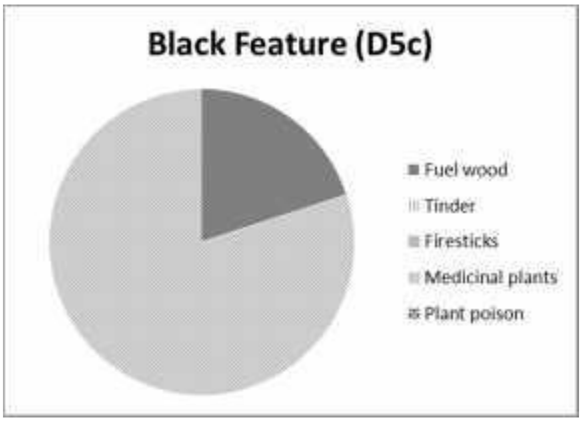

Hearth 1 (B4c)
Fuel wood
Tinder
Firesticks
Medicinal plants
Plant poison


Hearth 2 (C6a)
Fuel wood
Tinder
Firesticks
Medicinal plants
Plant poison


Hearth 3 (C6b)
Fuel wood
Tinder
Firesticks
Medicinal plants
Plant poison


Hearth 4 (D6a)
Fuel wood
Tinder
Firesticks
Medicinal plants
Plant poison


Hearth 5 (D6b)
Fuel wood
Tinder
Firesticks
Medicinal plants
Plant poison


Black Feature (D5c)
Fuel wood
Tinder
Firesticks
Medicinal plants
Plant poison

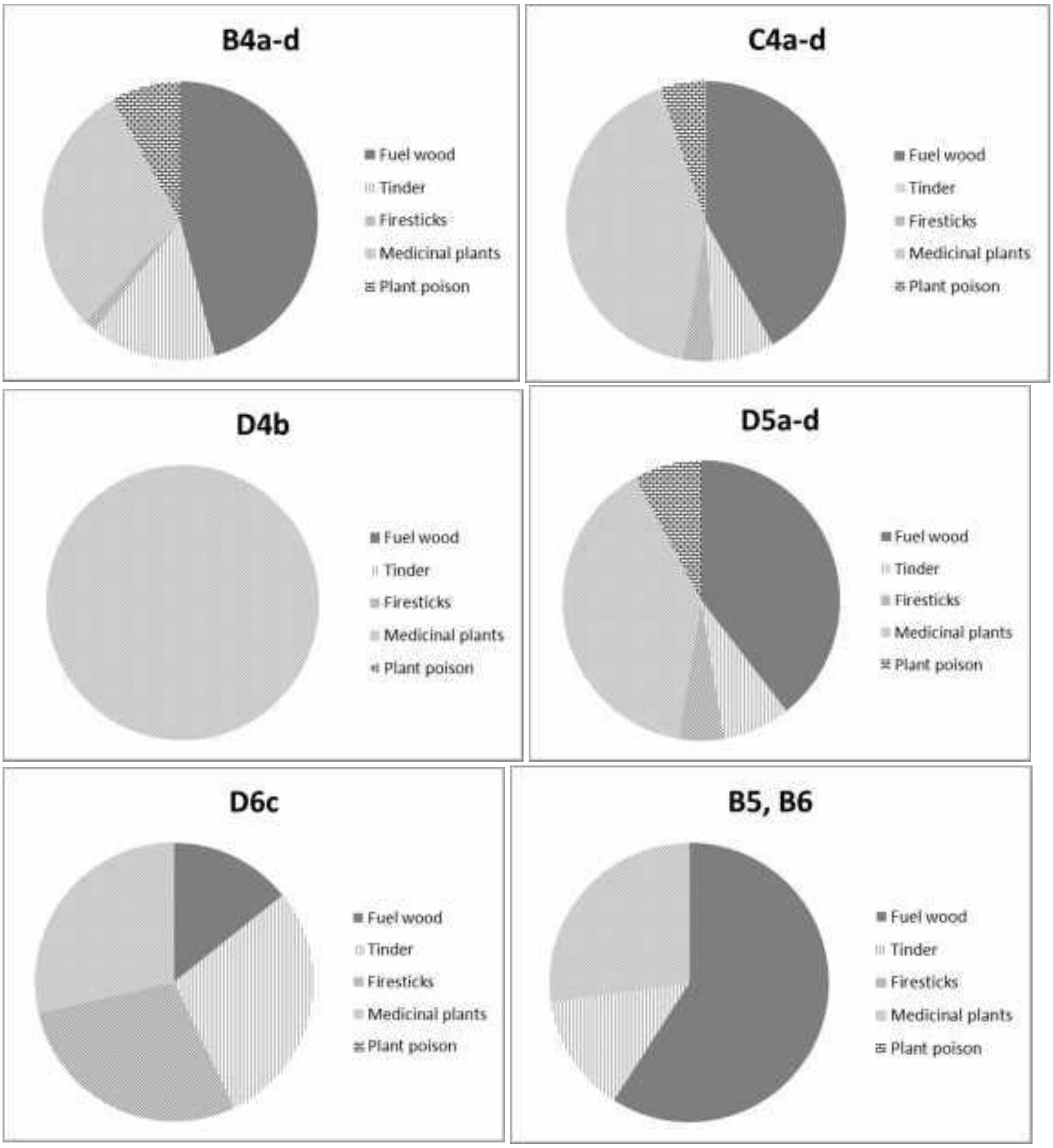


Figure 6.2: Percentage frequencies of the primary uses of wood in layer SPCA. The first pie chart is the combined sample from all squares, sediment and features (n of taxa = 110).

Table 6.2: The list of species identified from the charcoal samples in five use categories for each of the hearths studied from layer SPCA at Sibudu rock shelter, providing captions for Fig. 6.1. Note: “cf.” after the species name indicates an identification less confident than those without “cf”. The underlined woody taxa are restricted to one hearth or to the black feature.

1. SPCA sediment and features, all squares	**List of species identified from the charcoal**
Fuel n=48	*Acacia* sp., *Allophylus dregeanus* cf., *Annonaceae, Brachylaena discolor* cf., *Burkea africana* cf., *Caesalpiniaceae/ Fabaceae, Canthium mundianum* cf., *Canthium spinosum* cf., *Canthium suberosum* cf., *Celtis africana, Chionanthus foveolatus, Clusiaceae Hypericum* sp., *Cryptocarya wyliei* cf., *Deinbollia* sp., *Diospyros lycioides* cf., *Diospyros natalensis* cf., *Empogna lanceolata, Englerophytum natalense* cf., *Eugenia erythrophylla , Faurea saligna* cf., *Ficus burkei (*syn. *thonningii), Ficus lutea* cf., *Grewia flavescens* cf., *Harpephyllum caffrum* cf., *Kirkia acuminata* cf., *Leucosidea sericea, Maytenus albata* cf., *Maytenus peduncularis* cf., *Mystroxylon aethiopicum, Olea europaea* ssp. *africana, Olinia ventosa (*syn. *cymosa)* cf., *Peltophorum africanum* cf., *Protea caffra* cf., *Protea sp* cf., *Protea roupelliae, Psydrax obovata* cf. (syn. *Canthium obovatum), Searsia dentata* cf., *Searsia leptodictya* cf., *Searsia* sp., *Shirakiopsis elliptica, Sterculia rogersii* cf., *Syzygium cordatum, Terminalia phanerophlebia* cf., *Trimeria grandifolia* cf., *Vangueria cyanescens* cf., *Vangueria randii* cf, *Vitex* sp., *Zanthoxylum davyi* cf.
Tinder n=15	*Carissa macrocarpa* cf., *Volkameria glabra*, *Cussonia paniculata* cf., *Cussonia spicata* cf., *Cussonia zuluensis* cf., *Erica caffra*, *Erica* sp., *Morella pilulifera* cf., *Ochna serrulata*, *Olax dissitiflora* cf., *Pavetta eylesii* cf., *Podocarpus* sp., *Searsia burchelli* type, *Sophora inhambanensis* cf., *Virgilia oroboides* type.
Firesticks n=6	*Commiphora schimperi* cf., *Cordia caffra*, *Diospyros austro-africana*, *Ficus sur* (syn. *capensis*) cf., *Grewia flava*, *Halleria lucida* cf.
Medicine n=39	*Apodytes dimidiata* cf., *Bersama lucens* cf., *Calodendrum capense*, *Commiphora harveyi* cf., *Commiphora marlothii* cf., *Cryptocarya liebertiana*, *Cryptocarya woodii* cf., *Curtisia dentata*, *Diospyros mespiliformis* cf., *Dombeya rotundifolia* cf., *Ekebergia capensis*, *Euclea crispa*, *Gardenia volkensii* cf., *Grewia bicolor* cf. , *Heteropyxis natalensis* cf., *Kigelia africana* cf., *Loxostylus alata* cf., *Nuxia floribunda* cf., *Pappea capensis* cf., *Parinari curatellifolia* cf., *Pittosporum viridiflorum* cf., *Ptaeroxylon obliquum* cf., *Rapanea melanophloeos*, *Rauvolfia caffra* cf., *Rhamnus prinoides* cf., *Rhoicissus rhomboidea*, *Sclerocroton integerrimus*, *Searsia chirindensis* cf., *Searsia divaricata* cf., *Searsia erosa* cf., *Sideroxylon inerme*, *Tarchonanthus parvicapitulatus*, *Teclea gerrardii* cf., *Trema orientalis* cf., *Trichilia dregeana* cf., *Trichilia emetica* cf., *Vitex rehmannii*, *Ximenia caffra* cf., *Ziziphus mucronata* cf.

Poison n=6	*Euclea natalensis* cf. , *Ficus ingens*, *Hippobromus paucifloris* cf., *Protorhus longifolia* cf. ,
2. Hearth 1 (n=11).	**List of species identified from the charcoal**
Fuel	*Acacia* sp., *Brachylaena discolor, Cryptocarya* sp., *Cryptocarya wyliei* cf., *Shirakiopsis elliptica*
Tinder	*Cussonia paniculata*
Medicine	*Commiphora* sp., *Sclerocroton integerrimus* cf., *Tarchonanthus*
Poison	*Hippobromus pauciflorus* cf., *Spirostachys africana*
3. Hearth 2 (n=7).	**List of species identified from the charcoal**
Fuel	*Brachylaena discolor, Leucosidea sericea, Protea roupelliae*
Tinder	*Cussonia paniculata* cf.*, Erica caffra*
Medicine	*Ptaeroxylon obliquum*
Poison	*Ficus ingens*
4. Hearth 3 (n=7).	**List of species identified from the charcoal**
Fuel	*Brachylaena discolor*, Caesalpiniaceae/Fabaceae, *Chionanthus foveolatus*, *Leucosidea sericea*, *Protea roupelliae*, *Syzigium cordatum* cf.
Tinder	*Cussonia spicata*
5. Hearth 4 (n=13).	**List of species identified from the charcoal**
Fuel	*Diospyros natalensis, Leucosidea sericea, Maytenus albata*, *Mystroxylon aethiopicum*, *Olea africana*
Tinder	*Volkameria glabra, Erica caffra*
Fire-sticks	*Commiphora schimperi*, *Diospyros austro-africana*
Medicine	*Commiphora. harveyi*, *Commiphora marlothii, Rapanea melanophloeos*, *Vitex rehmannii*
6. Hearth 5 (n=5).	**List of species identified from the charcoal**
Tinder	*Erica caffra*, *Morella pilulifera*
Fire-sticks	*Commiphora schimperi* cf.
Medicine	*Cryptocarya woodii* cf., *Parinari curatellifolia* cf.
7. Black feature (n=5).	**List of species identified from the charcoal**
Fuel	*Leucosidea sericea*
Medicine	*Cryptocarya woodii*, *Nuxia floribunda, Trema orientalis, Ximenia caffra*

6.4 Discussion

The possible use of wood in five hearths, black feature and sediment is examined and thereafter, a description of the environment from SPCA at Sibudu is discussed.

6.4.1 Overview of hearths

As described in Chapter 1 Section 1.1 Background, the aim was to determine whether or not woods from medicinal plants were selected deliberately and burned for a particular purpose. If all five hearths contained all the woody taxa from layer SPCA, then the wood may have been indiscriminately collected from nearby. If one of the five hearths contained individual taxa burnt only there, this wood may have been deliberately selected for particular properties, for example aromatic smoke. For this reason it is important to examine the potential medicinal or other uses, not just suitability as fuel. In the case of the poisonous *Spirostachys africana* the small amounts of wood burnt would not be accidental as the poisonous plant is hazardous to work with and to burn, as previously discussed (Chapter 1 Section 3). As expected, all hearths contain fuel wood including tinder to initiate and maintain burning. The wood bundles and associated uses are visually represented in Fig. 6.2 with details in the captions in Table 6.2. The primary uses have been allocated according to literature in Appendix D as previously described (Chapter 1 Section 3 History and status of the study).

It is not certain whether people selected wood randomly or with specific properties in mind. Nonetheless, the ratios of "fuel wood" (fuel and tinder), to "medicinal wood" (wood from plants with medicinal or poisonous properties), have been compared. The wood use categories were introduced in Chapter 1 Introduction (Section 3 History and Status of the study). Equal amounts of fuel and medicinal wood were burnt in Hearth 1. Hearths 2, 4 and 5 represent fires with more fuel than medicinal wood. Hearth 3 contains only fuel wood, including tinder. The black feature, which may have been a fire, or an ash heap or a dump, has medicinal wood. The composition of woody taxa in each hearth differs and the combinations of woods are specific to each hearth. The woods with restricted distribution potentially imply a particular use. If these taxa occur in sediment away from the hearths, then this may be the result of scraping out hearths to re-use them (Fig. 6.2 with details in the captions in Table 6.2; Appendix D).

In Hearth 3 mostly fuel wood occurs, including tinder (Table 6.3). *Cussonia spicata* is a wood found only rarely and the fire may have been started with this tinder wood. *Chionanthus foveolatus* and *Syzygium cordatum* are restricted to this hearth and the *Brachylaena discolor*, *Leucosidea sericea* and *Protea roupelliae* occur in multiple hearths. This collection of fuel woods produces lasting charcoal which is suitable for cooking. The taxa in Hearths 2, 4 and 5 represent fuel wood (Table 6.3).

Hearth 2 is a predominantly fuel fire of tinder and wood, including *Erica caffra* tinder and *Brachylaena discolor, Leucosidea sericea* and *Protea roupelliae* fuel. Charcoal representing the medicinal plant *Ptaeroxylon obliquum* and poisonous plant *Ficus ingens* occur only in this hearth and in sediment. Hearth 4 is a predominantly fuel fire, with potential firesticks, tinder and fuel wood although charcoal representing medicinal plants is present. Three woods are restricted to this hearth, namely, *Diospyros austro-africana* and *Maytenus albata*, which are primarily fuel woods and *Vitex rehmannii* which is medicinal. Seven woods occur only in this hearth and in sediment, namely, *Volkameria glabra* tinder-wood, *Diospyros natalensis*, *Mystroxylon aethiopicum* and *Olea africana* fuel, in addition to *Commiphora harveyi, Commiphora marlothii* and *Rapanea melanophloeos* from medicinal plants. The fire in Hearth 4 may have been started with firesticks (*Commiphora schimperi* cf. is a base-stick), with the addition of tinder, for example *Volkameria glabra*. *Olea europaea* ssp. *africana* is favoured as fuel as it burns without much smoke (Esterhuysen and Mitchell, 1996). Hearth 5 is a fuel-rich fire of firesticks and tinder. Charcoal representing medicinal plants is present, including *Cryptocarya woodii*. Woods in only this hearth and in sediment are *Morella pilulifera* tinder and *Parinari curatellifolia* which is medicinal. The waxy oil from *Morella pilulifera* berries (Boon 2010) may be burnt to produce light. The charcoal in this hearth represents plants with good fuel and wax.

The fires in Hearths 4 and 5 may have been started by means of friction, for example, the *Grewia flava* upper or drill stick and *Commiphora schimperi* base stick were carried in the quiver to make fire during the hunt by the Ju/wasi (!Kung) (Lee 1979). Firesticks are normally kept and carried when hunting or moving (Lee 1979; Dee 1925). However, the fire sticks wear out fairly quickly and they may have been burned when they could no longer be used (Lee 1979; Dee 1925). *Cordia caffra, Diospyros austro-africana* and *Halleria lucida* may also be used as fire-sticks (Boon 2010; Coates-Palgrave 2002; Van Wyk and Van Wyk 2013). *Ficus sur* may be used as a base stick (Venter and Venter 2002).

Brachylaena discolor, *Leucosidea sericea* and *Erica caffra* are found in several hearths in SPCA and it seems that these good fuel woods were burnt frequently. *Acacia* charcoal occurs only in Hearth 1, representing less than three percent of all the charcoal from SPCA (Table 6.1) and less than the *Acacia* from MOD, ~49 ka (Lennox *et al*. 2015) in addition to RSp, OMOD and MOD, ~50 ka (Allott 2006; Jacobs et al. 2008 a, b). It seems that *Acacia* was burnt comparatively less than other good fuel woods in SPCA and less than Acacia from ~49 ka. Previously, *Acacia* spp. was not identified in the charcoal assemblage in sediment from SPCA (Allott 2006) and *Erica caffra* and *Leucosidea sericea* represented good tinder and fuel wood and charcoal representing *Acacia* spp. and *Afrocarpus/Podocarpus* spp. were mutually exclusive. In this new study, the low representation of *Acacia* in SPCA may be due to the type of wood, heat of the fire, the collecting strategy used by the people or due to the environment. It is worth noting that again fragment number is considered to be an incomplete measure of the initial volume of firewood utilised (Chrzazvez *et al*. 2014; Théry-Parisot, 2010a and b; Théry-Parisot and Henry 2012). Either a small amount of *Acacia* wood may have been burnt, or the wood has burnt away leaving few fragments. If three assumptions are made, first that people have collected wood from the vicinity according to the "principle of least effort" (Shackleton 1993; Shackleton and Prins 1992), secondly, that people who live off the land recognise and select wood according to known burning properties (Abbott *et al.* 1997; Cunningham 2001), and thirdly that this was the situation during the occupation of SPCA (Wadley 2013b), then the absence of a known good fuel wood is significant. Since *Acacia* is an efficient fuel wood, it may be that there was less *Acacia* sp. in the vicinity. The low representation of *Acacia* from SPCA may indicate an environment where these trees were scarce.

In Hearth 1 the ratio of fuel to medicinal wood is equal and the variety of woody taxa is highest in this hearth including *Cussonia paniculata* tinder and *Brachylaena discolor* fuel. *Acacia* sp., *Cryptocarya wyliei* and *Shirakiopsis elliptica* are unique and are fuel woods. *Spirostachys africana* and *Tarchonanthus parvicapitulatus* unique woods produce aromatic smoke, *Hippobromus pauciflorus* has aromatic, resinous wood and *Sclerocroton integerrimus* has antiseptic latex. While the charcoal from *Spirostachys africana* is evidence of the use of noxious smoke, the charcoal from *Tarchonanthus parvicapitulatus* suggests the use of insecticidal camphor smoke.

The use of the black feature, BF, is not known. It may represent an ash heap or ash dump formed by the ash and charcoal scraped from hearths. *Cryptocarya woodii, Nuxia floribunda, Trema orientalis* and *Ximenia caffra* are medicinal plants. *Nuxia floribunda* and *Trema orientalis* have bark tannins. *Trema orientalis* tannin may be used to waterproof string which action requires caution since it causes contact dermatitis (Boon 2010). *Ximenia caffra* viscous oil may be mixed with ochre and used to soften animal skins, hair or feet (Rodin 1985). *Leucosidea sericea* is a good fire-starter and fuel wood (Boon 2010).

Charcoals have been recovered from sediments between the hearths so it is assumed that they were scraped out of a nearby fire, and could represent woods from more than one hearth. It is notable that there are woods which occur only in SPCA sediment in squares B4 and C4, D5 and D6 but the reason for this is unknown.

Sediment in square B4 and quadrant D6c contains more fuel than medicinal woods (Table 2). Nonetheless, amongst the woody taxa unique to SPCA sediment in square B4, several have medicinal bark, leaves or oil, for example, *Cryptocarya liebertiana, Curtisia dentata* and *Pittosporum viridiflorum*. *Euclea natalensis* and *Vangueria randii* are avoided today as fuel woods (Boon 2010). *Euclea natalensis* produces smoke which may cause hypnosis, the bark tannins are poisonous and antiseptic and twigs may be used as toothbrushes (Boon 2010; Clarkson *et al.* 2004; Grace *et al*. 2002; Lall and Meyer 1999; Steenkamp 2003). Charcoal unique to sediment in square D6, *Cordia caffra*, represents firesticks which may have been used to start fires nearby (Van Wyk and Van Wyk 2013).

Sediment in square C4 and D5 has an equal ratio of fuel to medicinal wood but the particular fire or use of the wood is unknown. While the potential medicinal uses of plants at Sibudu based on modern knowledge cannot be applied uncritically to the past, suggestions may be made about the wood that would have produced characteristic smoke when it was burnt. Medicinal bark, leaves and wood can, amongst other uses, produce aromatic smoke with possible insect repelling properties (Appendix D).

Table 6.3: Summary of the frequency and distribution of woody taxa according to the possible uses in SPCA. The ratio of fuel to phytomedicine compares the sum of fuel, tinder and fire-sticks to the sum of phytomedicine and poison and the phytomedicine is shaded.

Frequency	**H1 (B4c)**	**H2 (C6a)**	**H3 (C6b)**	**H4 (D6a)**	**H5 (D6b)**	**BF (D5c)**	**Sediment B4**	**Sediment B5 & 6**	**Sediment C4**	**Sediment D4b**	**Sediment D5**	**Sediment D6c**	**SPCA**
fuel	5	3	6	5	0	1	28	13	24	0	15	1	48
tinder	1	2	1	2	2	0	9	3	4	0	3	2	15
firesticks	0	0	0	2	1	0	1	0	2	0	2	2	6
medicine	3	1	0	4	2	4	18	6	24	1	15	2	39
poison	2	1	0	0	0	0	5	0	3	0	3	0	6
No. taxa (n)	11	7	7	13	5	5	61	22	57	1	37	8	110
No. identified specimens	22	9	9	31	11	11	119	69	134	19	138	13	588
Total studied	26	10	10	31	11	11	125	120	139	19	147	14	663
Total fuel	6	5	7	9	3	1	38	16	30	0	20	5	69
Total medicine	5	2	0	4	2	4	23	6	27	1	18	2	45
Ratio fuel: medicine	1.2:1	2.5:1	1:0	1.6:1	1.5:1	0.25:1	1.7:1	2.7:1	1.1:1	0:1	1.1:1	2.5:1	1.5:1
	f=m	f>m	f	f>m	f>m	f<m	f>m	f>m	f=m	m	f=m	f>m	f>m

6.4.2 Environmental implications of plants from SPCA, ~58 ka

The woody taxa from SPCA represent a variety of vegetation types and habitats ranging from evergreen, riverine, woodland and bushveld (savanna) habitats. Hall *et al*. (2014) have illustrated this in a profile diagram showing for example evergreen trees and shrubs could grow against the cool, shaded cliff that houses Sibudu. Plants representing forest margins, woodland and riverine communities could grow close to the uThongathi River, on cooler, south facing slopes. Trees and shrubs that survive drier conditions may have grown on warm hillsides (Appendix E).

There are eight evergreen trees, 36 plants associated with water, 31 plants from open, deciduous woodland and 24 plants from the drier, bushveld/savanna. Of the 99 plants, 67 occur in the river valley. A large proportion of plants from SPCA represents the KZN Coastal Belt, a larger proportion represents forest vegetation in the Scarp, Northern Coastal, Southern Mistbelt and Northern Afrotemperate Forest and a small proportion represents savanna vegetation in the Ngongoni Veld and KZN Sandstone Sourveld (Mucina *et al*. 2011; Mucina and Geldenhuys 2011).

In the KZN Coastal Belt, *Syzigium cordatum* and *Rapanea melanophloeos* are associated with water. In the Scarp Forest, evergreen trees *Englerophytum natalense* and *Harpephyllum caffrum* occur. The woodland trees *Brachylaena discolor*, *Cryptocarya wyliei* (on forest margins and on rock outcrops), *Strychnos henningsii* and *Ptaeroxylon obliquum* occur in this type of forest (Mucina *et al*. 2011). *Commiphora harveyi* occurs in valley bushveld, dry forest and rock outcrops, also found in the Scarp forest, C. harveyi grows beyond the Sibudu dripline as does *Sideroxylon inerme* (Boon 2010). In the Northern Coastal Forest, *Sideroxylon inerme* is an important tall, deciduous tree, *Teclea gerrardii* and *Trichilia emetica* are trees associated with water, *Euclea natalensis* is from open, deciduous woodland, *Maytenus albata* is on forest margins and *Diospyros lycioides* grows in rocky areas (Mucina and Geldenhuys 2011).

Evergreen *Afrocarpus/Podocarpus* spp. occur in SPCA. In the Southern Mistbelt forest, *Allophylus dregeanus, Calodendrum capense, Chionanthus foveolatus*, *Curtisia dentata, Olea europaea,* and *Trimeria grandifolia* are riverine, forest margin or shade loving plants. *Celtis africana*, *Halleria lucida, Ptaeroxylon obliquum, Searsia chirindensis* and *Mystroxylon aethiopicum* are in the open, deciduous woodland. *Olea europaea* occurs on termitaria, away from water in the bushveld. In the Drakensberg Montane Belt and sub-alpine vegetation these plants may be found in Montane Belt scrub communities along stream banks and at the edge of pools (*Halleria lucida*), in boulder bed Mature Scrub (*Leucosidea sericea*) sometimes forming an extensive community which is soon invaded by forest precursor species (*Rhamnus prinoides*, *Euclea crispa* and *Searsia dentata*). The Cliff Scrub vegetation varies in habitats for *Eric* spp., rock-climbers (*Ficus ingens),* shrubs (*Morella pilulifera*) and trees (*Afrocarpus latifolius*, *Leucosidea sericea* and *Protea roupelliae*). Characteristic of the basalt cliffs is grey-green *Cussonia paniculata*. The Drakensberg *Ericas* include *Erica drakensbergensis.* In Montane Belt *Protea* savanna, *Protea caffra* and *Protea roupelliae* form an "orchard" community in river valleys. *Protea caffra* is ubiquitous as it is versatile, adapting to several different types of habitat. *Protea roupelliae* indicates sandstone soils. Montane Belt Forest margins consist of *Leucosidea sericea* and forest precursor species such as *Euclea crispa*, *Halleria lucida*, *Pittosporum viridiflorum, Rapanea melanophloeos*, *Rhamnus prinoides* and *Searsia dentata*. Climbers include *Rhoicissus tridentata* (*Rhoicissus rhomboidea* occurs in SPCA). The dominant tree layer includes *Afrocarpus/Podocarpus* spp*., Celtis africana*, and *Curtisia dentata*. In the sub-alpine belt, the Protea Savanna is dominated by *Protea caffra* and *Protea roupelliae*. Stream-bank communities have *Leucosidea sericea* scrub and associated shrubs, *Diospyros austro-africana* var. *rubriflora, Halleria lucida*, *Olinia emarginata* (*Olinia ventosa* occurs in SPCA), *Rhamnus prinoides* and *Searsia dentata*. Sub-alpine belt, outcrop vegetation includes low growing, *Erica* sp. and *Cliffortia* sp., in addition to *Halleria lucida, Protea caffra* and *Protea roupelliae. Protea roupelliae* is absent from BYA2(i).

The people who lived at Sibudu during the time of SPCA collected woods from a mosaic of vegetation, representing different types of forest as well as savanna in the region. Most vegetation was from the KZN Coastal Belt, Scarp Forest and Northern Coastal Forest. The vegetation from the Montane Belt has since disappeared. The evergreen plants could have inhabited the shady, cooler cliff face, above the river, where Sibudu is located. The river may have enabled these plants to survive drier conditions than today. There was savanna from the Ngongoni Veld, KZN Sourveld (Proteaceae) and a few from savanna bushveld which have since disappeared. These are deciduous and can take some frost. The climate was cooler and drier with cooler winters and drier summers at SPCA, ~58 ka (Bruch *et al*. 2012), woodland increased (Hall *et al*. 2014) and it seems that savanna increased at the cost of forest from the inland regions.

6.5 Conclusion

Charcoal from five hearths and one black feature in SPCA have been identified, with 110 woody taxa adding 42 new identifications for charcoal from Sibudu. A total of 544 charcoal specimens were studied and 516 were identified. This new study of charcoal from SPCA has focused on hearths.

Vegetation at Sibudu ~58 ka ago was different from that today and trees and shrubs representative of evergreen forest, forest margins, woodland, deciduous forest and bushveld suggest a vegetation mosaic. The presence of *Afrocarpus/ Podocarpus* spp. implies a component of evergreen forest which is no longer near Sibudu and supports the previous interpretation of the palaeoenvironment while noting the anthropogenic factors which may have led to clearing *Afrocarpus/Podocarpus* spp. *Leucosidea sericea* is a pioneer at high altitude where there is frost and does not usually grow near the coast. *Morella pilulifera* occurs in the ravines of the Drakensberg foothills. Several plants lost for anthropogenic reasons, occur in nature reserves in the vicinity and could grow near Sibudu.

Each SPCA hearth contains taxa that could have been fuel and tinder woods. Two fifths of the woods burnt in SPCA are plants that, today, have medicinal uses for bark, leaves or wood. Those which are poisonous may be used as medicine in small quantities. Plants which could potentially have been used as medicine were represented by charcoal burnt in Hearth 1 and in the black feature. Hearths 2, 4 and 5 represent fires with more fuel than wood with medicinal properties. Hearth 3 contains fuel wood only. Thus, there are differences in the collection patterns and use of woods between hearths. Several woody taxa are exclusive to Hearth 1, 3 and 4. Each hearth contains some wood not found in any of the other hearths and these restricted woods may been selected for a particular use. If charcoal occurs in one place only, this suggests that the particular wood was used sparingly, if it were a wood that produced aromatic smoke, then possibly it was intended to produce smoke. The presence of plants that produce aromatic smoke from bark and leaves may imply smoke fumigation of burnt sedge bedding. *Erica caffra* tinder and *Leucosidea sericea* fuel wood are found in several hearths and in the sediment in SPCA. This implies that tinder and fuel woods were commonly collected and burnt, which is to be expected. Sediment may incorporate charcoal that was raked from the hearths for cleaning them to allow the hearths to be reused. Constant raking out of hearths may lead to a wide variety of woody species represented outside the hearths and this combination of woods may make indiscriminate gathering seem more likely than it actually was, as a wide variety of spp. is likely to represent indiscriminate gathering.

The possibility that wood was selectively collected for different purposes and that the differences would be reflected in the five SPCA hearths was explored. The hypothesis here is that woods found only rarely in hearths were chosen for their specific properties. The individual wood parcels represented in the five hearths, the black feature and in the sediment suggests that that people at Sibudu gathered wood with full understanding of its properties. If the wood species in these hearths had been similar, this would imply unsystematic collection from around the site for their fires, for example from the evergreen forest nearby. In conclusion, each of the five hearths has some woody taxa that do not occur elsewhere in SPCA. The wood found only rarely may have been chosen for its specific properties. People may have started a fire by making use of preferred tinder together with a wide range of kindling and fuel wood, thereafter, adding the wood with special properties which is only rarely found in hearths. *Spirostachys africana* and *Tarchonanthus parvicapitulatus* added to the existing fire would generate aromatic smoke. The noxious fumes from *Spirostachys africana* and the camphor smoke of *Tarchonanthus parvicapitulatus* are insecticidal.

CHAPTER 7

CHARCOAL ANALYSIS FROM 49 000-YEAR-OLD HEARTHS AT SIBUDU: IMPLICATIONS FOR WOOD USES AND THE KWAZULU-NATAL ENVIRONMENT

The paper in this chapter contains the woody taxa identified from archaeological charcoal which had previously been excavated from four hearths in MOD (Mottled Deposit) layer, from approximately 49 ka. The distribution of the woody taxa in hearths on the layer, the fuel properties and possible uses of the woods are suggested. The paper contributes to the thesis by presenting the use of *Spirostachys africana* as medicinal smoke (Lennox and Bamford 2015). The environmental implications of the trees from MOD are discussed. This paper was published in the *South African Archaeological Bulletin* in 2015, volume 70, pages 36 – 52.

Contribution by the authors:

MKB helped with the research and with writing the paper.

LW initiated the research and helped with writing the paper

SJL identified the charcoal and wrote the paper.

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CHARCOAL ANALYSIS FROM 49 000-YEAR-OLD HEARTHS AT SIBUDU: IMPLICATIONS FOR WOOD USES AND THE KWAZULU-NATAL ENVIRONMENT

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ABSTRACT

Sibudu's layer, Mottled Deposit (MOD), has an age of 49 100 years. Four hearths are present and the charcoal from them was identified to genera and often to species level. Poisonous Spirostachys africana *occurred in one hearth that may have been designed as an insect-repelling fire.* Acacia *wood was generally favoured, probably as fuel wood, but a variety of taxa is represented. Each hearth has some taxa that do not occur in the others. The suite of taxa supports an interpretation of mosaic vegetation communities in an environment that was warmer and drier than that of preceding periods.*

Keywords: Middle Stone Age, Sibudu, anthracology, herbal medicine, *Spirostachys africana*, *Acacia*, firewood.

INTRODUCTION

In this paper we focus on the species identification of charcoal from Sibudu hearths in layer MOD, which has an age estimate of 49 100 ± 2100 (49.1 ± 2.1 ka [ka = 100 000 years ago/old]) based on single-grain Optically Stimulated Luminescence (Jacobs *et al*. 2008). We single out these hearths for a detailed study because we postulate that firewood may have been preferentially selected for tasks. Botanical studies have previously been conducted at Sibudu where there is organic preservation of charcoal, seeds, phytoliths and pollen. Woody taxa were identified based on charcoal derived from random samples taken from selected layers throughout the sequence (Allott 2005, 2006; Lennox & Bamford 2015). Silicified or charred seeds from all squares and all layers were identified (Wadley 2004; Sievers 2006), and Cyperaceae nutlets found in silicified or burnt plant bedding were the subject of several studies (e.g. Sievers & Muasya 2011; Wadley *et al*. 2011). Phytoliths are well preserved and are often articulated (Schiegl *et al*. 2004; Schiegl & Conard 2006; Wadley *et al*. 2011). Pollen occurs, but in small quantities only (Renaut & Bamford 2006).

Previous botanical work on the ~49 ka occupations of Sibudu included the seed and charcoal analyses mentioned above, and also a GIS-based Coexistence Approach (CA_{GIS}) analysis that made use of the seed and charcoal data to make a climatic interpretation (Bruch *et al*. 2012). The identifications of 471 seeds from MOD included 332 from Cyperaceae, as well as those from *Asparagus* sp., *Canthium* sp., *Chrysophyllum viridifolium*, *Cussonia* sp., *Cyphostemma* spp., *Diospyros* sp., *Ehretia rigida*, *Euclea* sp., *Harpephyllum caffrum*, *Lantana rugosa*, *Pavetta* spp., *Pappea capensis*, *Protorhus longifolia*, *Searsia* sp., *Sideroxylon inerme*, *Vepris lanceolata* and *Ziziphus mucronata* (Sievers 2006). Seeds can enter an archaeological site through a variety of non-human and human agents, whereas the presence of charcoal is more likely to reflect the anthropogenic selection of firewood. At Sibudu, younger layers like MOD are considerably richer in seed taxa than the older ones (Sievers 2006), but these upper layers yielded an immense volume of sediments and large sample sizes. When Allott (2006) conducted charcoal analysis in layer MOD, her study was restricted to samples from squares B5 and B6, and 120 fragments were studied. Woody taxa identifications included *Acacia* spp., *Albizia* spp., *Bridelia* sp., *Burkea africana*, *Cunonia capensis*, *Curtisia dentata*, *Diospyros* sp., *Drypetes* sp., *Erica* spp., *Macaranga* cf. *capensis*, *Mystroxylon aethiopicum*, *Nuxia* sp. *Pappea capensis*, *Rapanea melanophloeos* and *Ziziphus mucronata* (Allott 2006: 193). *Pappea capensis* and *Macaranga* cf. *capensis* were exclusively found in MOD (Allott 2006). Evergreen and deciduous taxa were found in the MOD assemblage and most can withstand some frost. The frequencies of deciduous taxa were greater than before and, notably, there were no *Podocarpus* specimens. The uThongathi River probably flowed at the time because taxa preferring riverine habitats, such as Cyperaceae, *Erica* spp., *Bridelia* sp. and *Macaranga* cf. *capensis* were present. Although riverine forest was evident, there were also woody taxa from dry, savanna contexts. *Albizia* spp. and *Acacia* spp. imply drier, warmer environments than was previously the case (that is, in the 58 ka occupations). Species from both these genera are found near Sibudu today, and they have a fairly wide environmental tolerance.

The CA_{GIS} analysis demonstrates that the late Middle Stone Age (MSA) (that includes layer MOD) was perceptibly warmer than earlier in the MSA, especially during winter (Bruch *et al*. 2012). Concurrently, summer precipitation increased marginally and vegetation became more closed than previously, though it was still at least as open as today's countryside. Variations through time in winter temperatures produced a gradual trend towards conditions not unlike those of the present (Bruch *et al*. 2012). The seasonal precipitation parameters produced by the CA_{GI} imply that the wet season was predominantly in summer as is the case today. Thus the same atmospheric circulations patterns as today are likely to have prevailed, together with transport of moisture from the Indian Ocean. The link between precipitation near Sibudu and Indian Ocean sea surface temperatures was previously made by Chase (2010). The CA_{GI} results are supported by isotope data from *Podocarpus* charcoal collected from layer RSp at Sibudu (Hall *et al*. 2014). RSp is stratigraphically older than MOD, but is part of the suite of layers with ~49 ka ages. The stable carbon isotope values of the *Podocarpus* charcoal from RSp show higher variance and range than those from earlier periods. This suggests that only certain habitats, perhaps close to the river, were moist enough for *Podocarpus* at ~49 ka (Hall *et al*. 2014). Although *Podocarpus* was still present in layer OMOD (Hall *et al*. 2014), which lies between RSp and MOD, no *Podocarpus* charcoal was found in MOD.

Otomys irroratus (vlei rat) and *Otomys angoniensis* (angoni vlei rat) were found in MOD (Glenny 2006). *Otomys irroratus* favours grass-covered ground near streams and marshes, while *Otomys angoniensis* lives in similar environments, but also in drier areas (Skinner & Chimimba 2005). The increase in closed environments at ~49 ka may well explain why small bovids like *Philantomba monticola* (blue duiker), and other types of duiker and steenbok appear at this time, having been absent from the faunal record since about 62 ka (Wadley *et al*. 2008).

We have elected to conduct a charcoal analysis of woody taxa from hearth features in MOD primarily because of the earlier tentative identification of *Spirostachys africana* Sond. (tamboti) by Lucy Allott (2005, 2006). Six charcoal specimens cautiously named *Spirostachys africana/Sapium* were recorded by Allott. Known as African mahogany, African sandalwood (Setshogo & Venter 2003) or tamboti, the scented wood is attractive, oily and resinous (Rodin 1985). Although *Spirostachys africana* is poisonous and cooking over its coals may cause poisoning, even death (Venter & Venter 2002: 276), its wood has many useful properties. Amongst these, it can dispel insects (Watt & Breyer-Brandwijk 1962), and its smoke is used as a fumigant (Sullivan 1998). Torches can be burnt from its wood (Rodin 1985; Curtis & Mannheimer 2005). Wood blocks are used as protection against Diptera maggots (Von Koenen 2001). People who use *Spirostachys africana* know how to avoid the poisonous effects, but working with the wood (or tree) can be dangerous, damaging eyes and skin, and causing diarrhoea (Wink & Van Wyk 2008). Wearing the wood, for example as a bangle, can cause skin rashes (Coates-Palgrave 2002). Its smoke is aromatic, triggering headaches, which is why it is known as the 'headache tree' in the vernacular in Botswana (Sullivan 1998). The wood is considered an extremely hazardous poison and the cytotoxins are phorbol esters (Wink & Van Wyk 2008). The latex is a fish and arrow poison (Rodin 1985; Von Koenen 2001; Curtis & Mannheimer 2005). The bark has antimicrobial activity, explaining its use in many African countries as a purgative against digestive ailments (Paulsen *et al*. 2012). The importance of recognising this tamboti wood species prompted a detailed study of its charcoal anatomy (Lennox & Bamford 2015). *Spirostachys africana, Sclerocroton integerrimus* Hochst. (syn. *Sapium integerrimum* [Hochst.] J. Léonard., duiker-berry) and *Shirakiopsis elliptica* (Hochst.) Esser (= *Sapium ellipticum* [Hochst.] Pax, jumping-seed tree) are difficult to separate because they have similar wood anatomy (Mennega 2005; Mugabi *et al*. 2012; Lennox & Bamford, in press). These three closely related trees are in the family Euphorbiaceae and subfamily Euphorbioideae (Westra & Koek-Noorman 2004). The common anatomical, IAWA (International Association of Wood Anatomists) features, are uniseriate rays with procumbent cells and apotracheal parenchyma with a diffuse or diffuse-in-aggregate arrangement (Allott 2005; Mennega 2005; Lennox & Bamford, in press).

Based on several features, Lennox and Bamford found that it is indeed possible to distinguish between *Spirostachys africana, Sclerocroton integerrimus* and *Shirakiopsis elliptica*. The following diagnostic characteristics were determined: xylem vessel width increases proportionally as vessel frequency decreases, from *Spirostachys africana*, through to *Sclerocroton integerrimus* to *Shirakiopsis elliptica*. *Spirostachys africana* ray cells contain prismatic, calcium oxalate crystals, whereas in *Sclerocroton integerrimus* and *Shirakiopsis elliptica* the ray cells contain spheroidal silica bodies. The prismatic crystals shine with a birefringent (rainbow) hue whereas the silica bodies are not birefringent, appearing opaque under polarised light (Lennox & Bamford, in press). *Spirostachys africana* has small to medium vessels (50–100 μm); there are several to many vessels (20–40–100 μm) arranged in long radial multiples (Mennega 2005; Mugabi *et al*. 2012). *Sclerocroton integerrimus* has medium to large vessels (50–100–200 μm); few vessels (5–20 mm^{-2}) are arranged in short radial multiples, with a variation of long radial multiples (Mennega 2005). *Shirakiopsis elliptica* has large to very large vessels (100–200 >200 μm); very few vessels (≤5 mm^{-2}) are arranged in short radial multiples (≤5 mm^{-2}) (Louppe *et al*. 2002; Mennega 2005). This anatomical study has given us confidence that *Spirostachys africana* can be identified amongst archaeological charcoal.

Identifying *Spirostachys africana* charcoal in a hearth in MOD will imply that the wood was deliberately used or burnt there. We therefore have three aims: first, to confirm the presence of *Spirostachys africana* and, secondly, to find out whether this wood was preferentially used in some fireplaces and not in others at ~49 ka. If people understood the properties of the wood, we expect that the poisonous wood would have been spatially restricted in its use. Thirdly, *Spirostachys africana* and a few other woody taxa tentatively identified by Allott, for example, *Burkea africana*, are not presently found near Sibudu. There is a chance, then, that we shall be able to confirm Allott's suggestion that vegetation communities at ~49 ka were different from those of today.

MODERN ENVIRONMENT AROUND SIBUDU

Sibudu Cave is positioned on a steep cliff above the uThongathi River, approximately 40 km north of Durban and about 15 km inland of the Indian Ocean. Nowadays, the Sibudu area receives average summer rainfall of about 750 mm and average winter rainfall of about 250 mm. Summer is hot and humid, and winter is mild and relatively dry. Mean January (mid-summer) temperatures are 22–25°C and mean July (mid-winter) temperatures are 17–20°C (Bruch *et al*. 2012). The current high summer precipitation is due to the southward expansion of the easterly wind regime in summer. This brings moisture to the land mass from the Indian Ocean. Clement winters are caused by the warm Agulhas Current and the transport of heat from the ocean to the land.

The bioregion is classified as the 'KwaZulu-Natal Coastal Belt' within the 'Indian Ocean Coastal Belt' (Mucina & Rutherford 2006). The forested patches in the region are the southernmost extremes of the tropical to subtropical coastal forests of East Africa. Forests, defined as woody vegetation with continuous canopy cover, are characteristically evergreen in the area (Rutherford & Westfall 1986). The forest around Sibudu is predominantly evergreen, yet deciduous and semi-deciduous species do occur, especially at the forest margins. Farther from the coast is the 'Montane Grassland and Shrubland' biome (Olson *et al*. 2001), elsewhere called 'Savanna' (Mucina & Rutherford 2006). Savanna is defined as tropical vegetation in which woody plants and grasses co-occur (Scholes 1997). The woody plant layer of savanna can comprise 75% canopy cover (called woodland), but woody plants can be more widely spaced (Rutherford & Westfall 1986). Many savanna woody species are deciduous and shed all their leaves in one season. Today there is a mosaic of vegetation types within a few kilometres of Sibudu. Forest grows in the well-shaded southern aspect, while open savanna thrives on the sunny northern slopes of the hill opposite the site. The river between the forest and savanna provides yet another vegetation community, where *Bridelia micrantha* and several sedge taxa thrive. Mosaic vegetation like this may also have occurred here in the past. The vegetation currently near Sibudu has been considerably affected by anthropogenic activities: forest has been cleared for sugar cane fields and alien taxa are common in the forest and along the river.

BACKGROUND TO LAYER MOD

The multidisciplinary team of archaeologists and students who worked at Sibudu from 1998 to 2011 was led by Lyn Wadley. This team excavated the material discussed in this

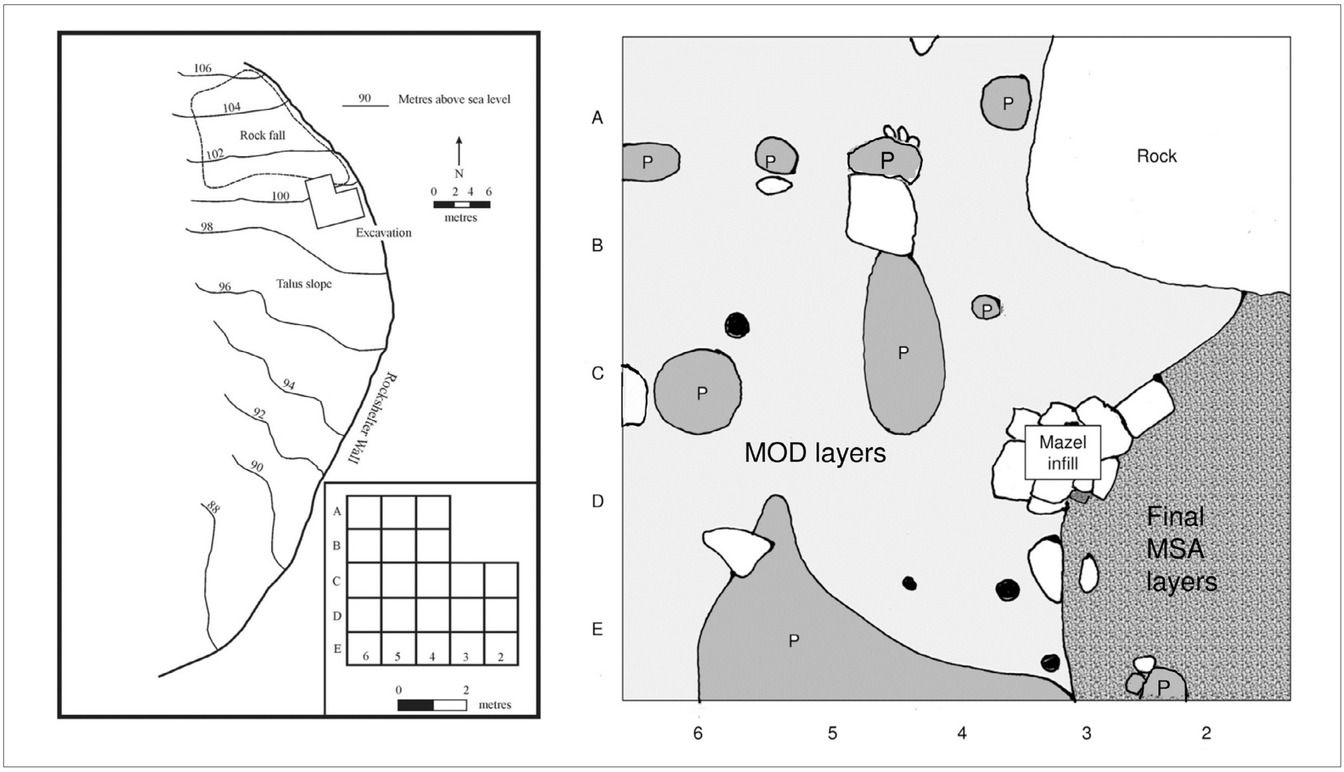


FIG. 1. *Sibudu site plan showing the position of the excavation grid (Wadley & Jacobs 2006). On the right is the floor plan of MOD. In black are the hearths from which charcoal was analysed. P = Iron Age pits that were dug into the MSA sediments. Rocks are white. Final MSA layers that are absent from most of the excavation grid are patterned grey. The positions of the four hearths are in C6a (Hearth 1), E3d (Hearth 2), E4a (Hearth 3) and E4d (Hearth 4).*

paper. The uppermost layer names at Sibudu follow Mazel's 1983 terminology (Wadley 2001). MOD is an abbreviation used by Mazel for Mottled Deposits. In most of the excavation grid (Fig. 1) the MOD layer lies directly below Iron Age ones (Fig. 2), but younger MSA occupations occur against the shelter wall in the eastern part of the excavation grid (Fig. 1). MOD sediment is mottled-brown, silty sand with flecks and nodules of white ash, gypsum and charcoal. The patchy yellow/orange/black mottled appearance of the sediments suggests that extensive burning took place when the site was occupied. Sediments mainly comprise anthropogenically derived ash, bone and worked stone together with many gypsum nodules in MOD, though FTIR spectroscopy values for calcite in MOD are even higher than those for gypsum (Schiegl & Conard 2006). High calcite values can be expected on exposed surfaces because, in arid soil profiles, calcite forms close to the surface whereas the more soluble gypsum forms below it (Goldberg & Macphail 2006). The less soluble calcite precipitates in the uppermost layer of an exposed surface. A mineralogical study of hearth and soil samples from Sibudu verifies ash as a major component (Schiegl & Conard 2006).

MOD is the youngest MSA occupation across most of the excavated area of the site, ~49 ka. The younger MSA occupations, near the shelter wall, have an age estimate of ~39 ka (Jacobs *et al*. 2008). MOD was exposed as the uppermost shelter floor for more than ten thousand years (Wadley & Jacobs 2006; Jacobs *et al*. 2008) before the ~39 ka occupations took place closer to the shelter wall. It is not possible to determine spatial patterns with any certainty on the MOD surface because Iron Age pits vandalised the upper MSA sediments. When excavating, these pits were removed first to avoid contaminating the MSA layers. Four undisturbed hearths were recognised (Fig. 1), but the mottled sediments of MOD probably represent raking of former hearths as well as burning of bedding. Three of the four hearths, those in C6a (Hearth 1), E3d (Hearth 2) and E4a (Hearth 3), are approximately circular and have black bases with white ash capping; the fourth hearth, in E4c (Hearth 4), is a small white ash feature. Organic preservation is good in MOD and the charcoal fragments collected from the layer are large (most are more than 1.5 mm in length) and well preserved. This observation was also made by Allott (2005, 2006). The good preservation of the charcoal means that some of the challenges often faced by anthracologists (Wheeler *et al*. 1989; Bamford & Henderson 2003; Théry-Parisot *et al.* 2010a,b; Gonçalves *et al*. 2012; Chrzazvez *et al*. 2014) are ameliorated in MOD.

MATERIAL AND METHODS

MATERIAL

We extended the KwaZulu-Natal reference collection of 209 indigenous species (Allott 2005) by adding 98 species of indigenous trees collected from farms in Limpopo and KwaZulu-Natal with permission from the landowners. A donation of 70 indigenous wood blocks from the South African Forestry Department, by the Larry Leach Herbarium, University of Limpopo, was added. Wood samples (1 cm^3) were carbonised and studied as a comparative reference of anatomical features. Stereomicroscope images were created and anatomical features were recorded. The charcoal, wood and voucher herbarium specimens with locality coordinates are at the University of the Witwatersrand, in the Evolutionary Studies Institute Palaeobotany Herbarium. Archaeological charcoal from four hearths (Hearths 1–4) in MOD squares, C6a, E3d, E4a and E4c (Wadley & Jacobs 2006; Wadley *et al*. 2011), was examined.

METHODS

The methods used here have been adapted from those used in other anthracology studies (Allott 2005, 2006; Gonçalves *et al*. 2012; Hubau *et al*. 2012, 2013; Py *et al*. 2013;

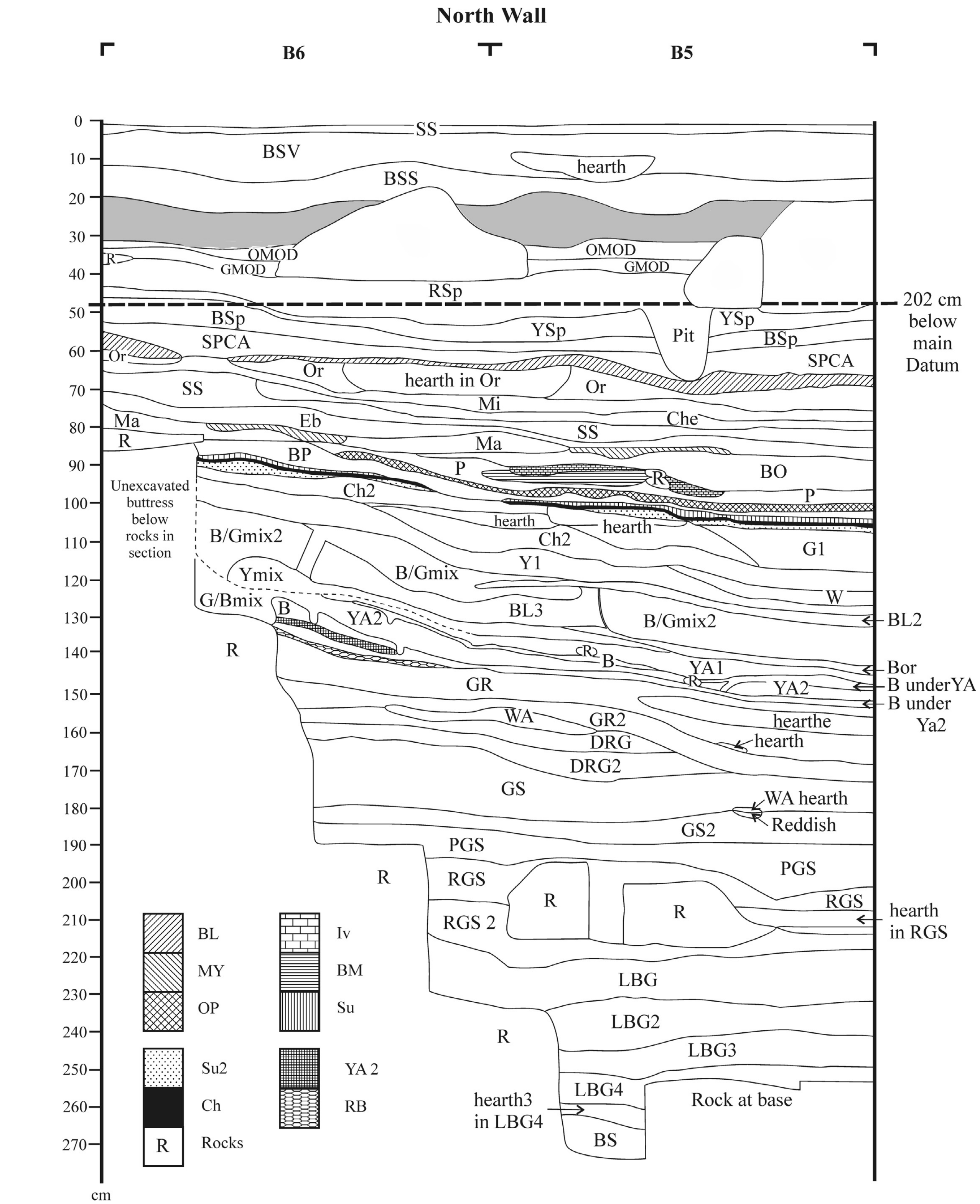


FIG. 2. *Stratigraphy of Sibudu's north wall in squares B5 and B6. Layer MOD is grey.*

Asouti & Kabukcu 2014). Reference wood blocks were charred in a LENTON 0861 muffle furnace, for 3.5 hours at 350°C at the Palaeosciences Centre, University of the Witwatersrand. Charcoal specimens were examined, photographed and identified according to the method of Allott (2006). Charcoal blocks were viewed by means of an Olympus SZX16 stereomicroscope, an OSIS USB digital camera and Olympus soft imaging solutions software. Characteristic anatomical features were studied in more detail by means of a reflective, polarised light microscope, Olympus BX51, and Olympus Stream Essentials® image analysis software with Extended Focal Image (EFI) capability. The anatomical features of archaeological charcoal in MOD were recorded according to the IAWA *List of Microscopic Features for Hardwood Identification* (Wheeler *et al*. 1989).

Woods were identified by different means. A matching suite of diagnostic features was sought comparatively, by means of a key for the KwaZulu-Natal Reference Collection (Allott 2005). Images of archaeological and reference charcoal were compared. This process was repeated by means of the supplementary modern reference collection and key. Published references were examined (Kromhout 1975; Ilic 1991; Neumann *et al*. 2000). The online database, InsideWood (2004–onwards), was consulted. The IAWA features of archaeological charcoal and reference material were matched. First, identified specimens were confirmed. Secondly, unidentified specimens were sought. A suite of IAWA numbers for anatomical features (1–221) identified the species. If not, then closely related southern African species were used to identify the genus or family. The Delta database (Richter & Dallwitz 2009), was consulted for unresolved identifications. The anatomical features and images of the identified archaeological charcoal specimens were cross-referenced with each other and with reference material, forming a database of descriptions and images for confirming identifications. Unique features were sought, where possible, such as the crystals and silica bodies which aid the distinction between *Spirostachys africana* and *Sclerocroton integerrimus* (Lennox & Bamford 2015).

RESULTS

TAXONOMIC COMPOSITION OF THE CHARCOAL ASSEMBLAGE

A total of 60 woody taxa was distinguished and 190/193 specimens studied were identified. Twenty-two woody taxa are represented in Hearth 1, 36 in Hearth 2, 25 in Hearth 3 and one in Hearth 4. Forty-eight new taxa have been added (Table 1) to those previously identified by Allott (2006). A summary of the anatomical features compared to reference material is in Appendix A. Three unidentified fragments, including a seed pericarp, were found in Hearth 2. Specimens smaller than 1 mm were not counted as these were too small to study microscopically. Unidentifiable fragments damaged by carbonisation were kept aside; these were vitrified, crystallised, powdered or fibrous specimens.

WOODY TAXA IDENTIFIED IN HEARTHS IN MOD

Three of the hearths are characterised by a wide range of taxa contained in each (Table 2), but Hearth 4 contained only *Acacia*. Each of Hearths 1 to 3 has some taxa that are specific to that hearth. There is, therefore, considerable variability in the wood packages in each hearth. The woody taxa restricted to Hearth 1 represent *Dalbergia obovata, Diospyros lycioides, Dombeya rotundifolia, Dombeya tiliacea, Rhoicissus romboidea, Shirakiopsis elliptica, Spirostachys africana, Syzygium cordatum* and *Trema orientalis*. The greatest variety of woody taxa is represented in Hearth 2. Those restricted to Hearth 2 are *Diospyros austro-africana, Ficus burkei, Ficus lutea, Halleria lucida, Heteropyxis natalensis, Mimusops obovata, Nuxia floribunda, Olea europaea* subsp. *africana, Ozoroa paniculosa, Peltophorum africanum, Protea nitida, Ptaeroxylon obliquum, Pterocarpus rotundifolius* and *Sclerocroton integerrimus*. Hearth 3 has the greatest frequency and the most variety of *Acacia* types. Woody species particular to Hearth 3 are *Celtis africana*, *Harpephyllum caffrum*, *Trichilia emetica* and *Vangueria randii*.

Acacia charcoal has been grouped into five different types until the reference collection can be expanded, enabling a more comprehensive comparative anatomical study of the 61 species of *Acacia*, including five subspecies in the southern African region (Coates-Palgrave 2002). Of these, 33 species, including five subspecies, occur in KwaZulu-Natal (Boon 2010). The original name *Acacia* Mill. is used throughout this paper. Fragments of charcoal from the *Acacia* genus were distinguished by long, thin, procumbent ray cells. The five types are according to ray width: the number of cells in the widest part of the ray seen in tangential section (Kromhout 1975; Robbertse *et al*. 1980;

TABLE 1. *Woods identified from a new charcoal study of 190 pieces in four hearths in MOD. Taxa shaded grey are new identifications that were not present in previous lists (Allott 2006). Taxa with an asterisk were identified in seeds by Sievers (2013). Names are conferred* (cf.) *where anatomical features and micrograph matched closely but not completely, usually due to distortion of the charcoal by the carbonisation process. Specimen numbers are referred to in each square.*

	Hearth 1: C6a	Hearth 2: E3d	Hearth 3: E4a	Hearth 4: E4c	Total no. fragments
*Acacia** sp. Type 1 Mimosaceae	2	4	15		21
Type 2	13	2	10		25
Type 3	1	0	10	1	12
Type 4	0	2	3		5
Type 5	0	0	2		2
Afzelia quanzensis Caesalpiniaceae	C6a 25	E3d 12 E3d 19			3
cf.			E4a 51		1
Allophylus dregeanus cf. Sapindaceae		E3d 44	E4a 17		2
Bauhinia galpinii Caesalpiniaceae	C6a 27	E3d 48			2
cf.			E4a 53		1
Brachylaena discolor Asteraceae	C6a 32		E4a 54 E4a 7		3
cf.		E3d 69	E4a 26		2
Bridelia mollis cf. Euphorbiaceae	C6a 13 C6a 18				2
Burkea africana Caesalpiniaceae	C6a 42 C6a 52				2
cf.		E3d 2	E4a 4		2
*Canthium** *mundianum* cf. Rubiaceae		E3d 5	E4a 60		2
Canthium suberosum cf.		E3d 3			1
Celtis africana Celtidaceae			E4a 62		1
*Clerodendrum glabrum** cf. Lamiaceae			E4a 46		1
Commiphora marlothii cf. Burseraceae			E4a 48 E4a 56		2
*Cordia caffra** Boraginaceae		E3d 55	E4a 22		2
*Cussonia*paniculata* cf. Araliaceae		E3d 66			1
Dalbergia obovata Fabaceae	C6a 15 C6a 40 C6a 41 C6a 53				4
*Diospyros** *austro-africana* Ebenaceae		E3d 16			1
*Diospyros** *lycioides*	C6a 28 C6a 54				2
*Diospyros** *mespiliformis*	C6a 31	E3d 9 E3d 18 E3d 33 E3d 38 E3d 57 E3d 60	E4a 63		8

Continued on p. 41

TABLE 1 (continued)

	Hearth 1: C6a	Hearth 2: E3d	Hearth 3: E4a	Hearth 4: E4c	Total no. fragments
Diospyros villosa*		E3d 42 E3d 63	E4a 12 E4a 61		4
Diospyros whyteana*		E3d 25	E4a 20 E4a 29		3
Dombeya rotundifolia Sterculiaceae	C6a 16				1
Dombeya tiliacea Sterculiaceae	C6a 1				1
Empogna lanceolata cf. Rubiaceae		E3d 67			1
Erica caffra Ericaceae	C6a 7 C6a 20 C6a 58		E4a 18 E4a 31		5
*Euclea*crispa* cf. Ebenaceae		E3d 43 E3d 58 E3d 72			3
Ficus lutea Moraceae		E3d 50			1
Ficus burkei syn. *thonningii*		E3d 71			1
Gardenia volkensii cf. Rubiaceae*		E3d 6 E3d 14 E3d 28			3
Halleria lucida Scrophulariaceae		E3d 1 E3d 21			2
*Harpephyllum caffrum** Anacardiaceae			E4a 3		1
Heteropyxis natalensis Heteropyxidaceae		E3d 7			1
Kiggelaria africana Achariaceae	C6a 19	E3d 34	E4a 9		3
Maytenus sp. Celastraceae*	C6a 43				1
Mimusops obovata Sapotaceae		E3d 24 E3d 27 E3d 31 E3d 59 E3d 70			5
Mystroxylon aethiopicum Celastraceae		E3d 41	E4a 59		2
Nuxia floribunda Buddlejaceae		E3d 11 E3d 30 E3d 32			3
Ochna serrulata Ochnaceae	C6a 50				1
Olea europaea* subsp. *africana* Oleaceae		E3d 49 E3d 54 E3d 65			3
Ozoroa paniculosa Anacardiaceae		E3d 35 E3d 51 E3d 62			3
*Pappea capensis** cf. Sapindaceae	C6a 47		E4a 67		2
Peltophorum africanum Caesalpiniaceae		E3d 56			1
Protea nitida Proteaceae		E3d 45			1
Protorhus longifolia *cf. Anacardiaceae		E3d 26		1	
Ptaeroxylon obliquum Pteroxylaceae		E3d 10 E3d 61 E3d 64			3
Pterocarpus rotundifolius Fabaceae		E3d 22			1
Rhoicissus rhomboidea* Vitaceae	C6a 6 C6a 10 C6a 26 C6a 48 C6a 51 C6a 56 C6a 57				7
Rothmannia capensis cf. Rubiaceae			E4a 73		1
Sclerocroton integerrimus Euphorbiaceae		E3d 8			1
Searsia chirindensis* cf. Anacardiaceae		E3d 36			1
Searsia divaricata* cf.		E3d 39			1
Searsia lancea* cf.		E3d 68			1
Searsia rehmanniana* cf.	C6a 44				1
Shirakiopsis elliptica Euphorbiaceae	C6a 46				1
Spirostachys africana Euphorbiaceae	C6a 39				1
Syzigium cordatum Myrtaceae	C6a 55				1
Trema orientalis Celtidaceae	C6a 33				1
Trichilia emetica Meliaceae			E4a 36		1
Vangueria cyanescens cf. Rubiaceae			E4a 15		1
Vangueria randii			E4a 33		1
cf.		E3d 47			1
Monocotyledon cf.			E4a 13 E4a 38		1 1
Total *Acacia* specimens	16	8	40	1	65
Total other identified specimens	35	60	30		125
Unidentified charcoal and 1 pericarp	0	E3d 53 E3d 29 E3d 4	0		3
Total no. specimens	51	71	70	1	193
Total no. identified woody taxa	22	36	25	1	60

TABLE 2. *Uses of MOD woods unique to Hearths 1 to 3. Palmer & Pitman 1961*[1]*, Watt & Breyer-Brandwijk 1962*[2]*, Von Breitenbach 1965*[3]*, Malan & Owen-Smit 1974*[4]*, Liengme 1981*[5]*, Fox & Norwood Young 1982*[6]*, Arnold & Gulumian 1984*[7]*, Rodin 1985*[8]*, Mabogo 1990*[9]*, Hutchings & Van Staden 1994*[10]*, Sullivan 1998*[11]*, Lin* et al. *1999*[12]*, Graham* et al. *2000*[13]*, Van Wyk & Gericke 2000*[14]*, Dzerefos & Witkowski 2001*[15]*, Coates-Palgrave 2002*[16]*, Venter & Venter 2002*[17]*, Grace* et al. *2003*[18]*, Obi* et al. *2003*[19]*, Setshogo & Venter 2003*[20]*, Schmelzer 2007*[21]*, Gundidza* et al. *2008*[22]*, Paraskeva* et al. *2008*[23]*, Wink & Van Wyk 2008*[24]*, Van Wyk* et al. *2009*[25]*, Boon 2010*[26]*, Paulsen* et al. *2012*[27]*, Van Wyk & Van Wyk 2013*[28] *and Cunningham, pers. comm. 2015*[29]

Identification	Hearth	Implements	Fuel	Food	Medicine
Bridelia mollis cf.[16,28]	1	Implements[20]	Avoided[16,20]	Fruit[11,16]	Leaf balm[20]
Canthium suberosum cf.[26,28]	2	–	–	–	–
Celtis africana[17,26]	3	Carving, handles[17,26], twine[28]	Hard: firewood, charcoal[28]	Fruit[17]	Bark: fever; leaf: eyes[7,9]
Clerodendrum glabrum cf.[16,26,28]	3	Carving[28], poles[26], shafts[8], tools[30],	Tinder-wood to start fires [26,28]		Leaves: several ailments[30]; repellent[2]
Commiphora marlothii cf.[16,28]	3	Bark sheets[16]	–	Fruit[28], root juice[28]	Leaf/stem: antimicrobial[23]
Cussonia paniculata cf.[26,28]	2	Blocks[28]	Soft[26]	Fruit, tuber[28]	–
Dalbergia obovata[26,28]	1	Sticks, carving, laths, twine[28]	Heavy[26]	–	Bark ash: snuff, antiseptic; root charms[28]
Diospyros austro-africana[26,28]	2	–	Fire-sticks [2,26]	–	–
Diospyros lycioides[17,26,28]	1	–	–	–	Root toothbrushes[28,20]
Dombeya rotundifolia[1,3,17,25,26,28]	1	Bows[16], handles[26], carving[26], poles[7], twine [17,28]	Fire resistant[26]	Honey bees[17]	Bark[2], root, wood: medicinal[17,26], extracts antibacterial, anti-inflamatory[25]
Dombeya tiliacea[26]	1	–	–	–	–
Empogna lanceolata cf.[16,26]	2	Shafts[26]	–		–
Euclea crispa cf.[26]	2	–	Avoided[26]. Branches: fire fighting[26]	Fruit[26]	Twig toothbrushes[26]; bark, fruit: medicinal[13,15, 18, 26]; laths, root dye[26]
Ficus burkei syn. *thonningii*[17,26]	2	Fibre mats[28], twine[17]	Soft: susceptible to borer[28]	Figs: wildlife[28]	Bark/root infusion: stops bleeding/abortion; latex: cateracts[17]
Ficus lutea[26,28]	2	Fibre mats[28]	–	Figs: wildlife[28]	Latex poison: bird lime[28]
Gardenia volkensii cf [17,26,28]	2	Carving[28]; traps from three angled side-branches for small mammals, monkeys[29]		Fruit: wildlife[17,26]	Roots medicinal: several ailments[17,26]; fruit: medicinal[28]; protection[26]
Halleria lucida[16,17,26,28]	2	Shafts[16]	Fire-sticks[26]: turning stick[17]	Fruit[26]	Leaf/root infusion: ears[17,26]; burnt wood, crocodile fat[26,27] and *Rhamnus prinoides*: protection[16]
Harpephyllum caffrum[17,25,26,28]	3	Carving[28]	Heavy[17], fuel[26]	Fruit[17,26]	Bark: purifier [2,17,26]; extracts anti-bacterial/fungal, anti-inflammatory[25]
Heteropyxis natalensis[2,17,25,26,28]	2	Hard[26]	–	–	Leaves, roots, twigs (dried/ tea[2]): respiratory infections [2,17,26]; essential oil, aromatic, anti-bacterial/fungal, anti-inflammatory[25]
Maytenus sp.[16,26]	1	Hard: sticks, carving[16,26]	–	–	–
Mimusops obovata[16,26,28]	2	Carving[17,26,28,]	–	Fruit[16]	Bark[28]
Nuxia floribunda[17,26,28]	2	Poles[26,28]	Hard, heavy[17]		Bark tannin medicinal[26,28]
Ochna serrulata[26,28]	1	–	–	–	Roots: bones, alimentary canal[26,28]
Olea europaea subsp. *africana*[2,17,25,26,28]	2	Carving[28], poles[17]	Fuel[26], charcoal: calorific value high	Fruit[28]: bitter/sweet[1, 7]	Leaf extract: lowers blood pressure[2,25]; relieves fever, eye infections[2,25], nose bleeds[17]; bark: colic[18,25,28]
Ozoroa paniculosa[26,28]	2		–		Fruit dye[26]; gum adhesive[28]
Peltophorum africanum[17,26,28]	2	Carving[28]	Firewood[16,17,26]		Bark, leaves, root: antiseptic[17,20,26]
Protea nitida[22,25,28]	2	Sticks, blocks[28]	Excellent firewood[28]	–	Bark: antidiarrheal[25]; tannin[28]

Continued on p. 43

TABLE 2 (continued)

Identification	Hearth	Implements	Fuel	Food	Medicine
Protorhus longifolia cf.[17,28]	2	Poles, carving[17]	–	Leaves: famine food (Maxixe, Mozambique)[6]; fruit: wildlife[28]	Bark tannin[17]: poison/medicine[17,18]
Ptaeroxylon obliquum[2,17,25,26,28]	2	Poles[17], hard[28]: carving[5], music (Mozambique)[14]	Excellent fuel[17]; flammable resin[28]; termite resistant[1]; medium to high density[3,14]; charcoal high calorific value[4]: fire starters[17]	–	Bark/wood (snuff [2])[10,18]: hypertension[25]/headache[2]; wood blocks/oil: insect repellent[17] resin antiseptic[17,26]; smoke: ritual[17]
Pterocarpus rotundifolius[17,26,28]	2	Carving[28]	–	–	Leaf drops: eyes[17]
Rhoicissus rhomboidea[26,25,28]	1	Twine[26]	–	Fruit (sour), roots[28]	Root: anti-inflammatory[12, 25]
Rothmannia capensis cf.[17,28]	3	Handles[28,26], engraving[17]	Hard, heavy[17]: hot [26] fire, fuel	Fruit: wildlife[17]	Fruit: wounds, burns[17,26] Root: leprosy, rheumatism[17,26]
Sclerocroton integerrimus[26,28]	2	Poles, carving[27]	–	Fruit: wildlife[27]	Clear latex poison/antiseptic[26] fruit tannin[28]
Searsia chirindensis cf.[2,17,25,26,28]	2	Carving[28], handles[9]	Hard	Fruit: wildlife [6]	Leaves[2,25]/latex[17,26]: heart complaints. Bark medicine[2,18]/ protection[28]
Searsia divaricata cf.[16,26]	1	Knobsticks[26]	–	–	Leaf smoke: colds and coughs[26]; rainmaking[26]
Searsia lancea cf.[17,28]	2	Bows[28], handles[20]	Hard[4,17,28]	Fruit[17]	Bark tannin[17,28]: antibacterial; leaf oil: antimicrobial[19,22]
Searsia rehmanniana cf.[26,28]	1	Poles[26]	–	Fruit[30]	–
Shirakiopsis elliptica[26,28]	1	Carving[26,28]	Fuel, charcoal[28]	–	Tannin; clear latex: bird lime, body markings, added to *Acokanthera schimperi* arrow poison; bark: antimicrobial (food poisoning), anthelminthic (skin, alimentary canal)[2,21,26]
Spirostachys africana[17,26,28]	1	Hard, resinous, blunts cutting, edges, does not glue readily[16]; skin irritant[16]; termite-resistant poles cut in late summer, when sap is not running (Namibia)[8]; bracelets, necklaces, sticks[11,16,17]	Avoided for cooking[16]; fragrant smoke: incense & fumigant[17]; torches[8]	Resin: famine food, (Tlokwa, Botswana)[9]; leaves: buck (digestion)[17]; freshly cut branches used to track stingless bees to nests[26]	Poisonous milky latex[24,30]; bark: antimicrobial, purgative, digestive system[27]; smoke inhaled: respiratory infections[26]; blocks stored under clothes: perfume[11]/insect repellant[16]; wood/bark stores amongst seeds repel borers (Vhavenda)[9]
Syzygium cordatum[17,25,26,28]	1	Medium hard, moderately [7] heavy [17]	Fuel[17]	Fruit[17]; medicine, rituals[28], purple dye	Bark: medicinal (respiration/ digestion)[4,25], fish poison[17], red-brown [7,25] dye[26]; leaf: medicinal[1]
Trema orientalis[26,28]	1	Carving[28]	Termite resistant[3]	Leaf relish[26]; fruit: wildlife[28]	Fruit: medicinal; bark tannins[28]: waterproof fishing twine[2]; contact dermatitis[2]
Trichilia emetica[17,25,28]	3	Carving[28,17]	–	Seed: edible "milk"[26] and arils[17]	Bark, leaves: medicinal[25]; seed oil: rheumatism, food preservative[17]
Vangueria cyanescens cf.[16,28]	3	–	–	Fruit[28]	
Vangueria randii[26,28]	3		Avoided[26]	Fruit[26]	–

Neumann *et al*. 2000; Allott 2005). Type 1 rays are one to two cells wide; Type 2 are one to three cells; Type 3 are one to five cells; Type 4 are four to 10 cells, and Type 5 has very wide rays, more than 10 cells wide (Table 1). Robbertse and colleagues (1980) found that wood anatomy could be used to distinguish between two groups, subgenus *Acacia* and subgenus *Aculeiferum*. Here we have reached the following conclusion regarding the possibility of distinguishing the species. In *Acacia* subgenus, wood has wide rays, similar to *Acacia* Type 4–5 charcoal. In *Aculeiferum*, wood has narrow rays, similar to Type 1–3 charcoal. Ray width in cell number, ray height in μm, vessel frequency and parenchyma arrangement may be used to distinguish between *Acacia* species. Several woods found amongst MOD charcoal are not found in the vicinity of the site today (Table 3).

DISCUSSION

First, we discuss the environmental implications of the plant identifications made from charcoal in layer MOD at Sibudu. Secondly, we consider the possible implications of the specific taxa distributions in the four MOD hearths.

ENVIRONMENTAL IMPLICATION OF WOODY TAXA REPRESENTED IN MOD

The trees and shrubs not found in the vicinity of Sibudu

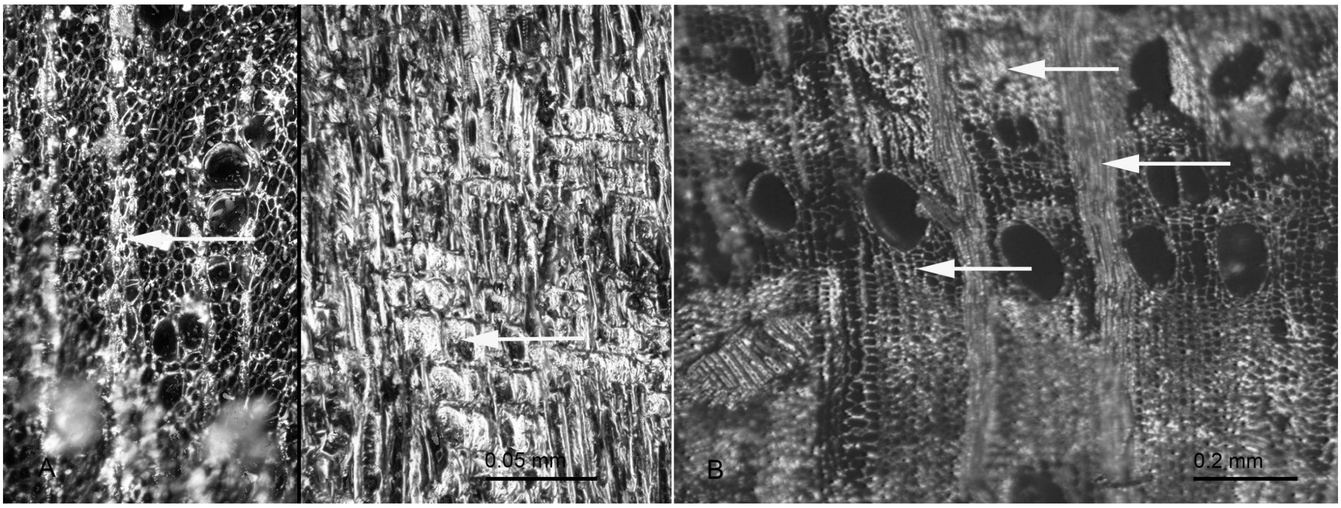


FIG. 3. *Microphotographs of archaeological charcoal from MOD.* (**A**) Spirostachys africana *specimen 39, Hearth 1. In this composite image, from left to right: rays (arrows) are seen in transverse and radial longitudinal sections. Procumbent ray cells containing prismatic crystals are on the right (Lennox & Bamford 2015).* (**B**) Acacia *Type 4, specimen 66, Hearth 3. As seen in this transverse section, the arrows from left to right indicate: thin-walled parenchyma arranged in a band associated with vessels (apotracheal), thick-walled fibres appearing shiny and a ray of four cells wide.*

today, nor in the region as a whole, are listed in Table 3. Vegetation listed in the vicinity of Sibudu Cave was according to Sievers (2013). Sibudu is located in PRECIS grid squares 29° 31′AC and 29°31′CA (Allott 2005: 14, 33). Plant localities were noted between 29 to 30 S and 30 to 32 E in *Spirostachys africana* distribution maps (Boon 2010; Richard Boon, pers. comm. 2014) and also in lists of vegetation from nature reserves in and around Durban: Springside NR, Hillcrest (Metcalf 2013) and Hawaan Forest (Sutherland, pers. comm. 2014). Some taxa recorded in the distribution maps have not been observed near Sibudu today, even though they could potentially grow there. These include *Canthium suberosum, Cordia caffra, Cussonia paniculata, Diospyros austro-africana, Diospyros lycioides, Diospyros whyteana, Dombeya rotundifolia, Erica caffra, Heteropyxis natalensis, Nuxia floribunda, Ochna serrulata, Olea europea* subsp. *africana, Ozoroa paniculosa, Rothmannia capensis, Sclerocroton integerrimus, Searsia rehmanniana* and *Shirakiopsis elliptica*. Anthropogenic behaviour, rather than environmental factors, may be responsible for their absence near Sibudu today. The natural vegetation near the site has been cleared for fields of sugar cane and subsistence crops.

However, some taxa in Table 3 would not be expected to occur in the Sibudu area under modern-day conditions; they are really bushveld taxa that are normally found in dry bushveld in the northern regions of South Africa and Zimbabwe. These include *Burkea africana, Commiphora marlothii, Bauhinia galpinii, Gardenia volkensii, Peltophorum africanum, Pterocarpus rotundifolius* subsp. *rotundifolius* and *Vangueria cyanescens*. Environmental conditions rather than anthropogenic influence seem to have promoted this vegetation community ~49 ka. The CA_{GIS} study (Bruch *et al*. 2012) implied that the winters were warmer than older periods and summers were slightly wetter. The *Acacia* representation in MOD suggests a relatively warm and dry environment and the presence of bushveld and savanna biomes, perhaps as part of a mosaic of vegetation patches in the vicinity. The five *Acacia* types suggest several plant communities near the site.

The growth of bushveld trees and shrubs near Sibudu most likely implies that a mosaic of vegetation communities existed in the region at 49 ka. Trees and shrubs that survive dry conditions may have grown on warm hillsides, whereas riverine communities grew close to the uThongathi River, and evergreen trees and shrubs thrived against the cool, shaded cliff that also houses Sibudu (see also Hall *et al*. 2014). Comparative records of ancient vegetation near Sibudu are rare (Roberts *et al*. 2006: 805–807; Porat & Botha 2008) and therefore do not add to the data presented here.

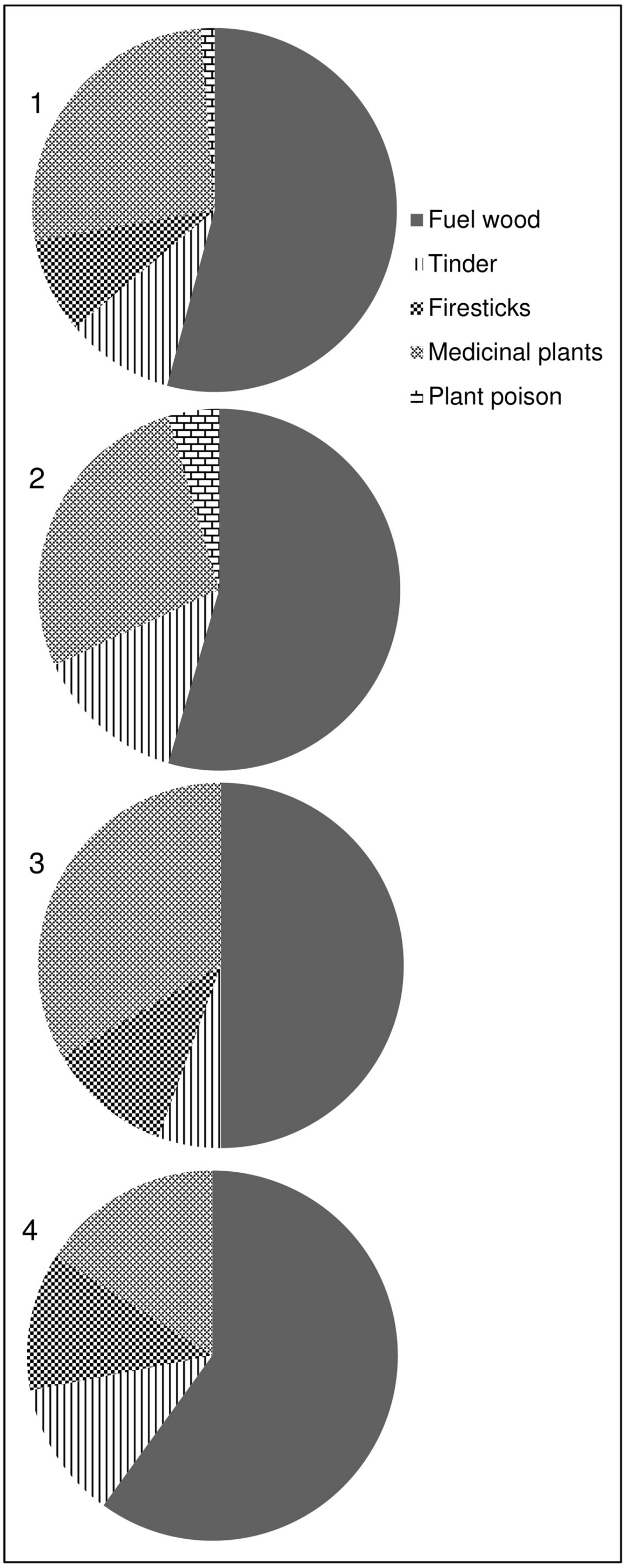
SPECIFIC ACTIVITIES IN AND AROUND THE HEARTHS

As mentioned earlier, a wide variety of woody taxa is present in three of the MOD hearths, with some of the taxa specific to particular hearths. We can, admittedly, only speculate on the reasons for this distribution. On the one hand, the Sibudu people may simply have gathered wood unsystematically from near the shelter. On the other hand, it seems reasonable to expect that they understood firewood properties, as it has been shown that people could have carefully selected rocks for knapping (Wadley & Kempson 2011) and they knew some medicinal plants even at 77 ka (Wadley *et al*. 2011). Wood anatomists use the 'burning splinter test' as a descriptive feature to record the production and colour of ash or charcoal: grey or white, black or brown (Wheeler *et al*. 1989). People who burn wood regularly for home fires may not have such a formal test, but they are able to recognise traits of ash and coals produced by trees, even in wood collected from the ground (Cunningham 2001: 33–37).

The possible uses of woods found in the MOD hearths are summarised in Table 2. Some of these woods have medicinal or other uses today (Table 2), but we cannot be sure that these uses necessarily applied in the deep past. The relative quantities of charcoal attributed to different plant species cannot be assessed by means of fragments, to compare uses. Some woods burn away to ash and some to fragments, due to different burning properties (Chrzazvez *et al*. 2014). Some uses exclude burning, for example when wood is fashioned into bark twine, blocks and boards, carved bowls, handles and poles, shafts for arrows or spears and sticks. Woods that are burnt are most likely tinder, fuel and medicines. Several woods have multiple uses, but only primary uses are visually represented in Figure 4, that is, wood used as fire-starters, tinder, fuel, or aromatic plants burnt for medicinal or poisonous smoke. Having made this distinction, we acknowledge that most wood can be used as fuel. Plant medicines are taken to be those where bark, leaves or wood has medicinal value. The tinder wood is taken to be from shrubs shorter than 3 m, known to be good tinder.

There are 17 woody taxa with medicinal value, occurring 21

FIG. 4. *Percentage frequency distribution of wood uses in hearths in MOD. Only the primary uses are listed for each taxon*. (**1**) *The combined woody taxa in MOD (*n *of taxa = 60). (***2**) *Hearth 1 (*n *= 22). Tinder*: Bauhinia galpinii, Erica caffra, Ochna serrulata; *Fuel*: Acacia *sp.*, Afzelia quanzensis, Brachylaena discolor, Bridelia mollis cf., Burkea africana, Diospyros lycioides, Dombeya tiliacea, Kiggelaria africana, Maytenu *ssp.*, Searsia rehmanniana cf., Shirakiopsis elliptica, Syzigium cordatum; *Medicine*: Diospyros mespiliformis, Dalbergia obovata, Dombeya rotundifolia, Pappea capensis cf., Rhoicissus rhomboidea, Trema orientalis; *Poisonous plant*: Spirostachys africana; (**3**) *Hearth 2 (*n *= 36). Fire-sticks*: Canthium mundianum cf., Cordia caffra, Diospyros austro-africana, Halleria lucida; *Tinder*: Cussonia paniculata cf., Bauhinia galpinii; *Fuel*: Acacia *sp.*, Afzelia quanzensis, Allophylus dregeanus cf., Brachylaena discolor, Burkea africana, Canthium suberosum cf., Diospyros villosa, Empogna lanceolata cf., Euclea crispa cf., Ficus burkei *syn.* thonningii, Ficus lutea, Kiggelaria africana, Mystroxylon aethiopicum, Ozoroa paniculosa, Peltophorum africanum, Protea nitida, Pterocarpus rotundifolius, Searsia lancea cf.; *Medicine*: Diospyros mespiliformis, Diospyros whyteana, Gardenia volkensii cf., Heteropyxis natalensis, Mimusops obovata, Nuxia floribunda, Olea europaea *subsp.* africana, Ptaeroxylon obliquum, Searsia chirindensis cf., Searsia divaricata cf., Sclerocroton integerrimus, Protorhus longifolia cf.; (**4**) *Hearth 3 (*n *= 25). Fire-sticks*: Canthium mundianum cf., Cordia caffra, Clerodendrum glabrum cf.; *Tinder*: Bauhinia galpinii, Erica caffra, Monocotyledon cf.; *Fuel*: Acacia *sp.*, Afzelia quanzensis, Allophylus dregeanus cf., Brachylaena discolor, Burkea africana, Canthium suberosum cf., Celtis africana, Commiphora marlothii cf., Diospyros villosa, Harpephyllum caffrum, Kiggelaria africana, Mystroxylon aethiopicum, Rothmannia capensis cf., Vangueria cyanescens cf., Vangueria randii; *Medicine*: Diospyros mespiliformis, Diospyros whyteana, Pappea capensis cf., Trichilia emetica.



times in MOD. Most (64%) occur in Hearth 2, while 35% occur in Hearth 1 and 23% occur in Hearth 3. Hearth 1 contains many medicinal woods when compared to the other hearths (Fig. 4). It was the only hearth to contain *Spirostachys africana* charcoal. People who live off the land recognise the burning properties of wood (Cunningham 2001: 33) and would have known that pruning *Spirostachys africana* is dangerous, as is cooking over its poisonous, aromatic smoke (Wink & Van Wyk 2008). The implication is that this wood was burnt deliberately (Wadley 2012), perhaps to create torches or possibly to create smoke as insecticide. Another likely use for this taxon is as an arrow poison, but no arrows are known to have been used in MOD. Woods unique to Hearth 2 (E3d) have a combination of friction sticks, tinder, fuel and medicinal plants. In addition, *Ficus lutea* is used as bird lime and *Ptaeroxylon obliquum* is an effective insect repellent and poison, but neither plant is poisonous to work with. The fire in Hearth 3 (E4a) seemed to have been a domestic fireplace, suitable for cooking and/or heating, since the most *Acacia* types were found in this hearth and 50% of the fragments were *Acacia* spp. The uses of the *Acacia* spp. were excluded from Figure 4.

Acacia species have several uses (Van Wyk & Van Wyk 2013) and they provide dry, dense fuel wood that catches alight easily and burns away, producing little ash and a lot of heat. The burning property of fuel wood is the energy produced, measured as calorific value (MJ/kg). This value is dependent upon wood density, moisture content and chemical composition. Dense woods have better burning properties than fast-growing, less dense woody species. The ash content is the inorganic component which cannot be burnt, and therefore 'wasted' as it is not converted into energy. Burning green wood produces smoke and the heat required to evaporate the inherent moisture is lost (Munalula & Meincken 2009). Other desirable attributes of *Acacia*, from a hunter-gatherer point of view, include its being a source of timber for tools or construction. In addition, *Acacia* twine and bark is a source of fibre rope, and chewed tree gum is a source of carbohydrates (Venter & Venter 2002). There are other woods burnt in MOD which produce copious smoke, some of which is poisonous, such as the Ebenaceae, for example *Diospyros lycioides* (Hearth 1). Although *Bridelia mollis, Euclea crispa, Gardenia volkensii* and *Vangueria randii* produce much smoke, they are not poisonous to work with.

CONCLUSIONS

The charcoal from hearths in layer MOD (~49 ka) at Sibudu was identified using: a) a stereomicroscope, digital photos and

TABLE 3. *The woods identified in charcoal from hearths in MOD which do not occur near Sibudu today. Plants that are present (P) in the region are shaded grey; (A) indicates absence.*[1–14]
Coates-Palgrave 2002[1]*, Boon 2010*[2]*, Van Wyk & Van Wyk 2013*[3]*, Metcalf 2013*[4]*, Sutherland 2014*[5]*, Richard Boon, pers. comm. 7 October 2014*[6]*.*

Woods not found near Sibudu today	Habit	Habitat	Distribution
Afzelia quanzensis	Medium-sized tree, 12 m[1]	Woodland[1]	N KZN – Somalia[1]; (A)[2]
Bauhinia galpini	Shrub/small tree, 6 m[1]	Bushveld, watercourses[1]	N KZN – tropical Africa[1]; (A)[2]
Bridelia mollis cf.	Shrub/small tree[1]	Streams, bushveld[1]	N southern Africa[1]; (A)[2]
Burkea africana	Medium tree[1]	Bushveld[1]	N southern Africa[1]; (A)[2]
Canthium suberosum cf.	Shrub/small tree[2]	Forest margins[2]	KZN – NE RSA[1]; (P)[2]; rare near Durban[6]
Commiphora marlothii cf.	Medium tree[1]	Woodland[1]	N RSA – Zimbabwe[1]; (A)[2]
Cordia caffra	Shrub/tree[2]	Forest, bushveld[2]	E Cape – NE RSA[2]; (P)[2] on Durban coast[6], Hawaan Forest[14]
Cussonia paniculata cf.	Short tree[1]	Bushveld[2]	KZN, Cape, Botswana[2]; (P)[2]; absent near Durban[6]
Diospyros austro-africana	Shrub/small tree[2]	Rocky slopes[2]	Drakensburg[1]; (P)[2]; absent near Durban.[6]
Diospyros lycioides	Shrub/small tree[2]	Forest margins, tropical[2]	KZN – N RSA[2]; (P)[2] near Durban, Krantzkloof[6], Springside[4]
Diospyros mespiliformis	Shrub/large tree, 25 m[1]	Rivers, termite mounds[1]	Swaziland and Namibia – tropical Africa[1]; (A)[2]
Diospyros whyteana	Shrub/small tree[1]	Forest, rocky slopes[1]	NE KZN and W Cape – Ethiopia[2]; (P)[2]; absent near Durban[6]
Dombeya rotundifolia	Small tree[2]	Bushveld, woodland[2]	KZN – Ethiopia[3]; (P)[2] near Durban[6]
Erica caffra	Shrub/small tree[2]	Cliffs, watercourses[2]	KZN – W Cape[2]; (P)[2] Krantzkloof, forest margins[6]
Gardenia volkensii cf.	Small tree[1]	Woodland, bushveld[1]	KZN – tropical Africa[1]; (A)[2]
Heteropyxis natalensis	Tree[2]	Woodland[3], riverine fringes[1]	KZN – Zimbabwe[3]; (P)[2] near Durban[6]
Nuxia floribunda	Shrub/tree[2]	Evergreen forest[1], bush clumps[2]	W Cape and KZN – Malawi[2;] (P)[2]; common near Durban, Vernon Crookes[6]
Ochna serrulata	Shrub/small tree[2]	Forest margins, grassland[1]	W Cape, KZN – Limpopo[2;] (P)[2]; common on Kloof scarp[6], Springside[4]
Olea europea subsp. *africana*	Tree[2]	Forest margins, bushveld[2]	RSA (and KZN) – Ethiopia[2]; (P)[2]; absent from Durban[6]
Ozoroa paniculosa	Shrub/small tree[1]	Woodland[1], savanna[2]	KZN – northern southern Africa[2]; (P)[2] on Kloof scarp[6]
Peltophorum africanum	Tree[1]	Bushveld, woodland[1]	N KZN – tropical Africa[1]; (A)[2]
Protea nitida	Shrub/small tree[1]	Wooded grassland[1]	Drakensburg, KZN[2] – W Cape[1]; (A)[2]
Pterocarpus rotundifolius subsp. *rotundifolius*	Shrub/ tree[1]	Woodland, savanna[1]	N KZN – tropical Africa[1]; (A)[2]
Rothmannia capensis cf.	Tree[1]	Forest, bushveld[1]	W Cape, KZN – Botswana[2]; (P)[2] Krantzkloof, near Durban[6]
Sclerocroton integerrimus	Small/medium tree[2]	Forest margins, grassland[1]	KZN – southern Mozambique[4]; (P)[2] on Durban coast[6], Hawaan Forest[5]
Searsia divaricata cf.	Shrub[1]	Scrub, outcrops[1]	Foothills of KZN Drakensburg[2]; (A)[2]
Searsia lancea cf.	Small/medium tree[1]	Woodland, river banks[1]	W Cape – Zambia[3]; (A)[2]
Searsia rehmanniana cf.	Shrub/small tree[1]	Grassland, forest margins[2]	KZN – Limpopo[2]; (P)[2] near Durban, valley bushveld, forest margins[6]
Shirakiopsis elliptica	Medium/tall tree[2]	Ravines, evergreen forest[2]	E Cape, KZN – tropical Africa[1]; (P)[2] scarp forest[6] and Hawaan Forest[5]
Vangueria cyanescens cf.	Shrub/small tree[1]	Bushveld, thickets[1]	N KZN, Zimbabwe[1] – N Namibia[1]; (A)[2]

Excel spreadsheets, b) a modern comparative reference collection, c) the online database InsideWood (2004–onwards), by d) cross-referencing the descriptions and images of several specimens, and e) confirmation with high-magnification images when necessary. A total of 60 woody taxa has been identified in this new study and 48 of these represent new taxa identifications for layer MOD.

Vegetation at Sibudu 49 ka was different from that of today and may have no modern correlate. Several trees identified in MOD do not presently occur near Sibudu. Amongst these are taxa that are common in modern dry bushveld vegetation communities, while others seem to have been lost from current plant communities of the area due to anthropogenic factors that include both habitat destruction for farming, and fuel collection.

Each MOD hearth consists of a high proportion of fuel wood and a low proportion of tinder. Woods used to start fires by means of friction are also represented. A quarter of the woods burnt in MOD are comprised of plants with medicinal bark, leaves or wood. The one poisonous plant, *Spirostachys africana* was identified in a single hearth, Hearth 1. Various woody parts are used medicinally, for insect repellent, poison, or torches. It may have been collected for multipurpose use, but very little tamboti charcoal is represented in MOD, suggesting that it was used sparingly.

All of the hearths contain some *Acacia* wood and most *Acacia* species are good firewood. *Acacia* spp. are particularly well represented in Hearth 3 where five types have been recognised. Three *Acacia* types were recognised in Hearth 1 and three in Hearth 2. Identifying the *Acacia* types to species will require the collection of modern reference specimens and the development of a new identification key for the Sibudu types.

We set out to explore the possibility that wood was selectively collected for different purposes and that such differences would be reflected in the four MOD hearths. To some extent, we have demonstrated differences. Certainly there is considerable species diversity in the MOD hearths, other than in Hearth 4. Furthermore, several taxa are exclusive to one or other hearth. Hearth 1 has tinder, fuel, poison and medicinal woods. Hearth 2 has the greatest variety of woods, including fire-sticks, tinder, fuel and medicinal wood. Hearth 3 has *Acacia* spp. *Burkea africana* and *Rothmannia capensis*; these are fuel wood associated with hot fires.

In conclusion, the uneven distribution of woody taxa between MOD hearths implies that the people at Sibudu did not gather wood indiscriminately around the site. If they had done this, we predict that all the hearths would have contained a similar range of taxa, mostly from the predominantly evergreen forest on the southwest slopes of the hillside where the site is situated. Instead, the MOD woods came from a wide range of plant communities with different habitat requirements. We can envisage a situation in which people started a fire by making use of preferred tinder together with a wide range of twigs and small, dry pieces of wood collected near the site. This method would have generated varied taxa even before the preferred firewood was added and the speciality woods were introduced.

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APPENDIX A. *The anatomical features of modern (shaded) and archaeological charcoal specimens identified in MOD: IAWA numbers (1–221). Bracketed features are variations.*

LEGEND

Vessel: *Vessel arrangement*: tangential (6), radial (7), dendritic (8). *Grouping*: solitary (9), long radials (10), clusters (11). *Outline*: angular (12). *Vessel diameter* (μm): ≤50 (40), 50–100 (41), 100–200 (42), ≥200 (43). *Vessel density* (mm^2): ≤5 (46), 5–20 (47), 20–40 (48), 40–100 (49), ≥100 (50).

Parenchyma: rare or absent (75), diffuse (76), diffuse-in-aggregates (77), scanty (78), vasicentric (79), aliform (80), lozenge-aliform (81), winged-aliform (82), confluent (83).

Banded: ≥3 cells wide (85), ≤3 cells wide (86), reticulate (87).

Rays: *Ray width (cells)*: uniseriate (96), 1–3 cells (97), 4–10 cells (98), ≥10–seriate (99). *Frequency* (mm^2): <4 (114), 4–12 (115), >12 (116). *Ray height* (μm): >1 mm (102). *Storied structure*: all rays (118); *Tracheids*: vascular/vasicentric (60). *Ray type*: heterocellular (he) or homocellular (ho). *Cells*: all procumbent (104), all upright and/square (105), body procumbent and 1 row marginal upright/square (106), body procumbent and 2–4 rows marginal upright/square (107), body procumbent and >4 rows marginal upright/square (108), mixed procumbent, square, upright (109).

Vessel deposits and tylose: tyloses (56), gums and other deposits (58). *Intercellular canals*: radial canals (130). *Tubes*: laticifers or tanniniferous tubes (132).

Mineral inclusions: *Prismatic crystals*: present (136), prismatic crystals in ray cells (138), crystals in procumbent ray cell (139), crystals in upright and/or square ray cells (140), crystals in non-chambered/chambered parenchyma (141/142), crystals in fibres (143). *Druses*: present (144). *Crystal Sand* (153). *Silica bodies*: present (159), silica bodies in procumbent ray cells (160)

Plant species	Charcoal specimen	Vessel distribution	Vessel diameter	Vessel density	Parenchyma apotracheal	Parenchyma paratracheal	Ray width	Ray frequency and height, storied structure and tracheids	Ray type and cells	Vessel deposits, canals, tubes and minerals
Afzelia quanzensis	Allott 183	9, (7, 10)	41	47	85	79	96, (97)	115	104	
	Miller (2007)		42	46, 47	85	80–83	97	115	104	58, 142
	E3d 19	7	41	48		80–83	97	115	104	
Allophylus dregeanus	SJL 79	10	40	48		78	96	115	104	
cf.	E3d 44	10	40	47	75	78	97	115	Ho:105	
Bauhinia galpinii	Allott 184	7	41	48		79	96		106	
	E3d 48	7	40	48	75	79	96	115	106	
Brachylaena discolor	SJL 56	7	40	49		79	97	115, (118)	He:105	138
	E4a 54	10	40	49		79	97	115, (118)	He:105	
Bridelia mollis	SJL 19	7	40	49	75	79	97	115	106	
cf.	C6a 13	7	40	50	75		97	115	106	
Burkea africana	Allott 185	7	41	48		79, 83	97		104	
	C6a 42	7	41	48		79, (83)	97	115	104	
Canthium mundianum	Allott 127	10	41	49			97	102, 115	106	
cf.	E3d 5	7	41	47			97	115	106	
Canthium suberosum	Allott 129	9	40	49	76		97	102, 116	108	
cf.	E3d 3	9	40	49	76		97	115	108	
Celtis africana	SJL 48	10, (11 , 9),	41	49		79	97	114	106	138
	Allott 169	9, 7, (10)	41	49	86	79, (80, 83)	97, (98)	116		
	E4a 62	10	40	48		79	97	116, 102	106	
Clerodendrum glabrum	SJL 42	7	40	49	75		97	115	106	159
cf.	E4a 46	7	40	47	75		97	115	105	
Commiphora marlothii	Allott 33	7, (9)	41	49		79	97, (98)		106	140
	E4a 56	7	41	49	75	79	97	115	106	138
Cordia caffra	Allott 31	9, (6, 7)	41	47	85		97, (98)	115	106	
	E3d 55	7, (9)	40	47	85	83	97	115	106	
Cussonia paniculata	Allott 23	7	40	49		78	96		He:105	
cf.	E3d 66	7	40	49	75	78	96	114	He:105	

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APPENDIX A (continued)

Plant species	Charcoal specimen	Vessel distribution	Vessel diameter	Vessel density	Parenchyma apotracheal	Parenchyma paratracheal	Ray width	Ray frequency and height, storied structure and tracheids	Ray type and cells	Vessel deposits, canals, tubes and minerals
Dalbergia obovata	SJL78	9, 7	41	49	77	78	96		He:105	
	C6a 40	7	41	48	77	78	96	115	He:105	
Diospyros austro-africana	Allott 48	9, 7	40	49		78	96	116	Ho:105	
	E3d 16	7, (9)	40	49		78	96	115	106	
Diospyros lycioides	Allott 49	7, 10	40	49		78	96	116	Ho:105	
	C6a 54	7	40, 41	49	75	79	96	115	Ho:105	138, 140
Diospyros mespiliformis	IND1288	10	41	47		78 (79)	97	116	109	138
	C6a 31	7, (10)	41	47	77	78	97	115	109	58, 138
Diospyros villosa	Allott 51	7	41	49		78	97		106	
	E4a 12	7	41	48	77	78	97	115	109	138
Diospyros whyteana	Allott 52	10	41	48		78	98		106	
	E4a 20	10	41	47		78	98	115	106	58, 138
Dombeya rotundifolia	Allott 162	9, 7	41	49		78	97 (98)		He:105	
	C6a 16	9, 7	41	48			97	115	109	
Dombeya tiliacea	Allott 163	9	(v)	48	76		97, (98)	115	Ho:105	
	C6a 1	9, 7	40	48	76		97, 98	115, (102)	Ho:105	
Empogna lanceolata	SJL 93	9, 10	40	50			97	116	109	
cf.	E3d 67	9	40	49	75	78	97	115	106	
Erica caffra	Allott 55	9	40	49	75	78	97	115	106	
	C6a 07	9	40	49	75	78	97	115	106	
Euclea crispa	SJL 29	7, (10)	40	47		78	96	116	105	
cf.	E3d 43	10, (7)	40	49	(76)	78	96		105	
Ficus burkei	Allott 94	9, (7, 10)	41	47	85		97	115, (102)	106, 107	56
Ficus burkei (= *thonningii*)	Allott 101	7, (10)	41	48	85		97	115, (102)	105	
	E3d 71	7	41	48	85		97	115	105	
Ficus lutea	SJL 16	7	41	47	85	78	98	115	106	56
	E3d 50	7	41	47	85	78	98	115	106	
Gardenia volkensii	Allott 131	6, 9	40	49	75		97	115	106	
	E3d 28	7, (9)	40	49	75		97	115	106	
Halleria lucida	Allott 158	9, 7, (10, 6)	40	49	75, (76)		97	115	Ho:105	
	E3d 21	7, (9)	40	49	75, (76)	78	97	115	Ho: 105	
Harpephyllum caffrum	IND 1170	10, (11)	41	48, 49		78	98	115	106	138
	Allott 2	7, (10)	41	49	75	78	97		106	56, 130
	Terrazas (1994)	9	41	47, 48		78	98		106, 107	56, 58, 138
	E4a 3	9, (10)	41	49		78	97	115	106	138
Heteropyxis natalensis	SJL 32	10, (11)	41	50		78	97	115	109	
	Allott 76	7, 10	40	49		78	97		109	
	E3d 7	10, (11)	40	49		78	97	115	109	
Kiggelaria africana	IND 1191	7	41	48	75		97	115	He:105, (104)	138
	E4a 9	7	41	48	75		97	115	105	
Maytenus sp.	Allott 36	7	40	49	77		97		He:105	
Maytenus sp.	C6a 43	9, (10)	40	49	77		97	114	He:105	140
Mimusops obovata	IND1272	7, (8)	41	48	86		97	115	108	
	Allott 154	10	41	48	86		97	115, 102	108	
	E3d 24	10	41	49, (48)	86		96, (97)	115, 102	108	

Continued on p. 51

APPENDIX A (continued)

Plant species	Charcoal specimen	Vessel distribution	Vessel diameter	Vessel density	Parenchyma apotracheal	Parenchyma paratracheal	Ray width	Ray frequency and height, storied structure and tracheids	Ray type and cells	Vessel deposits, canals, tubes and minerals
Mystroxylon aethiopicum	Allott 39	9	40	49	85		97	116	106	
	E3d 41	9	40	49	85		97	116	106	
Nuxia floribunda	IND1265	7	41	49		78, 79	97		107	
	E3d 30	7	41	49,		78, 79	97, (98)	115	107	
Ochna serrulata	IND 1063	10	40	49	76	78	96, (97)	115	106	
	C6a 50	10	40	49	76	78	96, (97)	115	106	138
Olea europaea ssp. *africana*	Allott 108	7	40	49		79	97	116	104	
	E3d 49	7	40	49		79	97	116	106	
Ozoroa paniculosa	SJL 20	7, (11)	41	48		78	97	115	106	
	E3d 51	7, (11)	41	47		78	97	115	106	58
Pappea capensis	SJL 91	7, (10)	41	49		78,79	97	116	106	58
cf.	C6a 47	7	41	49		78,79	96	116	106	
Peltophorum africanum	Allott 186	7	41	48		79, (80)	96	115	106	
	E3d 56	7	41	48		79, 80	96	115	106	
Protea nitida	IND 1184	9	40	46		79	99		106	58
	E3d 45	9	40	46		79	98	115	106	58
Protorhus longifolia	Allott 5	7, (6, 10, 11)	(v)	49		78	97	115	106	56, 136
cf.	E3d 26	7	41	48		78	97	115	106	58
Ptaeroxylon obliquum	Allott 118	10	40	49	75		96	116	Ho: 104 (105)	
	E3d 61	10	41	49	75		96	115	104	
Pterocarpus rotundifolius	Allott 209	9, (6, 7)	41	49	86, 85	79	96		Ho:104 (105)	
	E3d 22	7	41	49		80, 83	96	115	Ho: 104 (105)	138
Rhoicissus rhomboidea	SJL54	9 (11)	42	47, 48		78	97	60, 102, 114	Ho:105	58
	C6a 06	9	42	47		78	97	60, 102, 114,	He:105	
Rothmannia capensis	Allott 137	7	40	49		79	97	115	He:105	
cf.	E4a 73	7	40	48		79	97	115	He:105	
Sclerocroton integerrimus	SJL 88	7	41	48	76		96	115	104, (109)	159, 160
	E3d 8 (Lennox & Bamford 2015)	7	41	48	76		96	115	104, (109)	159, 160
Searsia chirindensis	Allott 7	7	41	49		79	97	116, 102		130
Searsia chirindensis cf.	E3d 36	7	40	49		79	96, (97)	116, 102	106	
Searsia divaricata	Allott 9	10	40	49		78		116		
Searsia divaricata cf.	E3d 39	10	40	49		78	97	116	He:105	
Searsia lancea	Allott 12	7, (11)	41	49		79	97	115	Ho:105	138
Searsia lancea cf.	E3d 68	7, (11)	40, 41	48		79	97	115	Ho:105	
Searsia rehmanniana	Allott 14	7, (11)	41	49	85	79	97	116	Ho:105	130
Searsia rehmannia cf.	C6a 44	7, (11)	41	48	85	83	97	115	104	
Shirakiopsis elliptica	SJL67	7	42, 43	47	76		96, (97)	115	109	159, 160
	C6a 46 (Lennox & Bamford 2015)	7	42	47	76		96, (97)	115	109	159. 160
Spirostachys africana	SJL 103	10	40	48, 49	76		96	115	104, (109)	58, 138, 139
	C6a 39 (Lennox & Bamford 2015)	10	40	49	76		96	115	104, (109)	138, 139

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APPENDIX A (continued)

Plant species	Charcoal specimen	Vessel distribution	Vessel diameter	Vessel density	Parenchyma apotracheal	Parenchyma paratracheal	Ray width	Ray frequency and height, storied structure and tracheids	Ray type and cells	Vessel deposits, canals, tubes and minerals
Syzigium cordatum	Allott 104	7	40	48		79, 80, 83	97	116, 102	108	
	C6a 55	9	42	47		79, 83	97	102	108	
Trema orientalis	IND1305	9, 7	41	47		79	97	115	106	
	Allott 172	9, 7, 10, (11)	(v)	49		79	97	116, 102	106	
	C6a 33	7, 11	41	49		79 (83)	97	115	106	
Trichilia dregeana	Allott 90	9, (7, 11)	41	40		78	96	115	Ho:105	
Trichilia dregeana/ T. emetica	Détienne: (n.d.)		42	47	86, (85)	79, 80, 82, 83	96	115	104, 106	136, 159
Trichilia emetica	IND1058	7, 9	42	47		79	96	115	Ho: 105, (104)	
	Allott 91	7, 9	(v)	49		79, 80, 83	96		Ho: 105, (104)	
	E4a 36	7, 9	41	49	75	79	96	115	Ho: 105, (104)	
Vangueria cyanescens	SJL 36	9, 7	40	49		78, 79	97	115	109, (106)	58
Vangueria cyanescens cf.	E4a 15	9	40	47	77	78	96, (97)	115	109	
Vangueria randii	Allott 142	9	40	49	76	79	97	115	He:105	
	E4a 33	9	40	49		79	97		106	
Vangueria randii cf.	E3d 47	9	40	48	76	78	96	116	Ho:105	
Monocotyledon cf. (Neumann *et al.* 2000)	E4a 13 E4a 38	Circular bundles	40 (metaxylem & protoxylem)			ground parenchyma	2–3	115	109	

CHAPTER 8
DISCUSSION

8.1 Introduction

People at Sibudu were probably collecting wood deliberately for particular purposes and this choice is potentially recognisable in the hearths. There were possibly fires for warmth, light, cooking or protection and some of the wood may have been burnt for aromatic, medicinal smoke. The charcoal was analysed from hearths in three layers, from BYA2(i), lower ~58ka and SPCA, upper ~58ka which represent the post-Howiesons Poort and from MOD, ~49ka, which represents the late MSA (Middle Stone Age). All three layers were formed during the last Glacial period, during Marine Isotope Stage 3 (MIS 3)(Wadley 2004, 2006; Wadley and Jacobs 2004; Jacobs *et al*. 2008a, b; Schiegl *et al*. 2004).

One of the aims of this new study of charcoal from Sibudu hearths was to discover potential use of medicinal plants. The earliest known use of medicinal plants was the *Scleria natalensis* and *S*. *melanomphala* sedge bedding overlaid with insecticidal *Cryptocarya woodii* leaves (Wadley *et al*. 2011), discovered in a MSA layer dated 77 ka ago. *Spirostachys africana* charcoal, which in a previous study by Allott was tentatively identified as *Sapium/Spirostachys* type, may imply the use of noxious fumes as an insecticidal smoke (Allott 2006; Wadley 2013b; Lennox and Bamford 2015). *Tarchonanthus parvicapitulatus* leaves may be used in the same way as *Cryptocarya woodii* leaves and the camphor wood may have been burnt for the smoke. Closely related *Brachylaena* spp. (Asteraceae) was previously identified in Sibudu charcoal (Allott 2006).

If the wood was randomly collected from the closest source of wood, then the hearths would contain wood exclusively from that source, for example the evergreen forest on the south facing slopes. On the contrary, if the wood was collected deliberately for a particular purpose, then a variety of woods from different vegetation communities would be found in the hearths. Taxa would then vary between the hearths suggesting different purposes for them. Another question is about the possible use of medicinal wood; if the wood was used deliberately then this would show in a restricted amount of wood being burnt and this combustion would be restricted to a particular hearth. First, not all aromatic smoke is poisonous. Secondly, it is possible that a large amount of wood was burnt but the frequency and distribution was restricted. Finally, it is possible that the wood with restricted distribution could have been burnt accidentally, but this is precluded for poisonous *Spirostachys africana* as previously discussed (Chapter 1. Introduction, Section 1. Background).

This anthracology study was done to resolve these issues by identifying the types of firewood burned in individual hearths, to discover evidence of the use of medicinal woods, to assess different types of hearth depending on the different types of firewood burnt there, to link the type of hearth as suggested by the properties of the wood burnt there with the possible activities around the hearth, to reconstruct the environment in which the wood collecting was done, to compare the species diversity in the hearths with that in the surrounding sediments in the charcoal record of Allott (2006) and to determine the vegetation succession and link vegetation from three moments in time to the climate.

8.2 Anthracological record: sampling and diversity

In BYA2(i), 69 trees and shrubs are represented from 598/700 charcoal specimens identified and in SPCA there are 110 trees and shrubs from 516/544 charcoal specimens. In MOD, 60 trees and shrubs were identified from 190/193 charcoal specimens (Lennox *et al*. 2015). In all, 150 woody taxa have been identified from 1 304/ 1 437 specimens from hearths and sediment from three layers, of these 133 are unidentified and the sampled charcoal specimens from BYA2(i) and SPCA remain. An abundance of woody taxa has been identified from each archaeological layer.

Table 8.1: A measure of the biodiversity from three archaeological layers

Layers	Total no. charcoal specimens	No. studied specimens	No. identified specimens	No. species	No. species/ no. identified specimens (%)
BYA2(i)	>2000	700	598	69	12
SPCA	>1000	544	516	110	21
MOD	193	193	190	60	32
Total	>3193	1437	1304	150	12

The charcoal in each packet of excavated specimens was sorted into size classes which removed the bias of studying only one size class of charcoal (Allott 2005: 77-78). The charcoal specimens were selected for identification by means of simple random sampling (Drennan 2009: 85), which represents the original charcoal excavated. The diversity of plants increases through time since there is 12 % in BYA2(i) from lower ~58 ka, 21 % in SPCA from upper ~58 ka and 32 % from MOD at ~49 ka (Table 8.1). The change in the diversity of plants over time could first be due to a change in the selection and use of wood (a social reason perhaps), secondly to the availability of wood in the environment (climatic restrictions), thirdly to the preservation of wood (sedimentary conditions) and finally due to other biases for example settlement (as discussed in Chapter 1. Introduction. Section 3 History and Status of the Study; Shackleton and Prins 1992; Théry-Parisot *et al*. 2010b). The parameters which interact to cause the differential preservation of charcoal have been modelled by Théry-Parisot (et al 2010: 151). There are four interactive factors, namely: (i) climatic factors (temperature, humidity, rainfall, wind action, freeze thaw cycles); societal factors (wood gathering, energetic needs, structures, hearth maintenance, cleaning and trampling); settlement factors (type of dwelling, duration of occupation, location), and finally sedimentary factors (nature of sediment, mechanical constraints, bio-pedoturbations and diagenesis). Alternative hypotheses could be drawn from these interactive parameters to suggest what else may have happened, how else the charcoal may have arrived in the hearths in this study.

8.3 Uses

8.3.1 Introduction

The possible uses of the woody taxa are listed according to the literature (Appendix D). The fuel, tinder and firesticks are collectively considered fuel. Woods from plants with medicinal and poisonous attributes are collectively considered medicinal wood.

8.3.2 Fuel wood

As expected, fuel wood including tinder is found in each hearth and in each layer and the variety of plants burnt on each layer, is termed here as bundles of fire-wood in each combustion feature for BYA2(i), SPCA and MOD. The fuel wood in BYA2(i) includes tinder *Afrocarpus/Podocarpus* spp. and fuel *Protea caffra* and *Mystroxylon aethiopicum.* The fuel wood in SPCA includes tinder *Cussonia paniculata* and *Erica caffra*, and fuels Brachylaena discolor, *Leucosidea sericea* and *Protea roupelliae.* The fuel wood in MOD includes *Acacia* spp. These woods occur in several hearths. *Protea* spp. are associated with hot fires (Appendix D). *Acacia* spp., *Brachylaena discolor*, *Leucosidea sericea* and *Mystroxylon aethiopicum* are associated with long-burning fires (Appendix D). It is possible that the use of wood may have been burnt in a sequence, starting with tinder wood, then adding wood for heat, then wood for long-burning coals (Lennox *et al*. 2015). The presence and absence of woody taxa was recorded, rather than the number of fragments which is interpreted as a measure of the burning properties rather than abundance of wood used (Chapter 1 Introduction, Section 3 History; Chapter 2 Material and Methods).

The distribution of wood spatially is an anthropic activity marker (Rondelli *et al*. 2014), which changes over time. The fuel and tinder in the strata of Hearth 1 in BYA2(i) confirm the succession of fires (Bentsen 2014b). This extremely large hearth includes burnt sedge bedding (Sievers 2013; Wadley *et al*. 2011). In SPCA the charcoal was excavated from five separate hearths without strata and from four hearths in MOD. The woods with a restricted distribution suggest a possible use other than simply for fuel (Appendix D).

8.3.3 Wood distribution, restricted woods and possible medicinal uses

Approximately two fifths of the wood burnt in BYA2(i) and SPCA and a third in MOD represent plants with medicinal properties. In BYA2(i) several woods are restricted to Hearth 1 base, middle and top, where *Cryptocarya liebertiana*, *Rhamnus prinoides*, *Tabernaemontana ventricosa* and *Spirostachys africana* are unique to Hearth 1 base. *Curtisia dentata* and *Dombeya rotundifolia* are unique to Hearth 1 middle. *Calodendrum capense* and *Croton sylvaticus* are unique to Hearth 1 top. These are medicinal. In SPCA, *Hippobromus pauciflorus*, *Sclerocroton integerrimus*, *Spirostachys africana* and *Tarchonanthus parvicapitulatus* are restricted to Hearth 1, these woods are medicinal and this hearth has proportionally more medicinal wood than the other hearths from SPCA. In MOD, *Dalbergia obovata* and *Spirostachys africana* are restricted to Hearth 1 (Appendix D).

Table 8.2.1: The wood with smoke that has possible medicinal uses

Scientific name	Properties	Restricted distribution
Spirostachys africana	Poisonous smoke	Hearth 1 in BYA2(i), Hearth 1 in SPCA and Hearth 1 in MOD
Tarchonanthus parvicapitulatus	Camphor smoke and leaves	Hearth 1 in SPCA

Table 8.2.2: The woods restricted to the hearth with *Spirostachys africana* that also produce aromatic and medicinal smoke

Scientific name	Properties	Restricted distribution
Cryptocarya liebertiana	Aromatic smoke inhaled for respiratory ailments as a replacement for *Ocotea bullata* smoke	Hearth 1 base in BYA2(i)
Hippobromus pauciflorus	Aromatic smoke	Hearth 1 in SPCA
Dalbergia obovata	Aromatic smoke	Hearth 1 in MOD

Table 8.2.3: The other woods which have a restricted distribution and possible medicinal smoke

Scientific name	Properties	Restricted distribution in
Rhamnus prinoides	Medicinal wood is antiseptic and used in rutuals	Hearth 1 base
Tabernaemon tana	Bark is fire-resistant and used for fever	Hearth 1 base
Curtisia dentata	Medicinal bark is antiseptic	Hearth 1 middle
Dombeya rotundifolia	Medicinal wood and bark for digestion	Hearth 1 middle
Calodendrum capense	Aromatic seed oil is used as soap	Hearth 1 top
Croton sylvaticus	Bark and leaves are poisonous and medicinal for fever	Hearth 1 top

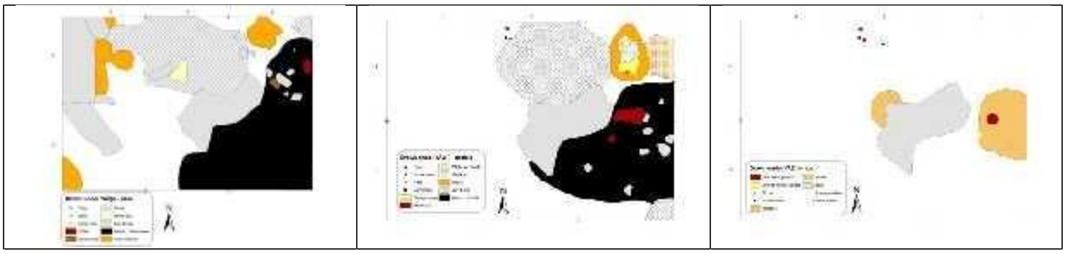

Figure 8.1.1: The position of Hearth 1 base, middle and top, Hearth 2 and 3 on layer BYA2(i) (Chapters 1 and 5).

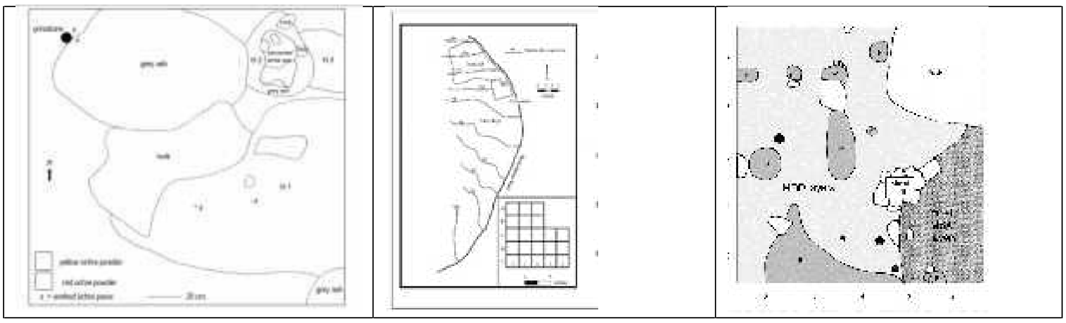

Figure 8.1.2: The position of the hearths on layers BYA2(i) and SPCA from lower and upper ~58 ka and from MOD, ~49 ka (Chapters 1, 5, 6 and Chapter 7).

Spirostachys africana is restricted to one hearth in each layer, in the base of one of three hearths in BYA2(i), in one of five hearths in SPCA and in one of four hearths in MOD. The hearth was most probably used for a medicinal rather than a cooking fire on account of the noxious fumes which could cause food poisoning and which would have had a knock down effect on insects. Poison may be used sparingly as medicine. This confirms the previously conservative identification of *Sapium/Spirostachys* type charcoal (Allott 2006) and the suggested use as an insect repellent (Wadley 2013b). The likely purposeful use of *Spirostachys africana* as herbal medicine provides a strand of evidence in support of the cognitive abilities of the people who built the fires (Wadley 2012a,b; 2013b). In the absence of evidence of use of herbal medicine on an archaeological artefact from BYA2(i), SPCA and MOD - plant residues have been recorded on stone tools in deeper layers (Lombard 2008 a and b) - the only evidence of the deliberate use of a medicinal plant from BYA2(i), SPCA and MOD is Spirostachys africana. So, the anthropic activity marker is the use of poisonous medicinal wood, used sparingly in one hearth on each of three levels from ~58ka (lower and upper) and 49ka (Fig. 8.1; Table 8.1). *Tarchonanthus parvicapitulatus* is restricted to one hearth and it occurs only in SPCA. This wood is burnt for camphor smoke (Chapter 4; Appendix D).

Woods common to all three layers have medicinal bark, aromatic resin and medicinal smoke, although little is known about the medicinal plants which produce smoke e.g. *Commiphora marlothii*, *Dombeya rotundifolia*, *Gardenia volkensii* and *Nuxia floribunda*. The restricted woods may have been used medicinally and then discarded into the fire, or burnt for aromatic smoke, for example, poisonous *Spirostachys africana* or medicinal *Tarchonanthus parvicapitulatus* and *Cryptocarya liebertiana* (Table 8.2.2). Woods with poisonous properties are *Spirostachys africana*, *Hippobromus pauciflorus*, *Croton sylvaticus*, *Ficus ingens* and *Protorhus longifolia*. *Hippobromus pauciflorus* has aromatic, resinous wood. *Protorhus longifolia* has aromatic bark and glue. *Nuxia floribunda* and *Searsia chirindensis*, *Curtisia dentata*, *Rapanea melanophloeos* and *Ziziphus mucronata*, *Mimusops obovata* and *Trichilia emetica* have medicinal bark. *Parinari curatellifolia* has bark tannin and *Dalbergia africana* has bark snuff. The medicinal bark is used for headaches, fever and digestion or as an antiseptic. The wood from *Commiphora marlothii*, *Ptaeroxylon obliquum* and *Dombeya rotundifolia*, *Commiphora harveyii*, *Halleria lucida* and *Tarchonanthus parvicapitulatus* has medicinal resin or smoke.

8.3.4 Research into the use of plant material at Sibudu

A study of the archaeological seeds (Sievers 2006), revealed many nutlets, identified as *Scleria natalensis, Scleria melanomphala* and *Cladium mariscus* sedges and the rush, *Juncus* sp. (Sievers 2013a, b; Sievers and Muasya 2011). A micromorphological study of Sibudu sediments showed that the sedge stems were arranged in a way that suggested bedding (Miller and Sievers 2012; Sievers

2013a and b). A taphonomic investigation showed that the sedges had been brought into the rock shelter by humans (Sievers 2013 b). Specimens of clay, with imprints of sedge stems demonstrated that the sedges had been brought in by people, with clay attached, from the river below the cliff where Sibudu is situated (Sievers 2013b; Wadley *et al.* 2011). It was found that the sedge bedding remained unburnt in older layers, for example at ~77ka, where *Cryptocarya woodii*, insecticidal leaves were laid on sedge bedding (Wadley *et al*. 2011). Bedding was burnt in the layers above ~73ka (Sievers 2013; Wadley *et al*. 2011). The burning of bedding was associated with site maintenance, as was cleaning and sweeping of ashes, which demonstrated camp organisation. There was burnt sedge bedding in Hearth 1 on BYA2(i). The succession of fires and differences in wood burning properties between hearths, particularly in Hearth 1 from BYA2(i) is according to Bentsen (2012, 2013, 2014a and b; in press). Charcoal was previously tentatively identified as *Sapium/Spirostachys* type (*Spirostachys africana)* on several layers (Allott 2006). Plant material has previously been found on stone tools from Sibudu (Lombard 2005, 2007, 2008a and b). Plant poison was identified on a wooden stick from Border Cave (d'Errico *et al.* 2012). Plant resin, probably *Podocarpus*, has been identified on two Sibudu tools (Villa *et. al.* 2015). *Afrocarpus* / *Podocarpus* spp. has been identified on a stone tool at Diepkloof Shelter (Charrié-Duhaut *et al.* 2013). There are current records of the use of plants in arrow poison and glue by the Bushman in Namibia (Wadley *et al*. 2015). The historical records of arrow poison recipes from Bushmen have been applied with caution, to illucidate the possible use of arrow poisons from plants in prehistory (Bradfield *et al.* 2015). This approach has been followed in the present study.

The most telling evidence for the use of medicinal wood is the *Spirostachys africana*. Since charcoal of *Spirostachys africana* can be distinguished from *Sclerocroton integerrimus* and *Shirakiopsis elliptica*, the use of the insecticidal smoke is more certain (Lennox and Bamford 2015; Lennox *et al*. 2015). *Spirostachys africana* charcoal in one hearth in each of three layers implies that one hearth was probably intentionally selected for the burning of medicinal wood. This wood has been used sparsely and provides evidence that at least in the case of *Spirostachys africana*, wood was collected deliberately, for a purpose. The interpretation is applied cautiously because the site has not been entirely excavated. In terms of the collecting strategy, if the wood taxa in each hearth of a single camp site were the same, then these woods may have been collected randomly from the closest forest, with the least amount of effort. This is not the case and the hearths contain a variety of woods, suggesting that the wood was collected deliberately for particular attributes. Other phyto-medicine may have been obtained from the wood, bark and leaves, probably in the form of aromatic smoke. Since the hearth with *Spirostachys africana* fire would not be used for cooking, the other woods restricted to this hearth were possibly also burnt for aromatic smoke, for example, *Cryptocarya liebertiana* in Hearth 1 base in BYA2(i), *Tarchonanthus parvicapitulatus* and *Hippobromus pauciflorus* in Hearth

1 in SPCA and *Dalbergia obovata* in Hearth 1 in MOD. It is emphasized, however, that the prehistoric use of plants may not be directly correlated with the present and historical use of plants. The variety of taxa occurring between the layers may have been due to environmental differences and this possibility is explored.

8.4 Environment

8.4.1 Introduction

A description of the vegetation and an indication of the climate from BYA2(i), SPCA and MOD is suggested. In each layer, the plant taxa represent the local vegetation to a large extent, even though taxa have been selected by people and plant taxa distribution is determined by soils, aspect and climate – rainfall and temperature – the plant data may be used for past climate. The species with limited environmental range suggest a limited climate range for each layer. A change in the forest, savanna and bushveld components indicate a vegetation succession. The plants from each layer, which do not grow at Sibudu, indicate a change in the environment or anthropogenic disturbance.

8.4.2 Vegetation succession from BYA2(i), SPCA and MOD

Plants from the three archaeological layers and from the present were compared to follow the succession in vegetation through time, ~58 ka (lower and upper) to ~49 ka, by means of vegetation units from the Forest and Savanna Biomes (Fig. 8.2; Table 8.4.1). The aim was to obtain an indication of a change in the environment due to the climate. The vegetation from each layer has been described in previous chapters. Plants from BYA2(i) with a narrow environmental range are Buxus *macowanii* (found in valleys along the coast with outliers inland), *Cliffortia repens* (found on rocky slopes and stream banks up to 2 250 m), *Leucosidea sericea* (a pioneer in scrub forest, occurs at high altitude, is frost hardy and an indicator of grassland) and *Afrocarpus*/ *Podocarpus* sp. (occurs in various habitats in evergreen forests) which are representative of the higher altitude Northern Afrotemperate Forest. Plants from BYA2(i) which indicate a different environment represent inland forests and savanna. Either the inland forest was closer than it is today or the riverine environment provided a refuge for these plants with evergreen plants on cool, moist South facing slopes, to plants adapted to cold, dry savanna conditions on the north facing slopes and open plateau facing Sibudu.

Table 8.3: The woody taxa identified in charcoal from BYA2(i) and SPCA, ~58 ka . Plants that occur in both layers are labelled with an asterisk *. Plants that occur only in BYA2(i) are underlined.

Environment	**Evergreen forest (SW face)**	**Riverine forest, forest margins, woodland (S facing slopes)**	**Open, deciduous woodland (NE facing slopes)**	**Bushveld**
Plants present at Sibudu	*Ficus burkei, Harpephyllum caffrum*, Sideroxylon inerme*	*Allophylus dregeanus*, Calodendrum capense*, Volkameria glabra*, Cryptocarya woodii*, Diospyros natalensis, Ficus sur, Syzygium cordatum,* <u>*Tabernaemontana ventricosa,*</u> *Trema orientalis*, Trichilia emetica, Zanthoxylum davyi, Teclea gerrardii*	*Brachylaena discolor*, Celtis africana*,* <u>*Cola natalensis*</u>, <u>*Croton sylvaticus,*</u> <u>*Dovyalis rhamnoides*</u>, *Ficus ingens, Ficus lutea*, Hippobromus pauciformis*,* <u>*Mimusops obovata,*</u> *Mystroxylon aethiopicum*, Ptaeroxylon obliquum*, Searsia chirindensis* Strychnos henningsii*, Vangueria randii**	*Apodytes dimidiata, Commiphora harveyi, Carissa macrocarpa*
Plants present in the region, but lost from Sibudu – anthropo-geny	*Cryptocarya liebertiana*, Buxus macowanii, Cunonia capensis, Englerophytum natalense, Trichilia dregeana,*	*Chionanthus foveolatus*, *Curtisia dentata*, Ekebergia capensis*, Empogna lanceolata, Erica caffra*, Hypericum* sp., *Nuxia floribunda*, Olea europaea* subsp. *africana*, Protea caffra**, *Protorhus longifolia, Rapanea melanophloeos*, Rauvolfia caffra*, Sclerocroton integerrimus*, Searsia dentata *, Shirakiopsis elliptica*, Spirostachys africana*, Trimeria grandifolia*, *Searsia dentata*, Tarchonanthus parvicapitulatus*	*Bersama lucens, Canthium mundianum*, Canthium spinosum*, Cussonia spicata, Cordia caffra*, Cryptocarya wyliei*, Dombeya rotundifolia*, Euclea crispa, Euclea natalensis, Halleria lucida**, *Heteropyxis natalensis, Loxostylus alata, Maytenus peduncularis, Protea roupelliae, Rhoicissus rhomboidea, Sophora inhambanensis*	*Diospyros lycioides*, *Ochna* sp., *Ochna serrulata, Rothmannia capensis, Ximenia caffra*, Ziziphus mucronata**

Plants absent from the region - climate	*Afrocarpus/ Podocarpus spp.*, Olinia ventosa,*	*Cliffortia repens, Erica* sp*., Leucosidea sericea*, Pittosporum viridiflorum*, Rhamnus prinoides*, Diospyros mespiliformis, Erica* sp*., Morella pilulifera**	*Commiphora marlothii*, Diospyros austro-africana*, Eugenia erythrophylla, Faurea saligna**	*Acacia* spp.**, Burkea africana, Commiphora schimperi, Gardenia volkensii*, Grewia bicolor, Grewia flava, Kigelia africana, Kirkia acuminata, Maytenus albata, Olax dissitiflora*, *Pappea capensis*, Parinari curatellifolia*, *Pavetta eylesii*, Peltophorum africanum*, *Sterculia rogersii*, *Terminalia phanerophlebia*, *Vangueria cyanescens**, *Vitex rehmannii**

The environment seems to have been colder and drier than it is now, whilst the river ameliorated conditions and enabled growth of some taxa that would otherwise not be there. Plants from SPCA with a narrow environmental range are *Leucosidea sericea*, *Protea roupelliae* (in grassy hills, on mountain slopes, in small patches and in open protea woodland), *Olinia ventosa* (in evergreen forest, on forest margins, in coastal scrub and on rocky hillsides) and *Afrocarpus/ Podocarpus* spp. which are representative of the Northern Afrotemperate Forest. Plants from SPCA which indicate a different environment represent inland forest which was either closer to Sibudu or grew in the refuge. Plants from the savanna represent frost hardy deciduous plants. The environment seems to have been colder and drier than the present. Plants from MOD with a narrow environmental range are *Bridelia mollis, Burkea africana* and *Searsia divaricata*. Each layer has some plants which are no longer at Sibudu and which are not expected to grow there. These plants do not occur near the coast and are absent from the distribution grid 29° to 30°S and 30 to 32°E (Boon 2010). So, a change in environment is indicated.

The contrast of trees to shrubs gives an impression of the vegetation density in each layer, but it must be remembered that smaller diameter stems possibly do not produce as much charcoal as larger diameter stems, and that some woods do not produce charcoal at all. If one looks at the charcoal as it stands, then mostly trees are represented in the BYA2(i), SPCA and MOD layers. Dominant trees are 12-22m, small trees are 4-6m and shrubs are lower than 3m (Boon 2010; Killick 1990). Plants common to BYA2(i), SPCA and MOD are mostly trees, with few shrubs or understorey, from the KZN Coastal Belt, Plants from BYA2(i) are trees, with several understorey shrubs from the KZN Coastal Belt (*Cunonia capensis*) and Northern Afrotemperate Forest (*Buxus macowanii* and *Cliffortia repens*). Plants from SPCA are mostly trees, with shrubs or small trees as understorey in the riverine, woodland or bushveld habitats, from KZN Coastal Belt, and the Savanna. Plants from MOD are mostly trees from bushveld habitats, for example *Bauhinia galpinii* with some shrubs from riverine forest, for example *Dalbergia obovata.*

8.4.3 Anthropogenic disturbance

Each layer has some plants which are no longer at Sibudu, but which could grow there, since these plants occur in nature reserves and ravines and are recorded in distribution maps between 29° to 30°S and 30 to 32°E (Boon 2010; Metcalf 2013; Sutherland 2014). Plants from BYA2(i) which indicate anthropogenic disturbance represent riverine forest and open woodland and are presently found in the KZN Coastal Belt. Plants mostly from the KZN Coastal Belt include evergreen *Buxus macowanii* and *Cunonia capensis,* riverine forest *Nuxia floribunda, Olea europaea* ssp. *africana* and *Rapanea melanophloeos,* woodland *Cordia caffra* and *Dombeya rotundifolia* and bushveld *Rothmannia capensis, Ximenia caffra* and *Ziziphus mucronata. Curtisia dentata*, *Olea europaea* subsp. *africana* and *Trimeria grandifolia* in the riverine forest, forest margins and in open woodland, occur in the Southern Mistbelt Forest. *Olea europaea* is however also found in dry savanna and occasionally on termitaria refugia. In open woodland, *Cryptocarya wyliei* represents the Scarp Forest and *Halleria lucida* represents the Northern Coastal Forest. Trees and shrubs that survive dry conditions on warm hillsides, include plants such as *Rothmannia capensis* found in forest and rocky areas up to 1 900m in bushveld. *Buxus macowanii* probably grew amongst the evergreen trees and shrubs against the cool, shaded cliff. This small tree is distributed from the eastern Cape to southern KZN, occurs disjunctly in Zululand, Mpumalanga, Limpopo and North West and since there is an outlier along the coast near Durban (Boon *pers. comm* 2013) could grow near Sibudu. *Cunonia capensis* is an evergreen tree which occurs in moist forest and near streams from the coast to the mountains. Plants from SPCA which indicate anthropogenic disturbance are mostly from the riverine forest and woodland from the nearby forests but also nearby savanna, KZN Coastal Belt, Scarp Forest, Northern Coastal Belt and the Savanna-Ngongoni Veld. Plants include evergreen *Englerophytum natalense* and *Trichilia dregeana* which occur in the KZN Coastal Belt. From the open woodland *Cryptocarya wyliei* occurs in the Scarp Forest. In the riverine forest *Chionanthus foveolatus* and *Searsia dentata* are from the KZN Coastal Belt, *Trimeria grandifolia* is from the Southern Mistbelt Forest and *Tarchonanthus parvicapitulatus* is from the Scarp Forest. In the woodland, several are from the KZN Coastal Belt, *Cussonia spicata* is from the Savanna-Ngongoni Veld, *Euclea natalensis* and *Sophora inhambensis* from the Northern Coastal Forest and *Protea roupelliae* from the Afromontane Forest. In the bushveld, *Diospyros lycioides* is from the Northern Coastal Belt and *Ochna serrulata* is from the KZN Coastal Belt. *Ximenia caffra* and *Ziziphus mucronata* are from the Savanna- Ngongoni-Veld. Most represent the KZN Coastal Belt, 9 and few represent the Scarp Forest, 1 the Northern Coastal Belt, 2 the Savanna-Ngongoni Veld, 1 and the Southern Mistbelt, 1. Plants from MOD, lost to anthropogenic disturbance include plants from near the coast, for example *Nuxia floribunda* in evergreen forest or bush-clumps, from ravines, for example Erica caffra and from nearby nature reserves, for example *Olea europaea* ssp. *africana* (Lennox *et al*. 2015). So, these trees may have been used for fuel and carvings initially, later for logging and agriculture, such as food gardens at homesteads, then small scale farming and more recently for large scale agriculture such as sugar cane. These activities are beyond the scope of this study but the question of when the impact of people on nature began is of interest.

There is a change in diversity over time, with an increase in variety from BYA2(i) to SPCA, followed by an increase in variety to MOD which could indicate a change in the environment. The increase in diversity could indicate an increase in savanna at the expense of forest as suggested in previous studies (Allott 2006; Hall *et al*. 2014)

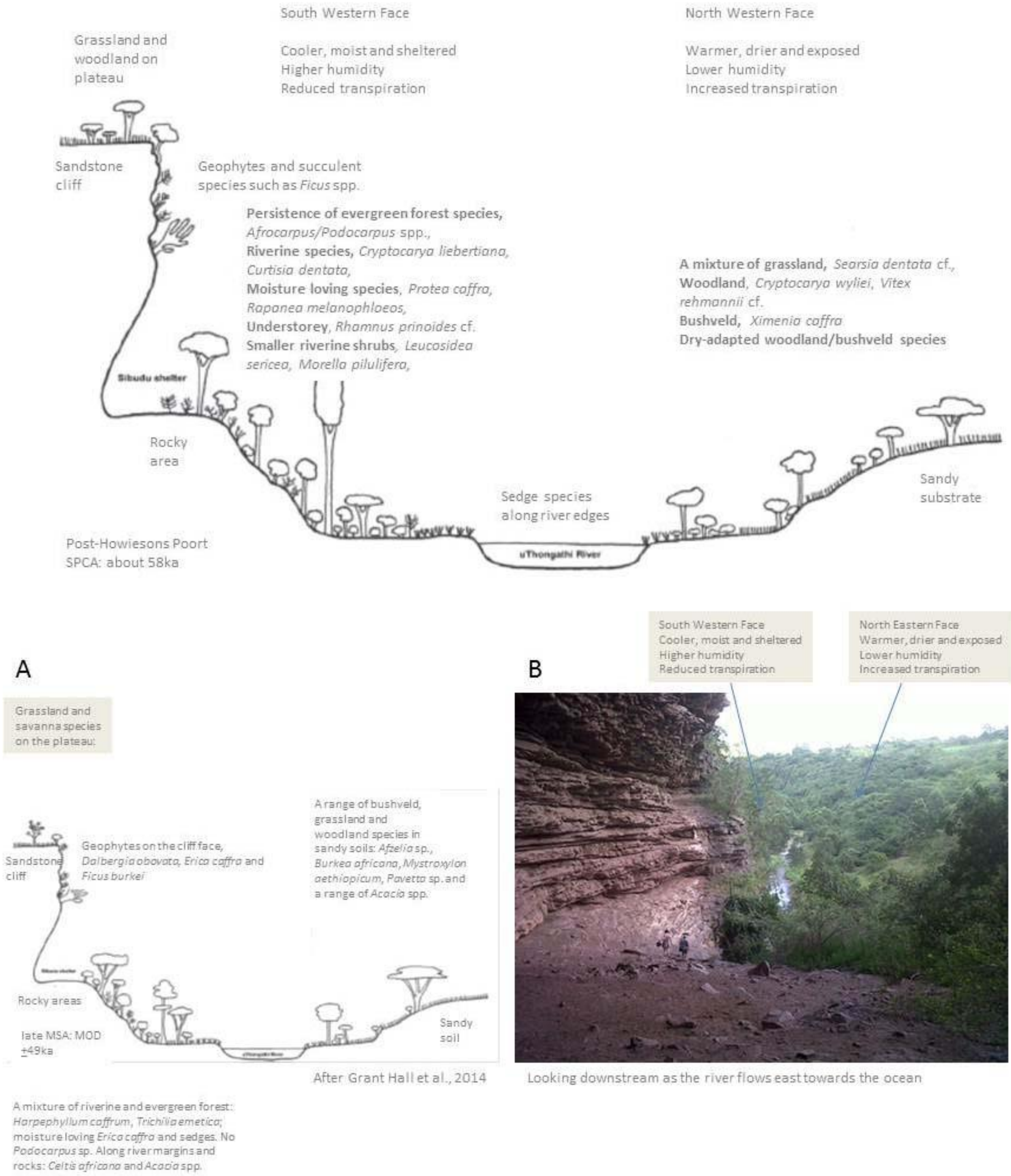

Figure 8.2: A profile of the vegetation from ~58 ka (top), ~49ka (A) and the present day (B) (after Hall et al. 2014)

Table 8.4.1: A summary of the woody taxa from BYA2(i), SPCA and MOD in vegetation units from the Forest and Savanna Biomes to show the vegetation succession and to show those which occur near Sibudu today (Mucina and Geldenhuys 2011; Mucina *et al*. 2011; Rutherford *et al*. 2011; Sievers 2013).

Woody taxa	BYA2(i)	SPCA	MOD	Present
Forest Biome	57	92	47	38
Savanna Biome	10	16	9	0
Total trees/shrubs	67	108	56	38
Ratio Forest:Savanna	6:1	4:1	5:1	4

Table 8.4.2: A summary of the woody taxa from BYA2(i), SPCA and MOD and those which occur near Sibudu today. Vegetation from the Forest Biome includes the Northern Afrotemperate Forest - FOZ 2, Southern Mistbelt Forest - FOZ 3, Scarp Forest - FOZ 5, Northern Coastal Forest - FOZ 7, and the KZN Coastal Belt - CB 3. Vegetation from the Savanna Biome includes the Ngongoni Veld - SVs4, KZN Sandstone Sourveld - SVs 5 and the Savanna Bushveld (Mucina and Geldenhuys 2011; Mucina *et al*. 2011; Rutherford *et al.* 2011; Sievers 2013). The vegetation from more than one vegetation unit were accommodated by using the habitat and distribution most commonly used by Boon (2010) and Van Wyk and Van Wyk (2013).

Woody taxa	BYA2(i)	SPCA	MOD	Present
CB3	33	51	30	23
CB3, FOZ 7, FOZ 5	11	29	13	13
FOZ 2, FOZ 3	13	12	4	2
SVs 4, SVs 5	6	12	8	0
S. Bushveld	4	4	1	0
Total woody taxa	67	108	56	38

Table 8.5.1: The habit and habitat of plants which occur on all three layers, BYA2(i), SPCA and MOD

Plants on all three layers	Forest Biome	Riverine Forest	Open deciduous woodland	Bushveld
Trees > 2 m	*Harpephyllum caffrum*	*Canthium mundianum, Nuxia floribunda, Sclerocroton integerrimus, Shirakiopsis elliptica, Spirostachys africana, Trema orientalis*	*Brachylaena discolor, Celtis africana, Commiphora marlothii, Dombeya rotundifolia, Ficus lutea , Halleria lucida, Mystroxylon aethiopicum , Olea europaea* ssp. *africana, Pappea capensis, Ptaeroxylon obliquum*	*Acacia* sp.*, Gardenia volkensii*

Plants on all three layers	Forest Biome	Riverine Forest	Open deciduous woodland	Bushveld
Shrubs < 2m	*Canthium suberosum*	*Allophylus dregeanus, Volkameria glabra, Erica caffra*	*Cordia caffra, Diospyros austro-africana, Protea sp, Searsia chirindensis*	*Vangueria cyanescens, Vangueria randii*

Table 8.5.2: Plants unique to BYA2(i)

Plants unique to BYA2(i)	Forest	Riverine	Woodland	Bushveld
Trees > 2 m	*Cunonia capensis*	*Tabernaemontana ventricosa*	*Croton sylvaticus, Dovyalis rhamnoides, Ochna* sp., *Protea* sp.,	Indeterminate Fabaceae cf.
Shrubs < 2 m	*Buxus macowanii*		*Canthium* sp., *Cliffortia repens, Cola natalensis*	

Table 8.5.3: Plants unique to SPCA

Plants unique to SPCA	Forest	Riverine	Woodland	Bushveld
Trees > 2 m	*Olinia ventosa, Sideroxylon inerme, Trichilia dregeana*	*Chionanthus foveolatus, Diospyros natalensis, Ficus sur, Rauvolfia caffra, Sapium/ Spirostachys* type, *Sophora inhambanensis, Zanthoxylum davyi*	*Loxostylus alata, Cryptocarya* sp, *Cussonia spicata, Cussonia zuluensis, Euclea natalensis, Ficus sp., Ficus ingens, Maytenus peduncularis, Nuxia* sp., *Protea roupelliae, Strychnos henningsii*	*Apodytes dimidiata, Commiphora harveyi, Commiphora schimperi, Grewia flava, Grewia flavescens, Kigelia africana, Kirkia acuminata, Maytenus albata, Olax dissitiflora, Parinari curatellifolia, Terminalia phanerophlebia*
Shrubs < 2 m		*Teclea gerrardii, Trimeria grandifolia, Vitex* sp.	*Bersama lucens, Deinbollia* sp., *Eugenia erythrophylla, Grewia bicolor, Hypericum* sp., *Syzygium* sp.	*Carissa macrocarpa, Englerophytum natalense, Sterculia rogersii*

Table 8.5.4: Plants unique to MOD

Plants unique to MOD	Forest Biome	Riverine Forest	Open deciduous woodland	Bushveld
Trees > 2 m		*Bridelia mollis, Diospyros whyteana, Searsia lancea, Searsia rehmanniana*	*Diospyros villosa*	*Afzelia quanzensis, Dalbergia obovata, Kiggelaria africana, Ozoroa paniculosa, Maytenus* sp.*, Pterocarpus rotundifolius, Dombeya tiliacea*
Shrubs < 2 m				*Bauhinia galpinii*

Table 8.6: Vegetation succession from BYA2(i), SPCA and MOD

Layer	Vegetation which indicates a change in environment	Vegetation which indicates a change due to anthropogenic disturbance	Vegetation from each layer present at Sibudu today
BYA2(i)	Inland forest and savanna	Riverine forest and woodand	Coastal forest
SPCA	Evergreen and deciduous plants from inland forest and savanna	Riverine forest and woodland	Coastal forest
MOD	Bushveld	Riverine forest	Coastal forest

8.4.4 A comparison with previous studies of the past environment at Sibudu

When the findings are compared with studies in the fields of charcoal, seed and other complementary studies from Sibudu, there are some interesting results. Most plants common to both layers BYA2(i) and SPCA, occur in the charcoal and seed record. Some are in genera for example *Celtis* sp., *Cryptocarya* spp. and *Ficus* spp., or in plant families previously identified from charcoal and/or seed (Allott 2006; Sievers 2006).

Pappea capensis is found in three archaeological layers and in the charcoal record, in MOD (Allott 2006) and in the seed record in OMOD from ~50ka (Sievers 2006), but presently does not occur at Sibudu. *Pappea capensis* is not expected to grow at Sibudu, since it does not grow at the coast or in the vicinity, although it occurs in a variety of habitats, including termitaria which are considered to be a refuge for past vegetation (Boon 2010).

Erica caffra is found in three archaeological layers and in the charcoal record according to Allott (2006), but presently does not occur at Sibudu. However, it could grow at Sibudu, since it is found in nearby reserves, for example the Karkloof, where ravines provide a refuge. The environmental conditions at Sibudu ~58ka and ~49ka were conducive to *Erica caffra* and the absence of the plant today may imply anthropogenic disturbance.

Plants which continue to occur at Sibudu include *Harpephyllum caffrum, Ptaeroxylon obliquum* and *Mystroxylon aethiopicum. Harpephyllum caffrum* occurs in three archaeological layers and is presently at Sibudu. It occurs in the seed record, in BMOD- OMOD2, MOD and MOD, from ~50ka (Sievers 2006) (Table 8.3). *Ptaeroxylon obliquum* is present in the charcoal from the three archaeological layers and presently occurs at Sibudu. It occurs in the charcoal record, in GS, GR2 and GR, from >60ka, and from Eb and BSp from ~58 ka. This fuel wood implies forest and riverine vegetation. *Mystroxylon aethiopicum* occurs in four layers, and it occurs in the charcoal record, in Hp from >60ka, in Eb and RSp, from ~58 ka, in OMOD and MOD from ~49 ka and in Bu, from ~35 ka (Allott 2006; Jacobs et al. 2008 a, b; Wadley 2015: 165). This study confirms the presence from ~58ka and ~49ka of *Harpephyllum caffrum, Ptaeroxylon obliquum* and *Mystroxylon aethiopicum.*

The plant record from archaeological charcoal and seeds is different. Charcoal is brought in as wood for fires so is anthropogenic of origin. Seeds are brought in by people, by may also be brought in by birds or animals, involving a study of the taphonomy. The charcoal represents the environment of the home range, but may also represent wood imported from a distance (Cartwright 2013). In this study, the focus has been on wood brought in as fuel or possibly medicine and the other useful characteristics have been ignored, including edible fruit. In summary, *Harpephyllum caffrum* and *Pappea capensis* are in the charcoal and seed record and here the fuel is the focus. *Harpephyllum caffrum* occurs at Sibudu, in the KZN Coastal Forest, whereas *Papea capensis* does not, suggesting different environmental conditions. On the contrary, *Erica caffra*, *Mystroxylon aethiopicum* and *Ptaeroxylon obliquum* are in the charcoal but not in the seed record. *Erica caffra* is tinder. *Mystroxylon aethiopicum* has medicinal, antiseptic fruit and leaves. *Ptaeroxylon obliquum* burns with long lasting, hot coals on account of the resin.

The vegetation mosaic unique to BYA2(i) suggests, firstly, cooler conditions at altitude and inland forests with *Buxus macowanii*, *Cliffortia repens* and *Cunonia capensis* which probably grew in the cool, moist and shaded, south facing slopes at Sibudu and, secondly, drier savanna with plants which probably grew in the warm, dry, sunny north facing slopes at Sibudu. Both growth conditions are found in the ravine near Sibudu (Allott 2006; Hall *et al.* 2014; Wadley 2006). In SPCA, the vegetation reconstruction is similar to that from previous research where a variety of woody taxa mostly from evergreen forest and riverine vegetation and less from dry bushveld vegetation were identified in charcoal from layers Eb, SPCA and BSp (Allott, 2006). The riverine forest community including *Bridelia* sp., *Erica* sp., *Leucosidea sericea* and *Rapanea melanophloeos* was also reported in the previous anthracological study. The woody taxa currently only found inland where it is seasonally cold with frost, such as *Leucosidea sericea* in the Drakensberg foothills are represented in the previous anthracological study. It was reasoned that a significant shift in vegetation at the end of OIS 4 and the beginning of OIS 3 may be suggested by these inland forest components (Allott, 2006). In MOD, the vegetation mosaic of dry bushveld is similar to that previously found in RSp, OMOD and MOD when an environment which is drier than that that of the modern environment, seemed possible from ~50ka (Allott, 2006; Wadley, 2006). The forest and riverine vegetation is present, including evergreen woody taxa, but mostly deciduous taxa, especially the Caesalpiniaceae, Mimosaceae and Papilionaceae are present.

The vegetation from BYA2(i), SPCA and MOD indicates a vegetation succession from inland forest and savanna at ~58 ka to savanna bushveld at ~49 ka. This is similar to previous climate and environmental analyses (Hall *et al*. 2014) from multiproxy records. The Sibudu environment pre ~60 ka was cold and moist. Evergreen forests were dominated by *Afrocarpus*/ *Podocarpus* sp., and sedge species dominated the seeds. *Podocarpus* charcoal dominated the charcoal assemblage which included other forest spp. Small forest spp. and aquatic spp. mammals, including the blue duiker, Gambian vlei rat, and Geoffrey's Horseshoe Bat, indicated forests and humid conditions. The period during BYA2(i), ~58 ka (older) was the coldest period of the MSA, with more open savanna, woodland and grassland, represented by sedge spp. seeds and by grass, sedge and *Acacia* sp. Phytoliths

Large bovids were present. In SPCA, ~58 ka ago, exhibited warmer conditions than before. Increased woodlands were indicated by factors including *Asparagus* spp. and sedge seeds, *Erica*, *Leucosidea and Afrocarpus*/ *Podocarpus* charcoal, sedge and *Acacia* phytoliths and by large and very large bovids. The period during MOD, ~49 ka was cooler than today, with an increase in deciduous taxa, than before as suggested by *Pavetta* and sedge seeds, *Acacia* and *Erica* charcoal, large and medium bovids (*Acypyceros melampus*, Impala) and rodent *Mastomys natalensis*. Different environmental conditions seem to have promoted the vegetation community from BYA2(i), ~58 ka ago. The CA_{GIS} study (Bruch *et al*. 2012) implies that the environment during the BYA2(i) occupation was cooler than today and somewhat drier, but not dry enough to prevent the growth of *Afrocarpus/Podocarpus* spp. that require approximately 900 mm precipitation annually (Allott 2004; Wadley 2006; Hall *et al*. 2014) The growth of *Afrocarpus/ Podocarpus* spp. near Sibudu most likely implies that evergreen forest existed in the region at ~ 58 ka ago (early), but it is unkown whether this was the temperate forest of *Afrocarpus falcatus*, the moist, inland forest of *Podocarpus* *henkelii*, or stunted, exposed growth of *Podocarpus latifolius* (Boon 2010). The evergreen forest at Sibudu today, along the cool, moist shaded cliff, but there are no *Afrocarpus/ Podocarpus* spp.

For BYA2(i), the previous CA_{GIS} study showed that winters were cool and summers were dry. For SPCA, the previous CA_{GIS} study and multiproxy environmental studies showed that the winters were cool but not as cool as BYA2(i) and summers were dry. For MOD, the previous CA_{GIS} study showed that the winters were warmer and the summers were wetter than lower layers (Bruch *et al*. 2012), supported by multiproxy environmental record (Hall *et al.* 2014). The climate during the occupation of BYA2(i) had the coldest winters and drier summers of the three layers studied here than today. The climate during SPCA had cooler winters and drier summers than today, but was warmer and wetter than before. The climate during MOD was cooler and drier than today, but warmer and wetter than before. According to a CA_{GIS} study of woody taxa identified in charcoal from sediment and from seeds (Bruch *et al*. 2012). The presence of inland forest and savanna from BYA2(i) and SPCA at ~58 ka and an increase in savanna bushveld in MOD at ~49ka may be climate, the pre-60 ka winters were warmer than ~58 ka and summers were wetter while the climate remained colder and drier than today, the ~58 ka winters were colder than today and summers were drier and this was the coldest period of the MSA (60 —49 ka) the 49 ka winters warmed up remaining colder than today and summers received more rainfall but remained drier than today (Bruch *et al*. 2012). Overall, from 58 to 49 ka to the present, representatives of the KZN Coastal Belt, Scarp Forest and Northern Coastal Forest vegetation types are present, but representatives of the Inland Forest and Savanna-Bushveld vegetation types are absent. This supports previous work which showed that the environment was cold in winter and dry in summer 58 ka then warmer in winter and wetter in summer 49 ka, and that the riverine environment provided a refuge for evergreen components from the inland forest. If not, then the inland forests were closer than today and this can be tested by further study of the Proteaceae as the plants would benefit from more winter rainfall.

Table 8.7: The plant taxa from BYA2(i), SPCA and MOD with matching plant taxa identified from charcoal and seeds, recovered from Sibudu MSA layers (Allott 2006; Sievers 2006; Wadley et al. 2011) grouped according to lithostratigraphic units and OSL dates (Jacobs et al. 2008a, b; Wadley 2015: 165).

SCIENTIFIC NAME	**FAMILIES**	***BYA2(I) (n=69)***	***SPCA (n=110)***	***MOD (n=60)***	***ANTHRACOLOGY MSA LAYERS (>60 ka: GS, GR2, GR)(~58 ka: Eb, SPCA, BSp) (~ 49 ka: RSp, OMOD, MOD)(~35 ka Bu)***	***CARPOLOGY MSA LAYERS (>60ka BS-LBG; RGS2-RGS; PGS-GR)(~60ka: YA2-G1; Su-Mi; OR-SPCA;BSp2-BSp)(~50ka Ysp-RSp; BMOD-OMOD2; OMOD; MOD)(~37ka Ore2-Co)***	***PRESENT***
Anacardiaceae	ANA				RSp, OMOD, MOD		
Protorhus longifolia	ANA		*	*		(YA2-G1, Su-Mi; Or-SPCA, BSp2 - BSp) (OMOD, MOD)	
Searsia sp.	ANA	*	*			(YA2- G1, Su-Mi)(OMOD, MOD)	,
Harpephyllum caffrum	ANA	*	*	*		(BMOD-OMOD2, MOD, MOD)	*
Anacardiaceae/ Burseraceae	ANA/ BRS		*		Eb, SPCA, RSp, MOD, Bu	*	
Annonaceae	ANN		*		SPCA, OMOD	*	
Apocynaceae	APO				GS, GR2, GR, OMOD		
Apocynaceae/ Rubiaceae	APO/ RUB				GS, GR2, GR, RSp, OMOD		
Monocotyledon: Phoenix reclinata	ARE				Bu		
Cussonia sp.	ARL					(MOD)	
Asteraceae	ASR	*			*		
Brachylaena sp.	AST				GS, GR2, GR, Eb, Bu		
Cordia caffra	BOR	*	*	*		(Su-Mi, Or- SPCA)(Ysp- RSp)	
Burserceae	BRS				BSp, RSp		
Buddlejaceae	BUD				RSp, OMOD		
Nuxia sp.	BUD		*		Eb, SPCA, BSp, MOD	*Nuxia* sp.	
Buxus sp.	BUX				GS, GR2, GR, BSp, OMOD		
Mystroxylon aethiopicum	CEL	*	*	*	Hp, Eb, RSp, OMOD, MOD, Bu		*
Celastraceae	CEL					BSp2-BSp	
Celtis spp.	CLT				SPCA, BSp		
Combretaceae	CMB				Eb, RSp		
Curtisia dentata	COR	*	*		GS, GR2, GR, MOD		
Burkea africana	CSL		*	*	OMOD, MOD		
Afzelia quanzensis	CSL			*	OMOD		
Caesalpiniaceae	CSL				BSp, RSp, OMOD		
Caesalpiniaceae,	CSL/F				GS, GR2, GR, Eb, RSp,	*	

SCIENTIFIC NAME	**FAMILIES**	***BYA2(I) (n=69)***	***SPCA (n=110)***	***MOD (n=60)***	***ANTHRACOLOGY MSA LAYERS (>60 ka: GS, GR2, GR)(~58 ka: Eb, SPCA, BSp) (~ 49 ka: RSp, OMOD, MOD)(~35 ka Bu)***	***CARPOLOGY MSA LAYERS (>60ka BS-LBG; RGS2-RGS; PGS-GR)(~60ka: YA2-G1; Su-Mi; OR-SPCA;BSp2-BSp)(~50ka Ysp-RSp; BMOD-OMOD2; OMOD; MOD)(~37ka Ore2-Co)***	***PRESENT***
Fabaceae, Papilionaceae	AB/PPL				BSp, RSp, OMOD, MOD, Bu		
Cunonia capensis	CUN	*			BSp, MOD		
Cyperaceae	CYP					All layers except (Su-Mi, BSp2-BSp), (BMOD-OMOD2) and (Ore2-Co)	
Ebenaceae	EBN				GS, GR2, GR		
Diospyros sp.	EBN				Eb, RSp, MOD	(MOD)	
Euclea sp.	EBN					(YA2-G1, Su-Mi, BSp2-BSp)(Ysp-RSp, MOD)	
Erica sp.	ERI		*		Eb, SPCA, BSp, RSp, OMOD, MOD, Bu		
Erica caffra	ERI	*	*	*	Eb, SPCA, BSp, RSp, OMOD		
Sapium/ Spirostachys type	EUP		*		GS, GR2, GR, SPCA, MOD		
Euphorbiaceae	EUP		*		Eb, SPCA, RSp, OMOD, MOD	*	
Bridelia sp.	EUP				Eb, MOD		
Fabaceae	FAB	*			BSp, RSp, MOD, Bu	*	
Flacourtiaceae	FLC				GS, MOD		
Vitex sp.	LAM		*		SPCA		
Lamiaceae	LAM				GS, GR2, GR, BSp, OMOD, MOD		
Volkameria glabra	LAM	*	*	*	Bu	(Su-Mi)(MOD)	*
Cryptocarya sp.	LAU		*		SPCA	*Cryptocarya* sp.	*
Lauraceae	LAU		*		Eb, SPCA	*	
Meliaceaea	MEL				OMOD		
Mimosaceae	MIM				RSp, OMOD, MOD,		
Acacia sp. type	MIM	*	*	*	Eb, BSp, RSp, OMOD, MOD, Bu	Mi, OMOD	
Malvaceae	MLV				RSp		
Malvaceae/ Tiliaceae	MLV/ TIL				OMOD		
Ficus sp.	MOR		*		SPCA, BSp	*Ficus* spp.	*
Rapanea melanophloeos	MRS	*	*		Eb, SPCA, BSp, RSp, MOD	(OMOD)	
Syzygium sp.	MRT		*		SPCA, BSp		

SCIENTIFIC NAME	**FAMILIES**	*BYA2(I) (n=69)*	*SPCA (n=110)*	*MOD (n=60)*	*ANTHRACOLOGY MSA LAYERS (>60 ka: GS, GR2, GR)(~58 ka: Eb, SPCA, BSp) (~ 49 ka: RSp, OMOD, MOD)(~35 ka Bu)*	*CARPOLOGY MSA LAYERS (>60ka BS-LBG; RGS2-RGS; PGS-GR)(~60ka: YA2-G1; Su-Mi; OR-SPCA;BSp2-BSp)(~50ka Ysp-RSp; BMOD-OMOD2; OMOD; MOD)(~37ka Ore2-Co)*	*PRESENT*
Myrtaceae	MRT				Eb		
Morella pilulifera	MYR	*	*		Eb, SPCA, BSp, OMOD		
Ochna sp.	OCH	*			GS, GR2, GR, Eb		
Ximenia sp.	OLC				Eb, RSp		
Oleaceae	OLE				GS, GR2, GR, BSp, RSp, OMOD, MOD		
Olea sp. (Type 5)	OLE					(BS - LBG, RGS2 -RGS, PGS-GR), (YA2-G1, Su-Mi, Or-SPCA, BSp2 - BSp) (Ysp -RSp, BMOD- OMOD2, OMOD, MOD)	
Afrocarpus/ Podocarpus sp.	PDC	*	*		GS, GR2, GR, RSp		
Afrocarpus	PDC					Su-Mi	
Poaceae	POA					MOD	
Proteaceae	PRT				GS, Eb, RSp, OMOD, MOD		
Ptaeroxylon obliquum	PTX	*	*	*	GS, GR2, GR, Eb, BSp		*
Rhamnaceae	RHB		*		SPCA	*	
Ziziphus mucronata	RHM	*	*		HP, Eb, SPCA, BSp, RSp, OMOD, MOD	(RGS2-RGS)(BSp2-BSp)(YSp-RSp, BMOD-OMOD2, OMOD, MOD) (Ore2-Co)	
Rhizophoraceae	RHZ				OMOD		
Leucosidea sericea	ROS	*	*		Eb, SPCA		
Rubiaceae	RUB		*		GS, GR2, GR, Eb, SPCA, BSp, RSp, OMOD, Bu	MOD	
Pavetta spp.	RUB					(YA2-G1, Or - SPCA)(Ysp - RSp, BMOD - OMOD2, OMOD, MOD)	
Canthium sp.	RUB					(OMOD, MOD)	
Calodendrum capense	RUT	*	*		SPCA, BSp	(SPCA)(Ysp-RSp, OMOD, MOD)(Ore2-Co)	*
Rutaceae	RUT				RSp, MOD		
Pappea capensis	SAP	*	*	*	MOD	OMOD	
Deinbollia sp.	SAP		*		Eb		
Kirkia sp.	SMR				HP, RSp, Bu		

SCIENTIFIC NAME	FAMILIES	BYA2(I) (n=69)	SPCA (n=110)	MOD (n=60)	ANTHRACOLOGY MSA LAYERS (>60 ka: GS, GR2, GR)(~58 ka: Eb, SPCA, BSp) (~ 49 ka: RSp, OMOD, MOD)(~35 ka Bu)	CARPOLOGY MSA LAYERS (>60ka BS-LBG; RGS2-RGS; PGS-GR)(~60ka: YA2-G1; Su-Mi; OR-SPCA;BSp2-BSp)(~50ka Ysp-RSp; BMOD-OMOD2; OMOD; MOD)(~37ka Ore2-Co)	PRESENT
Sideroxylon inerme	SPT		*		SPCA	(PGS -GR)(YA2 -G1, BSp2-BSp)(Ysp-RSp, BMOD-OMOD2, OMOD, MOD) (Ore2-Co)	*
Sapotaceae	SPT		*		GS, GR2, GR, Eb, SPCA, RSp, MOD, Bu	*	
Sterculiaceae	STR				GS, GR2, GR, BSp, MOD		
Tiliaceae	TIL				BSp, MOD		
Grewia sp.	TIL					(YA2-G1, Su-Mi, Or-SPCA, BSp2-BSp) (Ysp-RSp)	
Rhoicissus digitata	VIT					(Su-Mi)	
Verbenaceae	VRB				RSp		

8.4.5 A comparison with the past environment from other MSA sites

There are few sites with MSA archaeobotanical records (Wadley 2015: 198-200), namely Boomplaas (Scholtz 1986) from the Cape coast, Diepkloof rock shelter (Cartwright 2013; Charrié-Duhaut *et al*. 2013) and Elands Bay from western South Africa and its interior, Apollo 11 Cave from Namibia/Botswana (Vogelsang *et al*. 2010) and Border Cave (Anderson 1978; Beaumont 1978; Beaumont *et al.* 1978), Bushman rock shelter (Badenhorst and Plug 2012; Plug 1981; Wadley 1987), Melikane (Stewart *et al.* 2012; Stewart *et al.* 2016), Rose Cottage Cave (Harper 1997; Pienaar *et al.* 2008; Valladas *et al*. 2005; Wadley *et al*. 1993; Wadley and Harper 1989), Sibudu (Allott 2004, 2005, 2006; Chase 2010; Hall *et al*. 2014; Sievers 2006, 2013 a, b; Renault and Bamford 2006; Wadley 2004, 2006; Wadley and Jacobs 2004, 2006) and Strathalan Cave (Opperman and Heydenrych 1990) from Eastern South Africa, the interior and Lesotho. Woody taxa recorded repeatedly (Wadley 2015) include *Afrocarpus*/*Podocarpus* spp., *Celtis africana*, *Diospyros* sp., *Ficus* spp., *Olea* sp., *Searsia* sp. and *Maytenus* sp.. Border Cave provides the best comparison and includes *Bridelia* sp., *Diospyros* sp., *Sideroxylon* sp. and *Ziziphus sp.* in addition to resinous woods *Commiphora* sp. and *Ozoroa* sp. (Anderson 1978; Beaumont *et al*. 1978; Wadley 2015: 160-166). The palaeoclimate during the Quaternary has been studied from multiproxy evidence including archaeobotanical specimens excavated from Wonderkrater (Backwell *et al.* 2014). The closest sites to Sibudu geographically and contemporaneouly ($\leq$ 60 ka) are Border Cave and Melikane (Anderson 1978; Stewart *et al.* 2016; Wadly 2015). The plants recorded there are also in the record from charcoal from three layers at Sibudu. Plants from Melikane are Erica spp., *Protea* sp., *Leucosidea sericea* and *Olea africana*, all of which serve as tinder and fuel woods. Plants recorded mostly from seeds from Border Cave include *Commiphora harveyi*, *Sideroxylon inerme* and *Ziziphus mucronata*, with possible medicinal uses. The use of plant poison has been recorded at Border Cave (Villa *et al*. 2012). Sibudu now has the most detailed and diverse plant record in southern Africa, largely because of this new and detailed study.

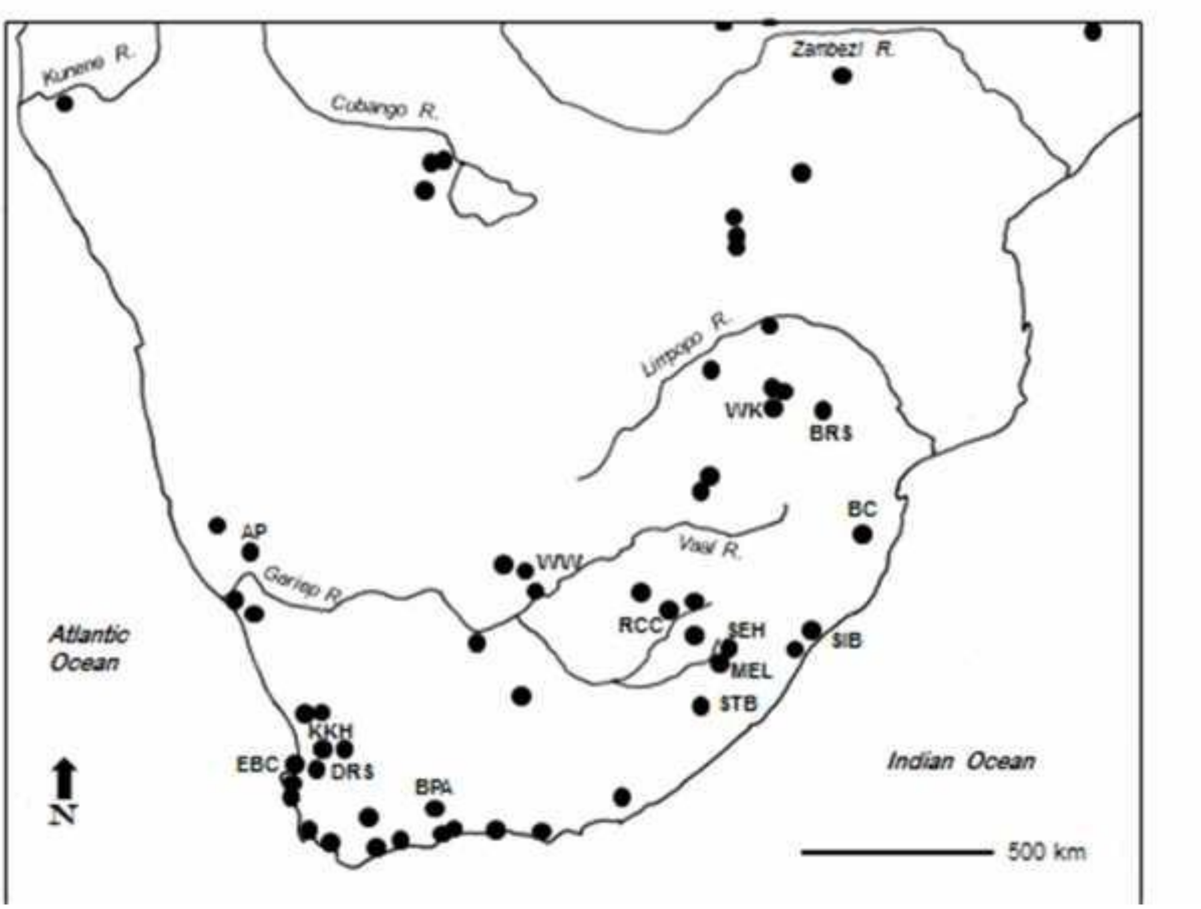

Figure 8.3: A selection of Southern African Middle Stone Age sites. The sites mentioned in the text are Apollo 11 AP, Border Cave BC, Boomplaas BPA, Bushman Rock Shelter BRS, Diepkloof Rock Shelter DRS, Elands Bay Cave EBC, Melikane MEL, Rose Cottage Cave RCC, Sehonghong SHE, Sibudu Cave SIB, Strathalan Cave STB, Wonderkrater WK and Wonderwerk W (after Wadley 2015).

Table 8.8: The plant taxa from BYA2(i), SPCA, MOD and Sibudu today which are also present amongst the identified seeds (s), charcoal (c), corms and other plant parts (l) from six southern African MSA sites which were reviewed by Wadley (2015).

Scientific name	***BYA2(I) (n=69)***	***SPCA (n=110)***	***MOD (n=60)***	***Sibudu charcoal***	***Sibudu seed***	***Melikane***	***Apollo 11***	***Strathalan Cave***	***Boomplaas***	***Diepkloof Rock Shelter***	***Elands Bay***	***Bushman Shelter***	***Border Cave***	***Recorded at Sibudu***
Acacia spp.	*	*	*	c	s		c							
Afrocarpus falcatus					s									
Afrocarpus/ Podocarpus	*	*		c								s		
Podocarpus elongatus										c	c			
Bridelia sp.				c									l	
Calodendrum capense	*	*		c	s									*
Canthium sp.					s									
Celtis africana	*	*	*							c	c	s		*
Celtis spp.				c										
Chionanthus foveolatus		*									c			
Volkameria glabra	*	*	*	c	s									*
Cliffortia repens	*									c				
Commiphora harveyi		*											s	*
Cordia caffra	*	*	*		s									
Cryptocarya sp.				c										
Cryptocarya woodii	*	*		l,c										*
Cunonia capensis	*			c						c				
Curtisia dentata	*	*		c										
Cussonia sp.					s									
Deinbollia sp.		*		c										
Diospyros sp.				c	s		c			c	c		s	
Erica caffra	*	*	*	c										
Erica magalies-montanum												s		
Erica sp.		*		c		c			c					
Euclea sp.					s					c				
Ficus spp.				c			c			c	c			
Grewia sp.					s	c	c				c			
Halleria lucida	*	*	*								c			
Harpephyllum caffrum	*	*	*		s									*
Kiggelaria africana			*							c	c			
Leucosidea sericea	*	*		c		c								

Scientific name	***BYA2(I) (n=69)***	***SPCA (n=110)***	***MOD (n=60)***	***Sibudu charcoal***	***Sibudu seed***	***Melikane***	***Apollo 11***	***Strathalan Cave***	***Boomplaas***	***Diepkloof Rock Shelter***	***Elands Bay***	***Bushman Shelter***	***Border Cave***	***Recorded at Sibudu***
Maytenus sp.						c			c		c	s		
Olea europaea ssp. africana	*	*	*			c				c	c	c		
Olea sp.					s									
Olinia ventosa		*								c				
Ozoroa sp.							c						c	
Pappea capensis	*	*	*	c	s									
Pavetta spp.					s									
Protea sp.	*					c			c	c				
Proteaceae				c										
Protorhus longifolia		*	*		s									
Ptaeroxylon obliquum	*	*	*	c										*
Rapanea melanophloeos	*	*		c	s		c			c				
Rhoicissus digitata					s									
Searsia sp.	*	*			s		c		c	c	c			*
Sideroxylon inerme		*		c	s								s	*
Spirostachys/Sapium type		*		c										
Syzygium sp.		*		c										
Tarchonanthu sparvicapitulatus		*					c		c					
Vangueria sp.												s		
Vitex sp.		*		c										
Ximenia sp.				c								c		
Ziziphus mucronata	*	*		c	s		c					s	s	

8.4.6 Summary

From BYA2(i) and SPCA, the evergreen forest contained a component of plants from the inland forests which no longer occur near Sibudu. From SPCA, savanna, open woodland occurs. From MOD, the *Bauhinia galpinii* and *Pterocarpus rotundifolius, Acacia* spp., and Mimosaceae, Caesalpiniaceae and Papilionaceae represent the dry bushveld. From BYA2(i), SPCA and MOD, mostly KZN Coastal and Scarp Forest, with some Northern Coastal Forest components occur.

From BYA2(i) the plants which suggest a change in environment are *Afrocarpus*/ *Podocarpus*, *Cliffortia repens* from the inland forest and *Acacia* spp., *Gardenia volkensii*, *Pappea capensis*, *Vitex rehmannii* and *Commiphora marlothii* from the savanna. These plants do not presently occur near the coast or in the area. Plants which suggest an anthropogenic disturbance are *Buxus macowanii* and *Cunonia capensis* from the evergreen forest and *Rothmannia capensis* from the plateau with bushveld type vegetation.

From SPCA the plants which suggest a change in the environment are similar in addition to *Olinia ventosa* (an evergreen from the Eastern Cape) and which occurs in the cool, moist South Western facing evergreen forest and riverine forest on the South facing slope. Charcoal of *Buxus* spp., *Erica* spp., *Leucosidea* spp. and *Morella* spp. with a vascular system of narrow, plentiful vessels to avoid airlocks in vessels caused by water scarcity implies a cool, dry, inland forest environment from SPCA. Additional savanna species occur, including *Burkea africana*, *Commiphora schimperi*, *Grewia bicolor, Grewia flava*, *Peltophorum africanum* in the dry, open plateau above the North facing slope. *Eugenia erythrophylla* open deciduous woodland on the North East facing slope and *Diospyros mespiliformis* in the riverine forest. Plants which suggest an anthropogenic disturbance are evergreen, riverine, woodland and bushveld vegetation including *Protea caffra* and *Protea roupelliae* representing KZN Coastal Forest, Scarp Forest and Northern Coastal Forest.

There is a loss of biodiversity (or usage of species, Appendix D) from SPCA, ~58 ka to MOD, ~49 ka, from inland forest or evergreen forest to savanna woodland at ~58 ka and savanna bushveld at ~49 ka, although the variety of woods could be affected by charcoal preservation.

CHAPTER 9
CONCLUSION

9.1 Introduction

The aim of the project was to examine and identify charcoal from Sibudu, concentrating on all hearths within three layers from the last Glacial, during OIS 3. The layers are BYA2(i) (early ~58 ka), SPCA (late ~58 ka) and MOD (approximately 49 ka)(Allott 2006; Jacobs et al. 2008 a, b; Wadley 2015: 165; Wadley and Jacobs 2006; Wadley *et al*. 2011).

Potential future work includes examining the wood burning properties of identified woods such as the energy content or calorific value. At present there is little literature about the density, ash content and elemental composition of indigenous woods, or on how hot the wood burns. However, by studying the pyrotechnology of hearths at Sibudu, including experimentally determining the wood burning properties associated with the hearths, Silje Bentsen has shown how hearth use differs (Bentsen 2012, 2013, 2014, 2015 *in press*) and by so doing, has discovered that people were using different types of fires in different parts of the shelter. Ideally, non-anthropogenic environmental records should be compared with the environmental record implied by the archaeological record. This should be done in future, but peat deposits of appropriate age have not yet been found in the area. It is therefore not yet possible to compare the human selection of wood with natural wood accumulations.

9.2 Woody taxa from charcoal in hearths

9.2.1 Anthracology

In all, 150 woody taxa have been identified from charcoal in hearths, 69 from BYA2(i), lower ~58 ka, 110 from SPCA, upper ~58 ka and 60 from MOD, ~49 ka, which are three occupational layers at Sibudu.

The anatomical differences distinguishing between similar *Spirostachys*, *Sclerocroton* and *Shirakiopsis* (*Sapium/Spirostachys* type), determine the presence of *Spirostachys africana* in one hearth on each layer. The vessel arrangement increases in width while decreasing in frequency from *Spirostachys*, *Sclerocroton* to *Shirakiopsis*, and prismatic crystals are present in *Spirostachys* ray cells, while silica bodies are present in *Sclerocroton* and *Shirakiopsis* ray cells.

Spirostachys africana was previously tentatively identified as *Sapium/Spirostachys* type in charcoal from the sediment in several layers at Sibudu (Allott 2005, 2006). The use of the noxious fumes of *Spirostachys africana* as evidence of the cognitive capacity of the people who lived at Sibudu has previously been described (Wadley 2013b). The charcoal of *Spirostachys africana* has been distinguished from the similar *Sclerocroton integerrimus* and *Shirakiopsis elliptica*. This is significant since *Sclerocroton integerrimus* and *Shirakiopsis elliptica* wood smoke is not poisonous.

The charcoal anatomy enables *Brachylaena discolor* to be distinguished from *Tarchonanthus parvicapitulatus* by means of vessel density, vessel diameter, ray width in cell number, rays tend to storied in *Brachylaena*, fibre wall thickness and vessel to fibre diameter ratio. In *Brachylaena discolor*, vessel density is low, 40-100/mm; vessel diameter is wide, 50 µm; ray width is wide, 1-3(-6) cells; rays tend to be storied; fibre walls are thick and vessel to fibre diameter ratio is more pronounced. In *Tarchonanthus parvicapitulatus*, vessel density is high, 100 vessels/mm; vessel diameter is narrow, $\leq$ 50 µm, ray width in cell number is narrow, 1-2 cells; rays do not tend to be storied, fibre walls are thin-thick, vessel to fibre ratio is more even. The identification of *Tarchonanthus parvicapitulatus* is significant because the leaves have insecticidal properties and because the aromatic wood may be burnt to produce camphor scented smoke.

9.2.2 Possible medicinal use of plants

In both layers from ~58 ka, approximately two fifths of the charcoal represents plants with medicinal and/or poisonous properties, with slightly less, one third, in MOD, from approximately 49ka. The identification of a few pieces of *Spirostachys africana* charcoal in restricted contexts, implies that this rather dangerous medicinal wood was selected on purpose, for its medicinal properties.

The potential wood uses in the bundles of wood in the hearths varies between hearths on each layer because, although there are some shared taxa, different taxa are often represented in the individual hearths. If the taxa in the hearths had all been the same, then it could be concluded that fire wood was collected indiscriminately from the evergreen forest nearby. However, since the charcoal in the hearths comprises a variety of species from several types of vegetation communities, the wood was probably collected from a wide home range, and may have been selected for its distinctive qualities.

9.2.3 Types of fire used in different parts of the shelter, determined by the burning properties of wood

In general, the proportions of fuel wood to medicinal wood vary between hearths on each layer, suggesting different types of fire in different parts of Sibudu. From ~58 ka, three fifths of the charcoal represents fuel wood from taxa presently considered good fuel including potential firesticks and from ~49 ka, two thirds represents fuel wood.

9.2.4 Activities around the hearth

In the oldest layer, BYA2(i), Hearth 1 is a complex combustion feature, with layers of burnt sedge bedding that alternate with ash layers that imply hearths. The abundant charcoal presence implies use as a hearth or series of hearths. Wood from *Spirostachys africana* was burnt there at some stage; this could not have been used for cooking and the wood may have been burnt for medicinal purposes, such as for the aromatic, insecticidal smoke from wood, bark or leaves. In BYA2(i), Hearth 1 has a balance of fuel and medicinal wood and there is mostly fuel wood in Hearth 2 and 3. The tinder wood in all strata, base, middle and top, indicate a succession of fires in Hearth 1. The charcoal analysis showed the succession of fires in Hearth 1 and Hearth 2. Activities may be most clearly linked to potential uses of the woody taxa identified in the wood bundles. The burnt bone may be the residue of food discarded into the fire.

The sedge bedding discovered, was found to have been burnt in ~58 ka layers (Sievers 2013; Wadley *et al*. 2011), probably to maintain the site, possibly making use of the noxious fumes of the *Spirostachys africana* to kill pests. The ash dump and ash heap represent scraped or swept out fires.

In SPCA, Hearth 3 is a fuel fire and Hearth 1 has the medicinal wood, including *Spirostachys africana* and *Tarchonanthus parvicapitulatus*. In MOD, the *Spirostachys africana* in Hearth 1 suggests the use of fire with aromatic smoke for repelling insects.

9.2.5 Comparing plant diversity

Afrocarpus/Podocarpus spp. are common in BYA2(i) and SPCA, in both the new study and in the previous anthracology study, previously *Afrocarpus/ Podocarpus* spp. and *Acacia* spp. were mutually exclusive. *Acacia* Types are prevalent in MOD in both studies.

In this new study, there is some *Acacia* spp. charcoal in the ~58 ka layers. This is a good fuel wood and fragments reflect presence or absence rather than frequency of species. In MOD, *Acacia* Type charcoal occurs in several hearths and one hearth is entirely fueled with this genus. This study seems to confirm that good fuel wood was being selected and used in all three layers and that the *Acacia* charcoal is most abundant in MOD, ~49 ka, where there is also greater species diversity than in the other layers studied.

The woody taxa identified from BYA2(i), SPCA and MOD are similar to the genera and families identified from the charcoal/seed record, but in this study the diversity of species has been increased. The two records complement each other because seeds are likely to have several agents of introduction, including birds, whereas charcoal has an anthropogenic agent of entry.

9.2.6 Vegetation succession

In BYA2(i), plants that at present grow in the inland forest, for example *Cliffortia repens* and *Leucosidea sericea*, no longer occur at Sibudu. Plants from savanna no longer occur, for example *Buxus macowanii* which occurs in the KZN Coastal Forest. In the early part of the ~58 ka occupation, climate was colder (in winter) and drier (in summer) than today. The inland forests seem to have grown closer to the rock shelter than today, where they are in the Drakensberg foothills, Southern Mistbelt and Northern Afromontane Forest. The plants could grow near the river on the South facing slopes, which is cooler, with less evapotranspiration. *Cunonia capensis* and *Cola natalensis* are unique to BYA2(i), *Protea roupelliae* and *Sideroxylon inerme* are unique to SPCA and *Cryptocarya wyliei* and *Hippobromus pauciflorus* are shared, inland forest were present at ~58 ka and savanna components have remained. Plants unique to MOD, from the 49 ka occupation are *Bridelia mollis* and *Bauhinia galpinii*, indicating a different environment associated with Sibudu.

Afrocarpus /*Podocarpus* and *Leucosidea sericea* occur in both BYA2(i) and SPCA, indicating a component of evergreen forest no longer there. *Leucosidea sericea* is a pioneer species of high altitudes and indicates cooler, moist conditions from the inland forest, does not grow near the coast today, but it can tolerate some frost and often grows near water, suggesting a climate near Sibudu different from today and demonstrating that the river flowed at the time.

In SPCA, woody taxa representing inland forest and some savanna occurred, perhaps implying the increase of savanna at the expense of forests when the climate warmed and rainfall increased. In MOD, dry bushveld species occurred, and these are no longer found near Sibudu. The climate warmed and rainfall increased, but it was nevertheless colder and drier than today.

The vegetation succession implied by the data presented here is similar to that from the charcoal study conducted by Allott. Trees and shrubs including *Afrocarpus*/*Podocarpus* and *Leucosidea sericea* from interior forests, with some savanna components, occur at ~58 ka, followed by bushveld components at 49 ka. It seems that savanna increased at the expense of forests, followed by bushveld. This supports a CA_{GIS} study of vegetation identified from charcoal and seeds at Sibudu, which showed that during this time the climate warmed during winter and rainfall increased during summer. This is also similar to a previous multiproxy environmental analysis, including archaeobotanical data, which suggested that the earlier evergreen forests were replaced by increasingly open woodlands, and later by bushveld.

9.3 Synopsis

The hypothesis here was that people living in Sibudu in the Middle Stone Age collected woods deliberately for specific tasks and that this would show in hearths with different taxa. In the light of the analysis of the charcoal from hearths on three occupation layers from Sibudu, the systematic and detailed consideration of each objective is summarised:

- 150 different taxa of trees and shrubs are represented in layers from ~58 ka and ~49 ka, and 1437 charcoal specimens were studied. At least 70 new taxa have been added to the previously identified charcoal assemblage. The trees and shrubs represent a high diversity, which is not surprising as Forest and Savanna Biomes are prevalent in the area and the KwaZulu-Natal Coastal Forest and Scarp Forest associated with Sibudu are taxa- rich. The Pondoland centre of endemism and the Scarp Forest which is characterized by endemic species in this region means that the biodiversity is to be expected. The physical situation of the site would have enabled access to various elements of the vegetation mosaic. Collecting on the hotter and drier slopes opposite the shelter may have been easier than negotiating the steep slopes surrounding Sibudu. It may have been unlikely that people would have restricted themselves to the south west facing cliff face.
- Sibudu now has the most detailed and diverse plant record in southern Africa, and this status is largely because of this new and detailed study.
- When compared to the charcoal and seed record, there are *Afrocarpus*/ *Podocarpus* spp. in older layers, from early and late ~58 ka and *Acacia* spp. from younger layer, ~49 ka, which may indicate a vegetation succession which demonstrates an increase of savanna at the expense of forest.This is more complex as *Leucosidea sericea* may also be pointing to plant succession.
- Many woody taxa are from medicinal plants, but it is not known whether people in the past would necessarily have exploited the medicinal uses of the plants. It is possible that those with medicinal wood, leaves or bark were burnt for their aromatic smoke. The most secure evidence of medicinal plant use is charcoal from the poisonous *Spirostachys africana* because this wood cannot be used for cooking.
- The fuel and medicinal properties of wood in hearths suggest uses of hearths on three Sibudu floors. The proportions of fuel to medicinal wood imply that one hearth in each of BYA2(i), SPCA and MOD layers was set aside for the use of medicinal wood. Clearly the interpretation must be cautiously made because it is not yet possible to test the hypothesis.
- Activities around the fires contains wood from medicinal plants including *Spirostachys africana* which suggest activities associated with the production of astringent smoke. In terms of collecting strategies, it

can be safely concluded that the wood species were collected purposefully. If all collections had been expediently made from nearby then there would be lower taxa diversity than has been recovered and there would not be spatial differences in the distribution of species. Wood collection at Sibudu was made intentionally with knowledge of the properties of the wood, and this is demonstrated by the combinations of taxa present in the charcoal assemblage of each combustion feature. Although wood that presently is considered good fuel is frequently represented in Sibudu, the collection and use of tamboti is particularly convincing evidence that medicinal woods were also used.

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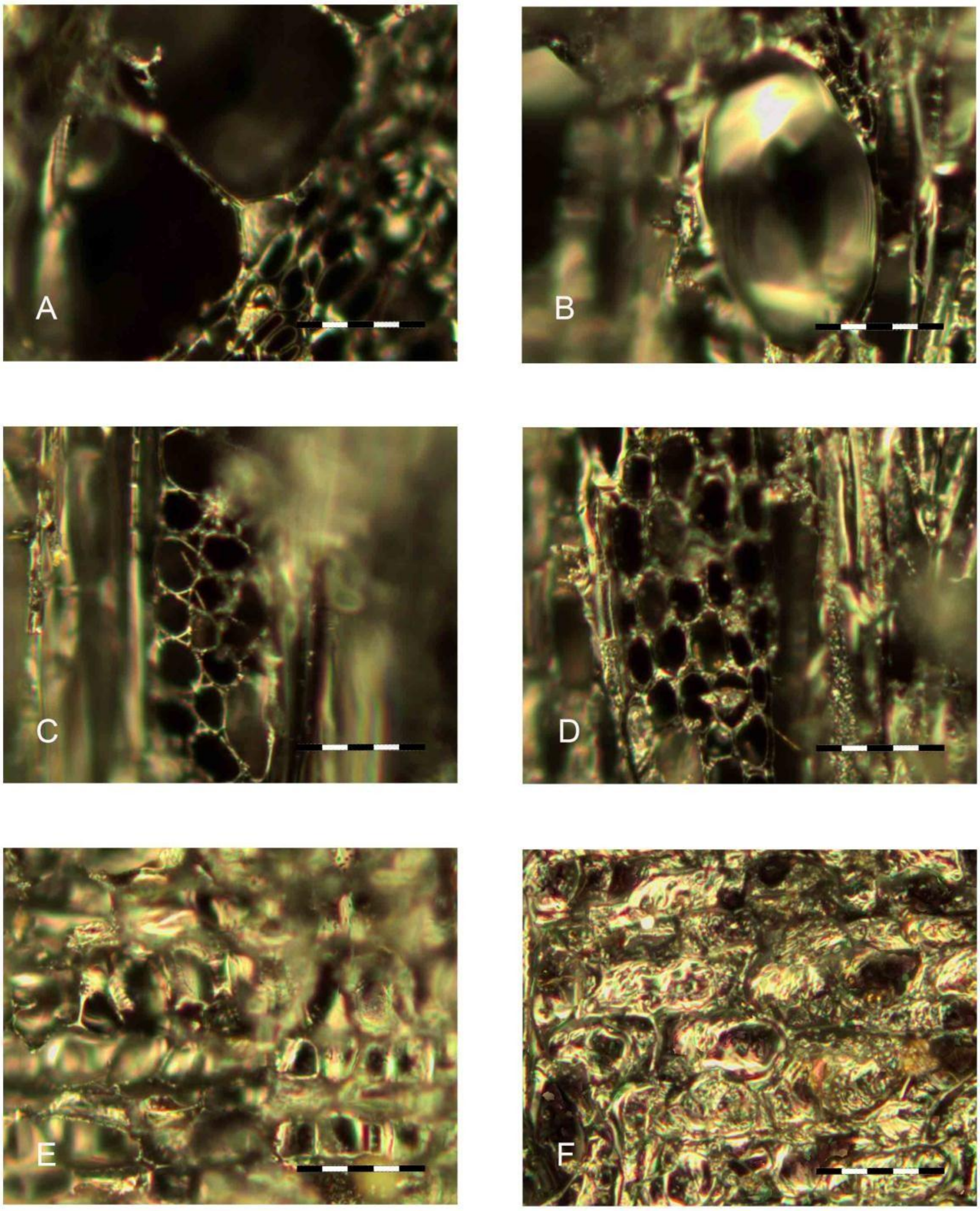
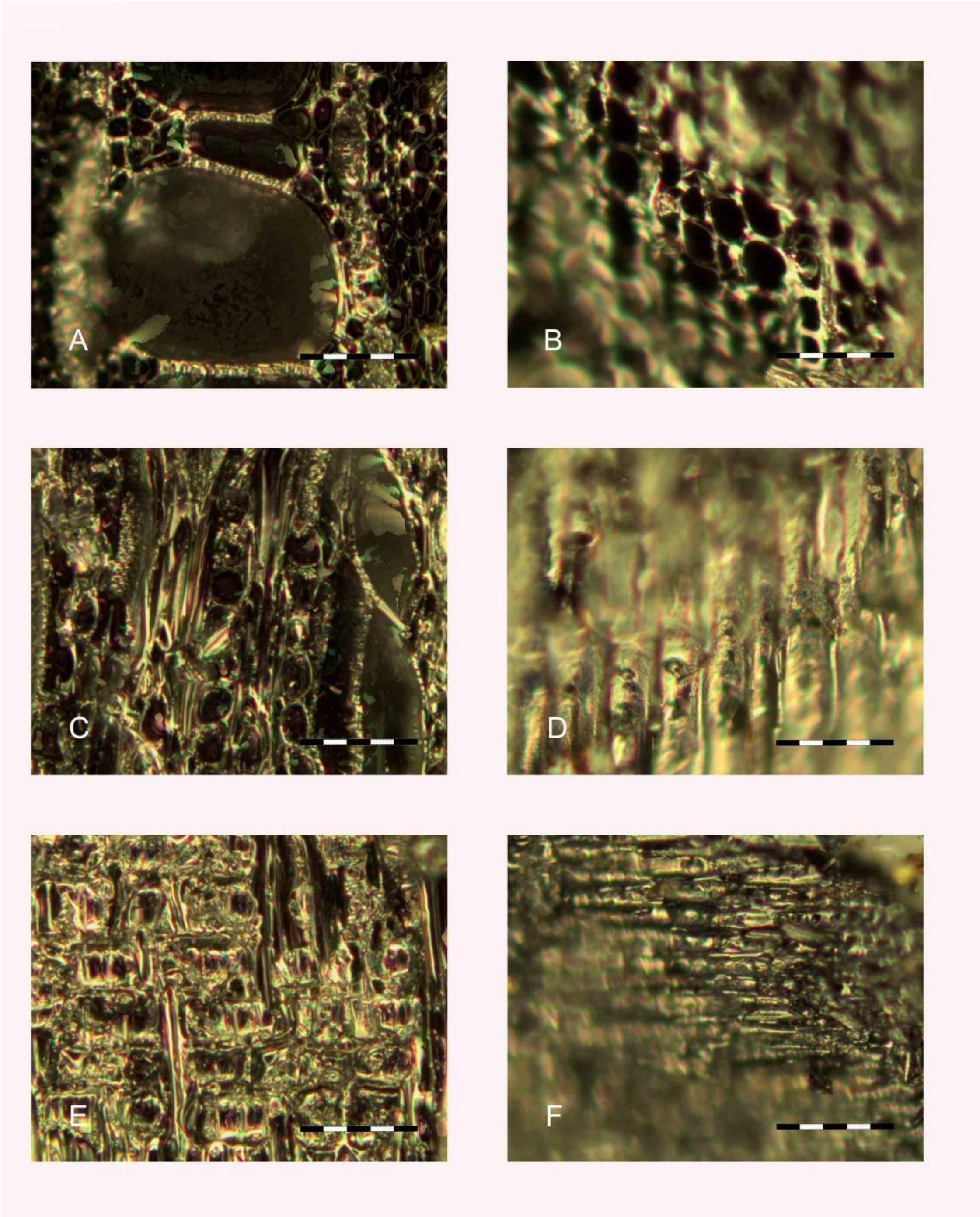
APPENDICES

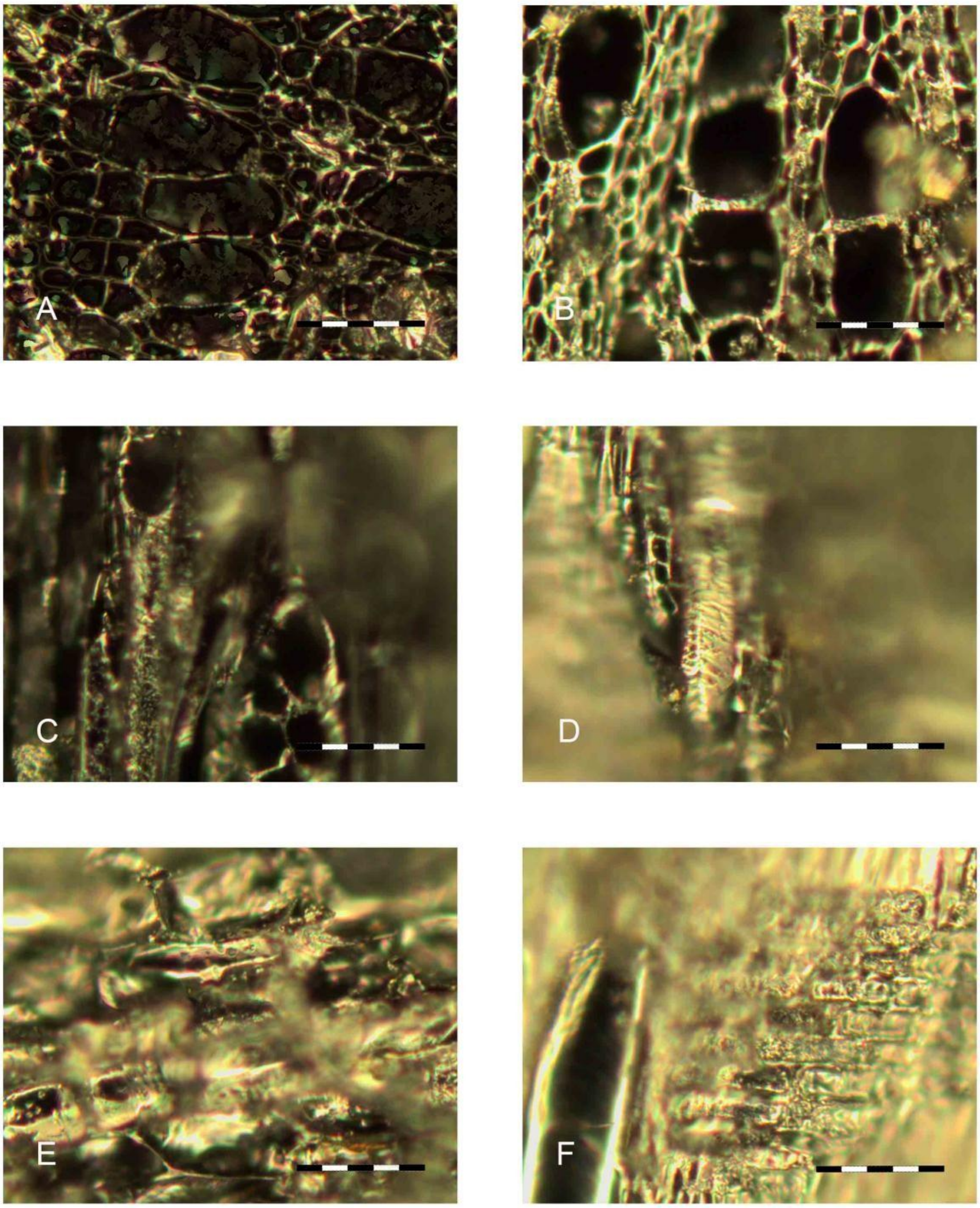
Appendix A



Appendix A.1: *Cryptocarya wyliei* SPCA B4c 15 (SJL 63), left column: A TS, vessels are arranged in long radial lines of four or more with a diameter of 80 µm and a density of 20-40/mm^2. Parenchyma is diffuse or scanty; C. TLS, rays are 4-12 cells wide with a density of 4-12/mm; E. TRS, ray cell arrangement is heterocellular, procumbent and square. *Commiphora marlothii* SPCA C4d 17 (Allott 33), right column: vessels are arranged in long radial multiples with a variation of clusters, vessels have a diameter of 50 µm and density of 100/mm^2. Parenchyma is vasicentric; B. TLS, ray canals are present; D. rays are 1-4(5) cells wide with 4-12 rays/mm; F. TRS, ray cell arrangement is heterocellular, procumbent and upright. The scale bar is 50 µm.



Appendix A.2: *Hippobromus pauciflorus* BYA2i B4d 33 (Allott 149), left column: A, TS vessels are arranged in long, radial multiples with a diameter of 100 µm and density of 50/mm^2. Parenchyma is vasicentric; C. TLS, rays are 1-2 cells wide, with 12 rays/mm; E, rays are procumbent. *Afrocarpus/ Podocarpus* sp. (Kromhout 1975): B, TS, tracheids are 40-50 µm in diameter; D, the tracheids have round to oval pits in the radial walls; F, the rays are 6/mm with procumbent cells and cross-field pits are bordered with a vertical aperture. The scale bar is 50 µm.



Appendix A.3: *Protea roupelliae* SPCA C6b 02 (SJL 18; Allott 116), left column: A, TS vessels are arranged in short radial lines, vessel diameter is 50 µm, density is 100/mm^2; C. TLS, rays are uniseriate, 4-10 cells wide and ten or more cells wide; 4-10/mm, occasionally rays are more than a mm high; E, rays are heterocellular, procumbent and square. *Ptaeroxylon obliquum* SPCA C4b 45 (Allott 118), right column: B, TS, vessels are arranged in long radial lines, vessel diameter is 50 µm and vessel density is 40-100/mm^2. Parenchyma is absent or rare; D TLS, rays are uniseriate and 12/mm^2 F. TRS, rays are homocellular, procumbent. The scale bar is 50 µm**.**

Appendix B

Summary of anatomical features of the archaeological charcoal in BYA2i and comparable modern woods from a selection of examples.

Plant species	Charcoal specimen	Vessel distribution: tangential, radial or dendritic; solitary (S.), short (1-3 cells) long (≥4 cells) or clusters (cl.); twinned (Tw.)	Vessel diameter (µm)	Vessel density (.mm^{-2})	Parenchyma apotracheal: r. or a. (r/a), diffuse (d.), diffuse-in-aggregate (d-i-a), bands (1-3 = 1-3 cells wide)	Parenchyma paratracheal: scanty, vasicentric (vasi.), aliform (ali.) confluent (confl.)	Ray width (cell number)	Ray frequency, height, storied or tending to (storied), aggregate	Ray type and cells: heterocellular (he), homocellular (ho); body cells: pro. (p.), upr. (u.), sq. (s);	Ray marginal cells: 1 or 2-4 rows	Anatomical note: growth rings, vessel deposits, mineral inclusions, fibres, tracheids
Allophylus dregeanus	SJL 79	solitary, lon radials	< 50	20-40		scanty	1	4-12 (7)	pro.		
	C4d 39	short radials	20	100	d	scanty	1		pro., sq		
Brachylaena discolor	SJL 56	short radials	< 50	40-100		vasi.	1-3	4-12	pro.,	upr., sq.	
	Allott 26	short radials, , long radials	50-100	40-100		vasi. (v) confl.	1-2-3	4-12	pro.		
	B4a 68	long radials	50	50	a/r	Vasi.	1(-3)		pro.		
	B4a 52	short radials (Tw)	50	100	d/d-i-a	scanty	1-2		pro, sq		
	B4a 87	long radials	50	50	a/r	Vasi.	1-3(-5)	12	pro		
Buxus macawanii	IND1293	short radials, (v) tangential bands	≤50	> 100	d		1-3	11	pro.,	sq	
	B4a 108	S	40	80	a/r	scanty	1	12	pro		
Buxus macowanii cf. .	C4a 12	S	20	100		scanty	1, 1-2	9	pro (short), sq		

	C4a 14	S	20	200	d	scanty	1-2	6	pro,	sq	
	C4a 49	S	20	>100	d	scanty	1	5	pro (short)		
	C4a 56	S	20	>200	d	scanty	1	7	pro, sq		
	C4b 37	S	20	100	d/d-i-a	scanty	1-2	5	pro, sq		
Calodendrum capense	Allott 143	long radials, clusters, tangential bands, diagonal and/or radial pattern, dendritic pattern.	50- 100	40-100	(v) b ~4 cells, marginal	vasi., ali./ conf.	2-5(-6)	4-12			
	IND1279	S, short radials, tangential bands	50-100	> 100		scanty	4-10	4-12	pro.		
	Metcalfe and Chalk 1950; Miller 2007	short radials (1-5), (v) clusters	50-100		d, (v) marginal bands	vasi. (v) ali./confl.	4-10	4-12	pro.	1 / 2-4 rows upr./sq	
	C4d 16	long radials	50	80	b ≥ 4c, 2/mm	confl.	1-4-6	8	pro		
Canthium mundianum	Allott 127	solitary, short radials	50- 100	40 - 100			1-4(-5)	4-12; >1000	pro. upr.		
	C4d 67	S	50	50	d	scanty	1-3(-5)	6, 1000	pro, upr, sq		
	B4a 23 (1)	S	20	50	d/d-i-a	scanty	1-5	5			
	B4a 51	S	20	50	d/d-i-a	scanty	1-5	5			
	B4a 147	S	50	50	a/r	scanty	2-5	12	pro		
	B4d 24	long radials	50	80	a/r	scanty	1-3	7	pro, upr		
Canthium spinosum	Allott 128	S	< 50	40 - 100	a/r	scanty	1-2	(v) > 1000	pro., upr.		
	B4a 37	short radials	50	10	d/d-i-a	scanty	1-3	5	sq, pro		
	C4d 58	long radials	50	150	d/d-i-a	scanty	1-5	6			

Canthium suberosum	Allott 129	S, short radials	< 50	40 - 100	d		1-2	> 12, > 1000			
	C4b 54	S	50	100	d	scanty	1-2		pro, sq		
	C4b 55	S	20	100	d	scanty	1-2	12	pro,	sq	
Celtis africana	SJL 48	S, short radials, (v) long radials	50-100	40-100		vasi.	1-3	10	pro., upr., sq.	upr.	
	Allott 169	clusters	50-100	40-100	b 1-4 c., < 6/mm	vasi. ali./ confl.	1-3(-5)	> 12			
	Détienne (undated b), Metcalfe and Chalk (1950).	solitary, tangential bands	50-100, 100-200	5-20	bands, marginal	vasi. (v) ali. (lozeng)/ confl.	4-10	4-12, (v) > 1000	pro.,	1/ 2-4 rows upr/sq.	
Celtis africana cf.	B4a 105	S (v) short radials	'100	20	b >4 c., 3/mm		1-3	12	pro		
	B4a 107	S (v) short radials	'100	20	b >4 c., 3/mm		1-3	12	pro		
	B4d 40	S	80	20	b(2-4c), 2/mm		1-5	8	pro,		
Volkameria glabra	Allott 173		< 50	> 40	a./r		1-4(-5)	4-12	sq. / upr.		
	B4a 10	short radials	20	60	d-i-a(lines)	scanty	1-5	6	pro, upr		
	C4c 32	short radials (Tw)	50	100	d	vasi.	1-5	6	pro (thin)		
	B4b 108	S	20	80	d	scanty	1-4-6	6	sq, upr		
Cliffortia repens	Allott 124	S	< 50	> 40	a./r.		1-2	4-12	pro, upr		
	B4a 03	S	20	50	d	scanty	1(-2)	5	pro, upr		
	B4a 05	S	20	50	d	scanty	1(-2)	5	pro, upr		

Cola natalensis	Allott 161	short, or long radials, (v) clusters	< 50	40-100	b > 4 c., 6/mm	vasi.	4-10	4-12	pro, sq.		
	IND1121 (616)		100-200	40-100	b > 3 c. , 4/mm scalarifom		4-10	4-12	pro.	upr.	
Cola natalensis cf.	B4a 101	short radials (v) tangential	< 50	> 40	b 4 cells, 2/mm		1-4	12, < 1000	sq		
	B4a 102	rm>4/ cl.	20	100	b 4 cells, 2/mm	scanty	1-4	12, < 1000	sq		
Commiphora marlothii	Allott 33	solitary, short radial multiples	50- 100	40-100		vasi.	1-4(-5)	4-12, < 1000	pro., upr.		
Commiphora marlothii cf.	B4a 19	short radials, (v) cl.	50	50	d-i-a	vasi.	1-3	6	pro.		
	B4a 50	short radials, (v) cl.	50	100	d/d-i-a	vasi	1-2	4	pro		
Cordia caffra	SJL 53	solitary, (v) cl.	50-100	40-100	b 1-3 c., 7/mm		1-3	4-12	pro., upr., sq.		
	IND1285(399)	short radials, (v) cl.	< 50	20-40	b. >3 cells, 3/mm		1=(2-5)	4-12 (5)	pro., upr., sq.		
	Allott 31		50-100	5-20	b. >4 c., < 6/mm		2-5(-6)	4-12	pro, , upr.		
	Gottwald, 1983	S., long radials	100-200, ≥ 200	5-20			4-10	4, > 1000	pro.,	1 row upr./ sq.	
Cordia caffra cf.	B4b 82	short radials	50	80	b 4-10 cells, 3/mm	scanty	1-3	12	pro, sq		
Croton sylvaticus	Allott 63	short radials, long radials	50-100	≥ 40	d; (v) b 1c, 6/mm	scanty	1-2	4-12	pro,	4 upr.	

Croton sylvaticus cf.	C4b 45	short radials (Tw)	50	40		scanty	1-2	6	pro,	4 upr	
	C4d 08	short radials (Tw)	50	80	d	scanty, vasi.	1-2-3	5	pro, upr		
Cryptocarya liebertiana	Allott 80	S. angular outline	< 50	> 40	a./r.	scanty	1-5	12	pro.,	upr	
Cryptocarya liebertiana cf.	C4b 07	long radials	80	30		scanty	1-3-5	5	pro, sq,		
	C4b 06	long radials	80	30		scanty	1-5	5	pro, sq,		
	C4c 16	long radials	80	100	d	scanty	1-5	8	pro.	sq./ upr.	
	C4b 62	short radials, (v) cl.	50	35		Vasi.	1-5	5	pro, sq		
Cryptocarya woodii	SJL 50	long radials, (v) tangential	< 50	40-100			1-4	4-12, < 1000	upr.		
	Allott 81	long radials	< 50	> 40		scanty	1-3(-5) 1=3	12	pro, sq, upr		
	B4a 92	long radials	<50	>40	a/r	scanty	1-3-5	12	pro, sq		
Cryptocarya wyliei	SJL 63	S., angular outline	≤50	40-100	d/ d-i-a		1-4	4-12, < 1000	pro. square		
	B4a 109	long radials	80	80	d/d-i-a	scanty	1-3-5	12	pro, sq		
Cunonia capensis	IND1297	S.	< 50	> 100	d	scanty	1-2	4	pro.,	sq.	
	C4d 68	S.	50	100	d	scanty	1	6	pro,	sq.	
	C4d 74	S.	50	100	d	scanty	1		sq, upr		
	C4d 71	lrm	50	150	d/d-i-a	scanty	1-2	6	pro,	sq., upr.	
Curtisia dentata	Allott 47	S., with angular outline	40-100	40 - 100	a./r		1-5(-6)	> 12			
	B4a 24.1	long radials	50	80	d	scanty	1-2	5	pro, sq.		
	B4a 24	short radials	50	80	d	scanty	1-3	4	pro.	upr.	

	B4a 26	short radials	80	50	d	scanty	1-5	5	pro, sq.		
	B4a 27	long radials	50	80	D	scanty	1-5	4	pro, sq, upr		
Diospyros austro-africana	Allott 48	short, or long radials, radial or oblique	< 50	40-100	a	scanty	1	> 12, < 1000	sq., up		
	B4a 100	long radials,(v)cl	20	100	a/r	scanty	1-2	12	pro, sq, upr		
	B4a 35	long radials, (v) cl	50-100	10	d/d-i-a	scanty	1	12	pro, sq		
	B4a 36	long radials, (v) cl.	50-100	10	d/d-i-a	scanty	1-2	12	pro, sq		
Dombeya rotundifolia	Allott 162	short radials, (v) S	50-100	40-100		scanty	1-3-5	4-12	sq./ upr.		
	B4a 28	short radials	50	60	d	scanty	1-3	7	pro,	sq.	
Dovyalis rhamnoides	Allott 72	short radilas	<50	>40	a./r/,	vasi., (v) ali. / confl.	1	>12			
	C4d 25	S	20	80	d/d-i-a		1	5	upr, sq		
Dovyalis rhamnoides cf.	C4d 32	S	20	200	d	scanty	1	1000	upr, sq		
Ekebergia capensis	Allott 39	short radials, long radials, (v) clusters	<50	>40		vasi.	1-2	4-12	pro., sq		
	B4a 30	long radials	50	40	d	vasi. /ali.	1-3	6	pro, sq.		
	B4a 45	long radials	80	60	d/d-i-a	Vasi.	1-3	10	pro, sq		

Erica caffra	Allott 55	S	< 50	> 40			2-4-6		pro.	sq.	
	B4a 43	S	20	100	r/a	scanty	2-4	12	sq,upr		
Erica caffra cf.	C4b 13	S	20	200	d	scanty	1-3-5	4	sq		
Faurea saligna	Allott 114	S, (v) short or long radials	< 100	> 40		scanty, ali./confl.	1, ≥ 10	4-12, > 1000	pro.		
Faurea saligna cf.	B4d 26	S	10	20	a/r	scanty	≥ 10	2	pro (long, thin)		
Faurea saligna cf.	B4d 35	S	20	5			≥ 10	5	pro, sq, upr		
Ficus lutea	Allott 96	short radials (2-4)	100	5- 20	b 4 c., > 6/mm	scanty	4-10	< 1000			
	Détienne, undated, a.		100 - 200	< 5	b > 3 c		4-10	4-12	pro.	1/ 2-4 rows upr. / sq.	
	B4b 70	S	50	100	b 2-4c, 3/mm		1-3	6	pro		
	B4b 76	S	80	25	b 2-4 c., 3/mm	scanty	1-3	6	pro		
Gardenia volkensii	Allott 131	S	< 50	40-100	a./r.		1-2	4-12	pro., upr.		
	B4a 32	S	20	100	d/d-i-a	scanty	1-3	5	pro, sq.		
Gardenia volkensii cf.	C4c 19	S	20	80	d	scanty	1-2	5	pro (short)		
Halleria lucida	Allott 158	short, (v) long radials	< 50	40-100	a./r	d	3-6	4-12	sq., upr.		
	B4a 08	long radials, (v) cl.	50	100	d-i-a (lines along ray)		1-4	7			

Halleria lucida cf.	C4a 09	short radials	50	30	a/r	scanty	1-3	3	upr, sq		
	B4a 07	short radials, (v) cl.	50	100	d-i-a(lines along ray)	scanty	1-4	7, > 1000	upr(sq)		
Harpephyllum caffrum	Allott 2	long radials, (v) Tw., (v)cl., 2-4(-4+)	50-100	40-100	a./r	scanty	1-2	4-12; >1000	pro. , sq.	1 upr.	
	IND 1170	S.	50-100	20-40, 40-100 (20-50)		scanty	4-10	4-12	sq.,	upr.	
	B4d 05	long radials	20	80	a/r	scanty	1-3	6	pro,	sq.	
	B4d 07	long radials	20	80	a/r	scanty	1-3	6	pro.	sq.	
Harpephyllum caffrum cf.	C4b 66	long radials	50	150	d	scanty	1-2	10	pro,	upr.	
Hippobromus pauciflorus	Allott 149	short radials, long radials	<50	>40	a./r	scanty	1-2	12	pro		
Hippobromus pauciflorus cf.	B4d 01	long radials	30	>100	a/r	scanty	1;1-2	7	pro		
	B4d 03	long radials	30	>100	a/r	scanty	1-3	5	pro		
	C4a 01	long radials	50	≥100	d/d-i-a	scanty	1-2	?	pro (long, thin)		
	C4a 39	S	20	80	d	scanty	1-2	6	pro, sq		
	C4b 67	short radials	20	100	d	scanty	1-2	12	pro,	1 row sq./ upr.	

Leucosidea sericea	Allott 125	S., short radials, (v)cl.	< 50	> 40	a./r		2-6	4-12			
	B4b 43	S	20	100	a/r	scanty	1-2	12	pro		
	C4b 60	S	20	100	d	scanty	1-2	6	pro, sq		
Fabaceae Caesalpiniodeae	Metcalfe & Chalk (1950)	(v) tangential, S.			(v) b.2-4c.	confl.,ali., vasi.	1-7(-12): 1-3, (v) 2-5, (v) storied	2-3	ho./he., (v)thin		gum, fibres septate, canals, (v) vessel spirals,
Fabaceae Papilionoideae	Metcalfe & Chalk (1950)	tangential	-	-	(rare) b. 1-2c.	(v)vasi./ali	1-3, (v) 2-5	-	he., (v) ho., (v)thin		vessel spirals, ring porous, (v) gum
Fabaceae Mimosoideae	Metcalfe & Chalk (1950)	-	-	-	b. 2-4c	confl.,ali., vasi.	2-5, (v) storied	-	ho.(thin)		fibres septate, (v) gum
Fabaceae Mimosoideae *Acacia* spp.	*Type 1* (B4a 42, B4a	S	30	40	d/d-i-a	scanty.	1	12	pro (thin)		
	Type 3 (B4d 23, B4a 21, B4a 39)	short radials, (v) S	50-100	20	a/r or b 2-4c.,3/mm		1-5	5	pro, (thin)		
	Type 4 (B4b 31,B4b 32)	S	50-100	< 50	a/r	vasi.	4-10	4-12	pro (thin)		
Mimusops obovata	Allott 154	short radials, tending to dendritic pattern	< 100	< 50 (40)	b 1-4 c, 6/mm		1-2	12, > 1000			
	IND1272		50	< 50 (20-40)	bands, irregular				pro. sq.,	sq.	

Mimusops obovata cf.	C4b 87	short radials, (v) Tw,	80	35	b 2-4c, 5/mm		1(-2)	6	upr, sq		
	C4b 86	long radials,	50	80	b. 2-4c, 5/mm		1	6	pro, upr		
Morella pilulifera	Allott 102		< 50	40-100	r/a		1-3(-5)	4-12	sq. / upr.		
	B4a 14	short radials	20	80	d/d-i-a	scanty	1	4-12	pro (short) , sq		
Mystroxylon aethiopicum	Allott 39	S, angular outline	< 50	40-100	b > 4 c, > 6/mm		1-2-3	> 12			
Mystroxylon aethiopicum	Detienne unpublished	short radials , long radials, radial or oblique lines	< 50, 50 - 100	> 100	b ≥ 3 c.		1-3	≥ 12	pro.,	2-4; ≥ 4 rows upr. /sq.	
Mystroxylon aethiopicum	B4a 04	S	20	≥100	B 2-4c, 4/mm		1	12	pro, upr		
	B4a 124	S	20	50	b 4-10c, 3/mm			10	pro, sq		
Nuxia floribunda	IND1265	long radials	50-100 (80)	40-100 (48)		scanty, vasi.	1-3		pro., 2 rows	2 rows sq.	
Ochna serrulata	InsideWood (anon)	short radials diffuse	100 - 200	20 - 40		vasi.		4-12, >	pro. ,	4 upr./ sq.	
	B4a 01	short radials (cl)	80	50	d	scanty	1-3	7	pro,	upr.	
	Allott 179,		≤ 50	40-100	d	scanty	1(-2)				
	IND 1063		≤ 50	≥ 100	d	scanty	1(-2)	4-12 (12)	pro. sq.		
Ochna sp.	C4a 58	short radials	50	20	d	confl.	1-2	ns	(short) pro		
Olea europaea ssp. *africana*	Allott 108	short radials, (v)oblique	< 50	40-100		vasi.	1-2 (1 = 2)	> 12	pro.		
	C4d 07	cl., long radials	50	100		vasi.	(1)-2 = 3	4-12	pro,	upr.	

	B4a 40	S	30-50	80	a/r	scanty	1=2	7	Pro. ,	4 rows upr/ sq	
Pappea capensis	Allott 150		< 50	40-100	a/r	scanty	1	> 12	pro.		
	Klaassen 1999		50-100	40-100		scanty, vasi.	1-3	>12	pro.	1 row upr./ sq.	
	B4a 38	long radials, (v) cl.	30-80	50	d/d-i-a	scanty	1-2	12	pro,	1row upr.	
Pappea capensis cf.	C4a 13	long radials	50	23	d		1	5	pro (short)		
Pavetta eylesii	Allott 134	short radials, radial/oblique, (v) cl.	< 50	40 - 100	d		1-2	12, < 1000	pro., sq., upr.		
	B4a 41	long radials	30-50	80	a/r	vasi	1-3	15	pro	1 row upr.	
Pittosporum viridiflorum	Allott 113	S, (v) cl.	<50	40-100	a/r		4-10				
	B4c 01	S	50	100	d/d-i-a	scanty	1-4		sq.	upr.	
Pittosporum viridiflorum cf.	C4a 25	S	20	100	d	vasi	1-3	7	pro		
Podocarpus falcatus	SJL 52; Kromhout 143; Bamford and Stevenson 2002	tracheids: pits round – oval, in radial walls;	40-50		a	a	1	6	pro.; cross-field pits: bordered, vertical		
Podocarpus sp.	C4c 25	o	o	o	o	o	o	o	o		
Protea caffra	Allott 115		< 50	> 40		vasi. ali. / confl.	1, 4-10, > 10	4, (v) > 1000	(v) pro. sq.		
Protea caffra cf.	C4a 30	S	20	50	d	scanty	2-4, >10	3	pro, sq		
	C4d 05	S	20-50	20	d	vasi.	1, 4-10, > 10	5	pro		

Psydrax obovata	SJL57	long radials, (v) oblique	≤ 50	40 - 100	d, d-i-a	scanty vasi.	1-2	4-12	pro. upr., sq.	sq.	Fibres thick. Pith outline rectangular .
	IND 1255	S	≤50	> 100	d	-	1-3	> 12	sq.,		
	Pearson and Brown 1932; Sosef et al. 1998.	S, short radials, (v) clusters	50-100	40-100, (v) 20-40			1-3	4-12, > 1000	pro.	1, 2-4, (v) >4	
Psydrax obovata cf.	B4d 32	long radials	50	80	a/r	scanty	1-2	9	pro	sq.	
	B4d 24	long radials	50	80	a/r	scanty	1-3	7, >1mm	pro,	upr	
Ptaeroxylon obliquum	Allott 118	long radials, solitary vessel outline angular	< 50	40-100	a./r.		1	> 12	pro. (short)		Rays (v) storied. Growth rings distinct: fibres.
	Metcalfe and Chalk 1950		≤ 50, 50-100	40-100, > 100	a./r.		1		pro.		Ray cells perforated, prismatic crystals
	B4b 107	long radials	50	80	a/r	scanty	1	12	pro, sq		
Ptaeroxylon obliquum cf.	C4b 17	long radials	40	150	d	scanty	1	4-12 (5)	sq.		
Rapanea melanophloeos	Détienne undated b	Solitary, (v) twin, short radials	< 50, 50-100	20-40	a./r.	scanty	4-10, ≥ 10	≤ 4, > 1000	pro., sq., upr.		
	IND1224	solitary, short radials	> 200	5-20		vasi.	> 10	≤ 4, > 1000	pro.		

Rapanea melanophloeos cf.	C4d 41	short radials (Tw)	50	80	d	scanty	1-3	5	sq		
Rhamnus prinoides	Allott 120	solitary, radial or oblique lines	< 50	> 40		vasi.	1-2	> 12, > 1000	sq./ upr.		
	B4b 29	long radials	50	200	d/d-i-a	scanty	1;1-3	8	pro, sq., upr.		
Rothmannia capensis	Allott 137		< 50	> 40		vasi.	1-2	12	sq.	upr.	
Rothmannia capensis cf.	C4d 46	S	20	80	d/d-i-a	scanty	1(-2)	10	sq		
	C4d 50	long radials	20	80	d/d-i-a	scanty	1(-2)		sq		
Sclerocroton integerrimus	Lennox and Bamford 2015		50-100-200	5-20	d-i-a	absent	1	12	pro. upr., sq.		
	C4a 61	short radials	50	40	d		1	12	pro, sq	(v) sq.	
	C4b 91	short radials (Tw)	60	40	d/ d-i-a		1	12	pro, upr, sq		
	C4b 93	short radials	60	40	d/ d-i-a		1(-2)	12	pro, upr, sq		
	C4d 72	short radials (Tw)	20-50	100			1(-2)		sq, upr		
	C4d 76	short radials (Tw)	30-50	80	d	scanty	1(-2)		sq,upr,		
Sclerocroton integerrimus cf.	C4d 70	short radials	80	50	d		1(-2)	12	pro, sq/ upr		
Searsia chirindensis	Allott 7	short radials	50-100	40-100		vasi.	1-2	>12, >1000			
	B4b 69	long radials	50	100	a/r	vasi	1-2	12	upr, sq		
	B4b 74	long radials	50	100	a/r	vasi	1-2	12	upr, sq		
Searsia dentata	Allott 8		< 50	40-100		scanty	1-2	> 12	upr., sq.		

Searsia dentata cf.	C4b 77	short radials	50	100	d	scanty/ vasi.	1-2	6	pro, sq		
	C4b 83	short radials	50	100	d	scanty/ vasi.	1-2	6	pro, sq		
Searsia leptodictya	Allott 13	short radials, (v) clusters	< 50	40-100	b 2-4 c, < 6/mm		1-2	> 12	upr., sq.		
	B4a 29	S	50	20	b 2-4c, 5/mm		1-2	6, > 1000	pro., upr., sq.		
Searsia leptodictya cf.	C4d 33	short radials	50	80	d	vasi.	1(-2)	6	pro., upr., sq.		
	B4d 25	short radials	50	20	b 2-4 c, 3/mm	scanty	1-5	12	pro (short)		
Shirakiopsis elliptica	Lennox and Bamford 2015	short radials	100-200 ≥ 200	≤ 10	d	absent	1(-2)	12	pro., sq., upr		
Shirakiopsis elliptica cf.	C4d 62	short radials (Tw)	50	80	d/ d-i-a	scanty	1	12	upr, pro		
	C4d 64	short radials (Tw)	40	80	d		1-2	12	pro	4 rows upr	
Spirostachys africana	Lennox and Bamford 2015	long radials	50-100	20-40-100	d-i-a	absent	1	4-12	mixed		
	C4d 66	long radials	40	100	d		1	12	pro.		
	C4d 77	long radials	30-50	80	d	scanty	1(-2)	12	pro		
	C4d 15	long radials (Tw)	20	100	d/ d-i-a		1(2)	12	mixed (mostly pro.,(v) upr./sq.		
Spirostachys africana cf.	C4a 57	long radials	30	100	d	scanty	1	ns	pro (short), sq		

Tabernaemontana ventricosa	Allott 22	(v) S, short radials, long radials	<50	>40	d-i-a		1-2	4-12	pro, upr		
Tabernaemontana ventricosa cf.	B4b 26	S	20	100	d/d-i-a	scanty	1-2	12	pro	4 rows upr	
Trema orientalis	Allott 172	S, short radials	variable	40-100		vasi.	1-2	> 12, > 1000			
	IND1305	S, angular outline	50-100	5-20	-	vasi.	1-3	10	pro.	upr.	
Trema orientalis cf.	C4a 29	short radials (Tw)	20	80	d	scanty	1-2	5	pro., upr., sq. -u-s		
	C4a 47	long radials	50	80	d	scanty	1-2	5	pro, upr		
	C4b 41	long radials	50	40			1-2	5	Sq ,upr		
Vangueria cyanescens	SJL 36	S	≤ 50	40-100		scanty, vasi.	1-3	4-12	pro., upr., sq.	upr.	
Vangueria madagascarensis cf.	B4d 38	S	20	150	a/r		1	8	pro (short)		
	B4c 05	S					1;1-2		pro, sq		
Vangueria randii ssp. *chartacea*	Allott 142		< 50	40 - 100	d	vasi.	1-2		sq., upr.		
Vangueria randii	B4b 27	S	20	150	d/d-i-a	scanty	1-2	8	sq, pro		
	B4c 04	S	50	100	d/d-i-a	scanty	1-2	6	pro, sq		
Vitex rehmannii	SJL 30		50-100	40-100		scanty, (v) vasi.	1	4-12	pro. , upr., sq.		
Vitex rehmannii	Allott 176	S, short radials	<100	>40	(v) d	scanty, vasi	2-6		pro, upr		
Ximenia caffra	Allott 105	S	<50	>40	a./r.		1-5	4-12	pro, upr.		

	C4b 43	S	50	80	d	scanty	1-3	5	sq, pro		
Ximenia caffra cf.	B4b 33	long radials	50	100		vasi. /ali.	1		sq		
Ziziphus mucronata	Allott 121	short radials, (v) long radials	<100	>40		vasi. (v), ali./ confl.	1	12	sq.		
	B4b 34	long radials	<100	>40		vasi.	1	12	sq		

Appendix C:

Summary of anatomical features of the archaeological charcoal and comparable modern woods of a selection of trees identified in SPCA.

Plant species	Charcoal specimen	Vessel distribution: tangential, radial or dendritic; solitary (S.), short (1-3 cells), long (≥4 cells) or clusters (cl.); twinned (Tw.)	Vessel diameter (µm)	Vessel density (.mm^{-2})	Parenchyma apotracheal: r. or a. (r/a), diffuse (d.), diffuse-in-aggregate (d-i-a), bands (1-3 = 1-3 cells wide)	Parenchyma paratracheal: scanty, vasicentric (vasi.), aliform (ali.) confluent (confl.)	Ray width	Ray frequency, height, storied or tend to (storied), aggregate	Ray type and cells: heterocellular (he), homocellular (ho), body cells: pro. (p.), upr. (u.), sq. (s)	Ray marginal cells: 1 or 2-4 rows	Anatomical note: growth rings, vessel deposits, mineral inclusions, fibres, tracheids
Brachylaena discolor	SJL 56	short radials	<50	40-100		vasi.	1-3	12, (storied)	pro.	upr./sq.	
	Allott 26	long/short radials	50-100	40-100		vasi., (v) confl.	1-2-3	12	pro.		
	B4c 11	long radials	<50	20-40	d.	scanty/vasi.	1-2	4-12, (storied)	pro.	upr.	
	B4c 18	long radials, (v) cl.	<50	20-40	d.	scanty	1-4	4-12, (storied)	pro.	upr.	
	B4c 32	long radials	<50	40-100		scanty/vasi.	1-4	4-12, (storied)	pro.		
Calodendrum capense	IND1279	short radials (1-5), (v) cl.	50-100	> 100		scanty	4-10	4-12	pro.		
	Allott 143	short radials/ tangential	50-100	40-100	(v) b. 4c	vasi., ali./confl.	2-5(-6)	4-12	weakly homocellular		
	B4b 58	short radials (Tw)	<50	40-100	a./r.	ali.-winged/confl.	4-10	4-12	pro./sq.		
	D5a 23	short radials (cl)	50	40-100	b. 4-6c.,		1-3	4-12	pro.	sq.	
	D6a 30	short radials (cl)	50	100	b. > 4c.,		1-3-5	4-12	pro.	upr.	

Canthium mundianum	Allott 127	long radials	50-100	40 - 100			1-4(-5)	>1000	pro.,upr.		
	C4c 15	long radials, (v) Tw.	50-100	40-100	d./d-i-a	vasi.	1;1-3	4-12, >1000	upr.,sq.		
	D5a 40	long radials	<50	>100	d./d-i-a	scanty	1-3	4-12, >1000	pro.,sq.		
Canthium spinosum	Allott 128	S., short radials	<50	40 - 100	a. /r.	scanty	1-2	(v) > 1000; aggregate	pro.,upr.		
	C4d 24	short radials	<50	100	d./d-i-a	scanty	1-2	12, >1000	upr.,sq.		
Celtis africana	SJL 48	long radials, (v) cl. , (v) S.	50-100	40-100		vasi.	1-3	10	pro.,upr.,sq.	upr.	
	Allott 169	S., short, (v) long	50-100	40-100	b. 1-4 c., <	vasi., ali./confl.	1-3(-5)	>12	heterocellular		
	Détienne undated b; Metcalfe and Chalk 1950.	cl.	50-100, 100-200	5-20	b.	vasi., (v) ali., lozenge-ali., confl.	4-10	4-12, (v) >1000	pro.	1/2-4 upr./sq.	
	C4b 24	long radials	50	> 100	d./d-i-a	vasi.	1-2	4-12	pro.,(v)upr.		
Chionanthus foveolatus	Allott 107	long radials, (v) clusters	<50	>40	b.1c	scanty	1-2	12, storied	he		
	C4d 21	long radials,	50	40-100	d./d-i-a	scanty!	1	12, storied	upr.	sq.	
	C6b 05	long radials, cl.	<50	100	d-i-a	vasi.	1		pro.	2 upr.	
Volkameria glabra	Allott 173	short radials	< 50	> 40	a./r		1-4(-5)	4-12	sq./upr		
	D5b 07	short radials	100	20-40	d./d-i-a	scanty	1-4	4-12	pro.,sq.,upr.		
	D6a 21	short radials	50	> 40	d.	scanty	1-4-6	4	sq.,pro.	4 upr.	

Commiphora africana	Détienne, undated a		50 -100, 100 - 200	5-20, 20-40	a./r.	scanty	1-3,4-10	4-12	pro.	1 upr./sq.	
Commiphora harveyi	SJL 73	S., (v) Tw., long radials, (v) cl.	50-100	20-40			1-3	4-12	sq.,(v)pro./upr.		
	Allott 32	S., (v) short radials	50- 100	40-100	a./r.		1-2	4-12, > 1000			
	D5b 09	short radials	<50	40-100	a./r.	vasi.	1	4-12	pro.,upr.,sq.		
Commiphora marlothii	Allott 33	S., short radials	50- 100	40-100		vasi.	1-4(-5)		pro.,upr.		canals
	D4b 07-D4b 20		50-100	<50 (20)	a./r.	scanty/vasi.	1-3		pro,upr		canals
	C4d 18	short radials	100	< 50 (20)	a./r.	scanty	1-3	4-12	pro.	2 upr.	
	C4d 17	short radials	50-100	< 50 (9)	a./r.	scanty	1-4	4-12	pro.	2 sq.	
	C4d 20	short radials	50-100	> 20	a./r.	scanty	1-4	4-12	pro.	2 upr.	
	C4d 27	short radials	50-100	20-40 (25)	a./r.	scanty	1-4	4-12	pro./sq.	upr.	
Commiphora schimperi	Allott 34	S., short radials	< 50	40-100	b. > 4 c., < 6/mm		1	4-12, >12	pro.,upr.		
	D6a 01	short radials	<50	20	a./r.	scanty	1	4-12	pro.,sq.	upr.	
Commiphora woodii	Allott 35	short radials	<50	40-100	a./r.	ali./confl.	1-2	4-12, storied.	pro.,upr.		
Cordia caffra	SJL 53	short radials, (v) cl.	50-100	40-100	b. 1-3 c., 7/mm		1-3	4-12, (storied)	pro.,sq.,upr.		
	IND1285	S., long radials	< 50	20-40	b. > 3 c., 3/mm		1=(2-5)	4-12	pro.,sq.,upr.		
	Allott 31	S., (v) short radials, tangential	50-100	5-20	b. > 4 c., < 6/mm		2-5(-6)	4-12, (storied)	pro.,upr.		
	Gottwald, 1983		100-200, > 200	5-20			4-10	4, >1000	pro.	1 upr./ sq.	
	D6c 09	S, (v) short radials	20	100	b. > 4 c., < 6/mm	vasi.	1-2	4-12	pro.,upr.		

Cordia spp.	Metcalfe and Chalk 1950	S., (v) cl.	>200	< 5	d., b.	ali., confl.	< 10	< 4, >1000, storied.	pro.,upr.		
Cryptocarya latifolia	SJL 60	short radials	<50	40-100			1-3	4-12	pro.,(v)upr.	(v)sq./upr..	
Cryptocarya liebertiana	Allott 80	long radials	<50	> 40	a./r.	scanty	1-5	12, storied	pro.	upr.	
	B4b 63	long radials	50	40	d./d-i-a	scanty	1-5	4-12	pro.	upr.	
Cryptocarya myrtifolia	Detienne undated a	S., angular outline	100-200	5-20	b.	scanty, vasi.	4-10	4-12	pro.	1 upr./sq.	
Cryptocarya transvaalensis	IND1289	short radials	50-100	20-40		scanty, vasi.	4-10		pro.,(v)sq.		
Cryptocarya woodii	SJL 50	short radials	< 50	40-100			1-4	4-12	upr.		
	Allott 81	long radials	< 50	> 40		scanty	1-3(-5)	12			
Cryptocarya woodii cf.	D5c 13	short radials	<50	40-100	d./d-i-a	scanty	1-4	4-12	pro.	upr.	
	D5c 05	long radials	<50	40-100	d./d-i-a	scanty	1-5	4-12	pro.	sq.	
	D5d 02	long radials	50	40-100	d./d-i-a	scanty	1-5	4-12	pro.,sq.		
Cryptocarya wyliei	SJL 63	long radials	≤50	40-100			1-4	4-12	pro.,sq.		
	B4c 15	long radials, (v) cl.	50-100	20-40	d.	scanty	1-3,4-10	4-12	pro.,(v)sq.		
	B4c 40	long radials	50-100	40-100	a./r.	scanty	1-5	4-12	pro.	sq.	
Curtisia dentata	Allott 47	S., (v) short radials	40-100	40 - 100	a./r.		1-5(-6)	>12	heterocellular		
	B4c 22	short radials	<50	40-100	d.	scanty	2-4	4	pro.	upr.	
Cussonia arborea	De Villiers et al. 2012; Détienne undated a; InsideWood	cl., (v) tangential	50-100, 100-200	5-20	a./r.	scanty	4 -10	4, >1000	pro.	1 upr. / sq.	

Cussonia paniculata	Allott 23	short radials	<50	40-100		scanty	1		pro.,upr.,sq.		
	B4b 29	short radials	50-100	5-20 (8)	d./d-i-a	scanty	1		sq.	1 upr.	
	B4c 26	short radials, (v) dendritic	50	40-100 (70)	a./r.	scanty	1	4-12	upr.,sq.		
	B4d 01	short radials	50-100	40	a./r.	scanty/vasi.	1	4-12	sq.		
	C4b 04	short radials	50	5-20	a./r.	scanty	1	12	pro.,sq.		
	C4b 05	short radials	50	5-20 (15)	a./r.	scanty	1(-2)		pro.(short)		
	C4b 18	short radials	50-100	5-20 (15)	a./r.	scanty	1	4-12	pro.(short)		
	C4b 27	short radials	50	20	d./d-i-a	scanty	1		sq.,upr.		
	C4bd 06	cl., (v) long radials	<50	20	a./r.	scanty	1	4-12	pro.(short)		
	C6a 05	long radials, (v) dendritic	<50	> 100	d./d-i-a	scanty	1(-2)	4-12	pro.,upr.,sq.		
Cussonia spicata	IND1194	S., short radials	50-100	40-100			4-10, storied	13	pro.	upr.	
	C6b 08	S.	<50	40-100 (80)	d./d-i-a	scanty	4-10	4-12	pro.	1 sq., 1 upr.	
Cussonia zuluensis	Allott 24	short radials, long radials, (v) cl.	<50	40-100			1-3(-5)	4-12	pro.,upr.,sq.		
Cussonia zuluensis cf	B4b 42	short radials, (v) long radials	50-100	< 40 (30)	a./r.	scanty/vasi.	1-3	4-	pro.(short)	upr.	
Diospyros abyssinica	Western, undated; Détienne undated a;	long radials	<50, 50-100	20 - 40, 40 - 100	d., d-i-a, b. < 3 c.	(v) scanty	1	12, (storied)	pro.	1 / 2-4 upr./sq.	

Diospyros austro-africana	Allott 48	S., short radials	< 50	40-100	a.	scanty	1	>12	sq./upr.		
	D6a 20	short radials	50	100	d.	scanty	1	4-12	sq.,pro. (short)		
Diospyros lycioides	Allott 49	short/long radials	< 50	40-100		scanty	1	>12	upr.		
	D5d 18	long radials	< 50	> 100	d./d-i-a	scanty	1	storied	upr.		
Diospyros mespiliformis	IND1288		50-100	20-40	a.	scanty/vasi.	1-3	>12	pro.,upr.,sq.		
	Kribs 1968; Lens 2005	long radials	50-100, 100-200	< 5	d-i-a, b. < 3 c., (v) reticulate	scanty	1-3	12	pro.,upr.,sq.		
	B4c 16	long radials, (v) cl.	50-100	> 120	d.	scanty	1	12	sq.		
	C4d 01	short radials	50-100	20-40	a./r.	vasi.	1	10	sq./upr.		
Diospyros natalensis	SJL82	S., short radials	<50	20-40	a.	vasi., confl.	1	7	pro.,upr.,sq.	upr.	
	Allott 50	short/long radials	<50	40-100	b. 2 c., < 6/mm	vasi.	1-2	>12			
	D6a 08	long radials	20	100	d.	scanty	1(-2)	4-12	sq.	upr.	
Diospyros whyteana	Allott 52	long radials	<100	20-40		scanty	4-10				
Dombeya rotundifolia	Allott 162	S., short radials	50-100	40-100		scanty	1-3-5		sq./upr.		
	B4b 18	short radials, (v) long radials	50	20-40	a./r.	scanty	1-3(4)	4-12	sq.,upr.		
Ekebergia capensis	IND 1306	short radials	<50	>40		vasi.	1-2	4-12	pro./sq.		tylose
	Allott 89	short radials	<50	>40		vasi.	1-2	4-12	pro/sq.		tylose
	D5a 33	long radials	50-100	20-40		vasi.	1-3-5	4-12	pro./sq.		
	B4c 05	long radials	50	40-100	a.	vasi.	1-3	4-12	pro.,upr.,sq.		
Erica caffra	Allott 55	S.	<50	> 40			2-4-6		pro.	sq.	
	C4b 34	S.	<50	40-100	d./d-i-a	scanty	5	4-12	pro., sq.		
	D5c 24	S.	<50	40-100	d./d-i-a	scanty	1-5	4-12	pro.,sq.,upr.		

	D6a 03	S.	<50	40-100	d./d-i-a	scanty	1-4	4-12	pro.,sq.		
Erica drakensbergensis	Allott 56	S.	<50	> 40	a./r.		2-6	4-12	pro.	2-4 upr.	
Erica melanthera	InsideWood 2004 onwards	S., (v) angular outline	50-100	< 40 (20 - 40)	d.		4-10, 2 sizes	12	pro.	> 4 upr./sq.	
Ericaceae	Metcalfe and Chalk 1950	S.	<50	numero us	a./r.		3-10,(1)		heterocellular		
Euclea crispa	SJL 29	short radials 1-4 (-10)	≤50	5-20		scanty	1	>12	pro.	1-2 upr./sq.	
	IND 1166	S., long radials (1)-8	50-100	20-40	d.,/d-i-a				sq.,(v)upr.		
	Allott 55	S., long radials	< 50	40-100, >100		scanty	1, 4-10	12	sq./upr.		
	Lens 2005	long radials	50-100	5-20	d.,/d-i-a	scanty	1-3	>12	pro.	>4 ,	
	C4d 05	long radials	50	40	d./d-i-a	vasi.	1-2	4-12	pro.	sq.	
Eugenia erythrophylla	SJL 85	cl.	<50	20-40	b. 1c.		1-3	4-12, >	he		
	C4b 12	cl., (v) long radials	<50	20-40	a./r.	ali./confl.	1-3	4-12	pro.,sq.		
Fabaceae Caesalpiniodeae	Metcalfe and Chalk 1950	(v) tangential, S.			(v)b.2-4c.	confl.,ali., vasi.	1-7(-12): 1-3, (v) 2-5, (v) storied	2-3	ho./ he., (v)thin		gum, fibres septate, canals, (v) vessel spirals,
Burkea africana cf.	Allott 185										
	B4a 21, 22	short radials	50	20	-	confl.	3-4-6	4-12	pro		
Peltophorum africanum cf.	Allott 186										
	C4a 14	short radials	50-100	40-100	-	ali.confl.	1	4-12	pro, sq, upr		

Fabaceae Papilionoideae	Metcalfe and Chalk 1950	tangential	-	-	(rare) b.1-2c.	(v)vasi./ali..	1-3, (v) 2-5	-	he., (v) ho., (v)thin		vessel spirals, ring porous, (v) gum
Fabaceae Mimosoideae	Metcalfe and Chalk 1950	-	-	-	b.2-4c	confl.,ali., vasi.	2-5, (v) storied	-	ho.(thin)		fibres septat e, (v) gum
Acacia spp.	Type 1 Type 3 Type 4 Type 5	-	<50, 50-100 or >100	<5, 5-20 or 20-40	a/r or b.	vasi. or ali.confl.	1-2, 1-5, 4-10, >10	-	pro (thin)		
Faurea saligna	Allott 114	S., tangential	<100	> 40		scanty, ali./ confl.	1, > 10	4-12, >1000	pro.		
	D5a 30	S.	50-100	5-20	d./d-i-a	scanty	4-10(8), > 10	1-3, >1000	pro.(short)		
	D5a 35	S.	<50	20-40	d./d-i-a	scanty	1,4-10	4, >1000	pro.		
	D5a 44	S.	<50	100	d./d-i-a	scanty	4-10	4, >1000	pro.		
	D5d 29	S.	<50	40-100	d./d-i-a	scanty	1,>10	4-12, >1000	upr.		
Ficus burkei	Allott 94	S., (v) short/ long	50 -100	5- 20	b. > 4c., < 6/mm		1-4(-5)	4-12, >1000, storie	pro.,sq.		
	B4b 28	short radials, (v) cl.	<50, 50-100	5	b. > 4 c.		1-3	4-12, > 1000	sq.,	4 upr.	
	B4b 54	short radials	100-200	5-20	b. 2-4 c., 3/mm		1-3	4-12, > 1000		upr.	
	C4c 09	short radials, (v) cl.	50	40-100	d./d-i-a	confl.	1,1-3	4-12, > 1000	pro.,upr.,sq.		
	D5a 34	short radials	100	20-40	b. > 4 c., 6/mm		1-5	4-12	pro.	sq.	

Ficus burkei syn. thonningii	Allott 101	short, (v) long radials	50-100	20-40	b. > 4 c., 6/mm	a.	1-2	4-12	sq., upr.		
Ficus ingens	Allott 95	S.	50 -100	5- 20	b. > 4 c.	scanty	1-3(-5)	12, (v)>1000			
	Détienne undated b		100-200	< 5, 5 - 20	b. > 3 c.		4-10	4-12	pro.	1 upr./sq.	
	C6a 03	short radial	50-100	20	b. 2-4 c., 4/mm		1-2	4-12, >1000	pro.	1 upr.	
	B4a 04	S., (v) Tw.	50	5-20	b. > 4 c., 2/mm		1-4	4-12	pro.(short)	upr./sq.	
Ficus lutea	Allott 96	short radials	100	5-20	b.4c., 6/mm	scanty	4-10	4-12			
	Détienne undated a		100-200	< 5	b. > 3 c.		4-10	4-12	pro.	1/2-4 upr./sq.	
	B4b 51	cl., (v) short radials	50-100	20-40	b. 2-4 c., 3/mm		4-10	4-12	pro.	upr.	
Ficus natalensis	Allott 97	S., long radials	50-100	20-40	b. > 4 c., > 6/mm		1-2				
Ficus polita	Allott 98	Short radials, radial	50- 100	5- 20	b.		4-12	4-12			
Ficus salicifolia	Allott 99	long radials	100-200	40-100		vasi., ali./confl.					
Ficus sur (=capensis)	IND1235	S., short radials	>200	> 100			4-10	≤ 4	pro.,sq.	upr.	
	Allott 100	short radials	100	20	b. > 4 c., < 6/mm	vasi.	1-3(-5)	4-12			
	B4b 10	cl., (v) short	50	20-40	b. > 4 c., 4/mm		1-2	4-12	pro,(short)		
	B4b 13	short radials, (v) cl.	100-200	5-20	b. > 4 c., 5/mm		4-10	4-12	pro., sq., upr.. Tile cells: durio-type	.	
Gardenia ternifolia var. *goetzei*	Détienne undated b	S.	<50	20-40	a./r., d.		1-3,4-10	>12	pro.	2-4 / > 4 upr./sq.	
Gardenia volkensii	Allott 131	S., tangential	<50	40-100	a./r.		1-2	4-12	pro.,upr.		
	C4 01	S.	50	20	d./d-i-a	scanty	1-2		pro.,upr.,sq.		
	C4a 08	S.	<50	>100	a./r.	scanty	1-2(1)	4-12	pro.,(short),		

	C4a 12	S.	<50	100	a./r.	scanty	1(-2)	4-12	pro., sq.		
	C4d 08	S.	<50	40-100	d./d-i-a	scanty	1-4	4	sq., pro.		
Grewia bicolor	Allott 164	S,(v) short radials	100	>40	diffuse	vasi.	2-6	12	pro, upr.		
	D5a 03	short radial	50-100	20	d./d-i-a	scanty	1-4	4-12	pro., sq.		
	D5b 12	long radials, (v) Tw.	50	40-100	a./r.	vasi.	1-3	4-12	pro., sq.		
	D5c 50	long radials	50	100	a./r.	vasi.	1-2	4-12	pro., sq.		
Grewia flava	SJL 23	short radials, (v) S,	40	100	diffuse	scanty	1-5	12	pro., upr.		
	D5a 05	long radials, (v) cl.	50-100	40	d-i-a	ali./confl.	1-3	4-12	pro./sq. (v) Tile cells, as high or higher than pro. cells		
Grewia lasiocarpa	SJL 80	S., (v) Tw., short radials	<50	5-20			1-3,1 = 2		sq.		
Grewia monticola	SJL 34	short radials, (v) cl.	50-100	40-100		vasi.	1-3	4-12	pro.,upr.		
Harpephyllum caffrum	IND 1170	long radials, (v) Tw., (v) cl.	50-100	20-40, 40-100		scanty	4-10	4-12	sq.	upr.	
	Allott 2	short, (v) long radials	50-100	40-100	a./r.	scanty	1-2	4-12, 1000	pro.,sq.	1 upr.	
	Terrazas 1994	S.	50-100	5-20, 20-40		scanty	4-10		pro.	1/2-4 upr. / sq.	
Harpephyllum caffrum cf	B4a 19	long radials	50	40-100	a./r.	scanty, (v) vasi.	1-3	4-12	pro.	upr.	
	B4b 43	long radials	<50	40-100	d.	scanty	1-2	4-12, >1000	sq.	upr.	

Heteropixidaceae	Metcalfe and Chalk 1950	< 50, 50-100	5,20			scanty, vasi., ali., confl.	1,2-3		hetero- / homocellular		
Heteropyxis natalensis	Allott 76	long/short radials	50	40-100		scanty	1-2		pro.,sq.,upr.		
	SJL 32	long radials, (v) cl.	50-100	> 100	a.	scanty	1-3	4-12	pro., sq.,upr.		
	D5a 11	long radials	50	> 150	a. /r.	scanty	1-2	4-12	pro., sq.		
Hippobromus pauciformis	Allott 149	short/ long radials	50	40	a/r	vasi.		12	Pro.		
	C4a 18	short radials, (v) Tw.	50-100	20-40	a. /r.	vasi., (v) ali. or confl.	1,1-2	4-12	pro.(short)		
	B4a 07	long radials	50-100	40-100	a./r.	scanty/ vasi.	1-2	4-12	pro.(short)	upr.	
Leucosidea sericea	Allott 125	S.	< 50	> 40	a./r.		2-6	4-12	pro., sq.		
	D5d 26	S.	<50	> 100	d./d-i-a	scanty	1-5	4	pro., sq.		
	D6a 02	S.	50	>100	d./d-i-a	scanty	1-6	4	pro.,sq.		
Maytenus albata	Allott 37	short, (v) long radials, reticulate, (v) cl.	< 50	40-100	a./r.		1-2	>12	pro./sq.,upr.		
	D6a 28	long radials	20	100	d.	scanty	1-3	4	pro.	upr.	
Maytenus peduncularis	D5a 18	S.	<50	> 100	b. 4 c., 8/mm		1	12	pro.	2 upr.	
Maytenus peduncularis cf.	B4b 59	S.	<50	>150	b. 2-4 c., 3/mm		1-3	> 12		upr., sq.	
Morella californica	Wheeler 2003	S.	< 50, 50 - 100	40 - 100, > 100	d.		1-3	4-12	pro.	$\geq$ 4 upr./sq.	
Morella pilulifera	Allott 102	S., short radials	< 50	40-100	r./a.		1-3(-5)	4-12	sq./upr.		
	D6b 03	short radials	50	> 100	d./d-i-a	scanty	1-4	4-12	pro., sq.		
	D6c 04	short radials	<50	> 100	d./d-i-a	scanty	1-2	1-3	pro., upr., sq.		
Mystroxylon aethiopicum	Allott 39	S.	<50	40-100	b. > 4 c., > 6/mm		1-2-3	>12	pro.,	2-4 upr./sq.	
	D5a 31	S.	50	100	b. 5 c., 6/mm		1-2	12	pro.,	upr.	

	D5d 11	S.	<50	> 100	b. 4-10 c., 6/mm		1(-3)	4-12	pro., upr., sq.		
Mystroxylon aethiopicum ssp. *aethiopicum*	Détienne undated a	S., angular outline	<50, 40 - 100	> 100	b. > 3 c.		1-3	>12	pro.	2-4/ $\geq$ 4 upr./sq.	
Nuxia floribunda	IND 1265	long radials	50-100	40-100	d//d.i.a	scanty	1-5	4-12	pro., sq.		
	C4c 11	long radials	50-100	60	d./d-i-a	vasi.	1-4	4-12	pro., sq., upr.		
	D5b 16	long radials	50-100	25	d./d-i-a	scanty	1-5	4-12	pro., sq.		
Ochna serrulata	IND 1063		<50	> 100	d.	scanty	1(-2)	4-12	pro., sq.		
	Allott 179	long radials	<50	40-100	d.	scanty	1(-2)				
	B4c 01	short radials, (v) Tw.	<50	40-100	a./r.	scanty/vasi.	1-2	4-12	pro., (short)		
Olea europaea ssp. *africana*	Allott 108	short radials, radial	<50	40-100		vasi.	1-2(1 = 2)	>12	pro.		
	B4b 57	short radials, (v) Tw.	<50	40-100	d./d-i-a	scanty	1-2,1=2	4-12, >1000	pro.	upr.	
	D6a 10	long radials	20	100	d.	scanty	1-2	12	pro.	sq./upr.	
	D6a 19	long radials	20	100	d.	vasi.	1-2 (-3)	4-12	pro.	sq /upr.	
Olea woodiana	Allott 109	short/long radials, (v) cl.	<50	40-100	a.	scanty	1-4 (-5)	12, >1000	pro.	4 upr.	
Pappea capensis	Allott 150	short/long radials, radial	<50	40-100	a./r.	scanty	1	>12	pro.		
	Klaassen 1999		50-100	40-100		scanty, vasi.	1-3	>12	pro.	(v) 1 upr./sq.	
	B4a 20	long radials	50	40-100	a./r.	scanty/vasi.	1	12	pro.	upr.	
	C4b 44	short radials	50	40-100	a./r.	vasi.	1	4-12	pro.	upr.	
Parinari cf. *curatellifolia*	Detienne undated a	S.	200	5	b. < 3 c., 3/mm		1	12	upr.,sq.		
Parinari cf. *curatellifolia*	B4b 49	S.	50	5-20	d.		1	4-12	pro.	upr.	

Parinari cf. *curatellifolia*	D6b 06	S.	50	20	b. < 3 c., 3/mm	scanty	1	4-12	pro.		
Podocarpus sp.	SJL 52; Kromhout 143; Bamford and Stevenson 2002	tracheids: pits round – oval, in radial walls;	40-50		a.	a.	1	6	pro.; cross-field pits: bordered, vertical aperture		
	C4b 01	tracheids; pits round: radial walls	a.	a.	a.	a.	1	4-12	pro.; cross-field pits: bordered, vertical aperture		
	D5a 26	tracheids; pits round: radial walls	a.	a.	a.	a.	1	4-12	pro.; cross-field pits: bordered, vertical aperture		
Protea caffra	Allott 115	S., tangential, (v) cl.	<50	> 40		vasi., ali./ confl.	1, 4-10, >10	4,(v) >1000	(v) pro., sq.		
	C4b 47	S.	50	20	d-i-a	ali./confl.	1-5	4-12, >1000	pro.,upr.,sq.		
Protea roupelliae	Allott 116 SJL 18	S., short radials, tangential	≤50	40-100		vasi., ali./ confl.	1, 4-10, >10	4-12, >1000	pro./sq.		
	C6b 02	long radials, cl.	50	100	b. 2-4 c., 6/mm		(1-2), >10	4-12, >1000	pro./sq.		
Protea welwitschii	Allott 117	S., short radials, tangential	<50	40-100	a./r.		1, >10	4-12, >1000	pro./sq.		
	SJL 46	S., short radials	≤ 50	> 100	a.	vasi.	>10	4-12	pro.,upr.,sq.	pro.	
Ptaeroxylon obliquum	Allott 118	Long radials, radial	<50	40-100	a./r.		1	>12	pro.,short cells		
	Metcalfe and Chalk 1950	Long radials, S., vessel outline angular	<50, 50-100	40-100, >100	a./r.		1		pro.		

	C4b 45	long radials	50	> 100	a./r.	vasi.	1	>12	pro.		
	D5a 09	long radials	50-100	> 100	d./d-i-a	scanty	1	4-12	pro.,sq.		
	D5c 37	long radials, (v) Tw.	50	40-100	d./d-i-a	scanty	1	4-12	pro.,sq.		
Rapanea melanophloeos	IND1224	S., (v) Tw., short radials	>200	5-20		vasi.	>10	≤4, >1000	pro.		
	Détienne undated b	cl., S., angular outline	<50, 50-100	20-40	a./r.	scanty	4-10, >10	<4, >1000	pro.,sq.,upr.		plates simple (v) scalariform
	D6a 31	long radials	50	80	d.	vasi.	1-3-5	6	pro.	upr.	
Rhoicissus revoilii	Allott 180	S., radials	100	<50	a./r.			<4	upr.		
Rhoicissus rhomboidea	Allott 181	(v) S., short radials, (v) cl.	100-200	< 50	r.	scanty		<4, >1000	upr.		
	SJL54	S., long radials	>200, 50-100	20-40, 5-20		scanty/vasi.	1-2	<4, >1000	upr.		
	C4b 19	S	100	20	r	scanty	1-2	<4, >1000	upr.		
Rhoicissus tridentata	Allott 182	short/long radials	50	40-100, > 100	d.	scanty	4-10	<4	sq.,upr.		
Sclerocroton integerrimus	SJL 88	short radials	50-100-200	5-20	d./d-i-a	a.	1	12	pro.,sq.,upr.,		
	B4b 66	short radials, (v) Tw.	50-100	20	d./d-i-a	scanty	1	4-12	pro.,upr.,sq.		
Shirakiopsis elliptica	SJL67	short radials	100-200 > 200	< 10	d.	a.	1(-2)	12	pro.,sq.,upr.		
	B4c 45	short radials	100	<10	d.	a.	1	12	pro.,sq., upr.		
Spirostachys africana	SJL 103	long radials	50-100	20-40-100	d-i-a	a.	1	4-12	pro.		
	B4b 62	long radials	50-100	5-20	d./d-i-a	scanty	1	4-12	pro.		
	B4c 31 "bored piece"	long radials	50	40	d./d-i-a	scanty	1	12	pro.		

Syzigium cordatum	Allott 104	short radials	>50	< 40		vasi., ali. or confl.	1-2	>12	pro.	upr./sq.	
	B4a 03	short radials, (v) cl.	<50	40-100	a. /r.	ali./confl.	1-2	>12, > 1000	pro.,upr., sq.		
	C6b 03	long radials, (v) cl.	<50	100	d./d-i-a	scanty	1-2	4-12	pro.	2 sq.	
Syzygium guineense	Détienne undated b		100 - 200	5 - 20	(v) d., d-i-a, (v) b. < 3 c.	ali., winged-ali., confl.	1-3, (v) 4-10	4-12	pro.	2-4, >4upr./sq.	
Tarchonanthus parvicapitulatus	SJL 92	short radials, 1-3-5	<50	> 100		scanty	1-2	12	pro.,(v)sq.	(v)sq./upr.	
	B4b 08	short radials, 1-3-5	<50	> 100	d./d-i-a	scanty	1-2	4-12	pro.,(v)sq.	(v)sq.	
	B4b 22	short radials, 1-3-5	<50	> 100		scanty	1-2	4-12	pro.,(v)sq.	(v)sq.	
	B4c 27	short radials, 1-3-5	<50	> 100		scanty	1-2	4-12	pro.,(v)sq.	(v)sq.	
Teclea gerrardii	Allott 145	short/long radials, (v) cl.	<50	40-100	b. 1-4 c., > 6/mm	vasi, confl.	1-2	4-12	pro.		
	D5d 08	long radials	50	40-100	d./d-i-a	scanty	1-3	4-12	pro.,upr., sq.		
	D5d 09	long radials	<50	40	d./d-i-a	scanty	1-3	4-12	pro.,upr., sq.		

Trema orientalis	IND1305	S., short radials	50-100	5-20		vasi.	1-3	10	pro.	upr.	
	Allott 172	S., short/long radials, (v) cl.	variable	40-100		vasi.	1-2	>12, >1000	pro.	upr.	
	Ogata and Kalat 1997; Yang and Yang, 1987	S., angular outline	100-200	5-20	r.	scanty	1-3	4-12	pro.	2-4 upr. /sq.	
	C4a 22	S.	<50	20-40	d-i-a	vasi.	1(-2)	4	pro.,sq.	upr.	
	D5c 07	short radials, (v) Tw.	50	40-100	a. /r.	vasi.	1(-2)	4-12, > 1000	pro.,sq.		
Trichilia dregeana	Allott 90	S., (v) short radials, (v) cl.	<100	40	a.	scanty	1	4-12	upr.		
	C4 05	short radials	50-100	20-40	d./d-i-a	scanty	1	4-12	upr.		
Trichilia emetica	IND1058	short radials, Tw.	100-200	20	a.	vasi.	1	4-12	sq.,short pro.		
	Allott 91	short radials	variable	40-100		vasi., ali./confl.	1		sq., short pro.		
	D6c 12	long radials	50-100	40-100	d./d-i-a	vasi., ali.	1	4-12	upr., sq.		
Trichilia dregeana/ emetica	Détienne undated b		100-200	5-20	b. < 3 c., (v) b. > 3 c.	vasi., ali., winged-ali., confl.	1	4-12			
Vangueria randii	Allott 142	S.	< 0	40 - 100	d.	vasi.	1-2		sq., upr.		
	D5d 10	S.	<50	> 100	d./d-i-a	scanty	1-3	4-12	pro., upr., sq.		
Vitex rehmannii	SJL 30	short radials, (v) cl.	50-100	40-100		scanty, (v) vasi.	1	4-12	pro.,upr.,sq.		
	Allott 176										
	D6a 29	short radials	20	100	b. < 4c, 3/mm		1-2	4-12	pro.	upr.	

Ximenia caffra	Allott 105	S.	>40	< 50	a./r.		1-3(-5)	4-12	pro.,upr.		
	Détienne undated a and b; Van den Oever undated	S.	<40	50-100	a. /r., d., d-i-a		1-3	4-12, > 12	pro.	2-4/ >4upr./sq.	
	C4b 58	short radials	50	20	d./d-i-a	vasi.	1-3	4-12	sq.	upr.	
	C4bd 03	S.	<50	20	d-i-a	scanty	1-6	4-12	pro.	upr.	
Ziziphus mucronata	Allott 121	short, (v) long radials	50-100	40-100		vasi., ali./ confl.	1	>12	sq./upr.		
	B4c 03	short radials	50	40-100	a. /r.	vasi.	1(-2)	>12	pro.(short)		
	C4a 21	short radials	100	5-20	a. /r.	scanty/vasi.	1		sq.		

Appendix D:

A summary of possible uses for a selection of plants represented by charcoal identified in SPCA and BYA2(i). The wood uses are summarised as: timber, (handles, tools, carving), fuel, food, and medicine (aromatic, poisonous). Plants which occur in BYA2i but not in SPCA are marked with an asterisk.

Scientific name	Timber	Fuel	Food	Medicine
Afrocarpus/ Podocarpus *A. falcatus* (common or small-leaf yellowwood), *P. henkelii* (Henkels or drooping-leaf yellowwood), *P. latifolius* (real or broad-leaf yellowwood)	*A. falcatus* may live to 1000 years. *P. latifolius* is most commonly used: carved, boards [10]	-	-	*Afrocarpus falcatus* and *Podocarpus latifolius* contain tannin[82]. *A. falcatus*: Bark used for dermatitis[36, 55], *P. latifolius:* roots[2] or leaves medicinal[18, 56]
Allophylus dregeanus (forest false-currant)	Hard, densely grained, white wood [10]	-	Fleshy fruit[75]	-
Brachylaena discolor (coast silver-oak)	Strong, durable wood: handles, shafts, rims [10]	Charcoal and fire-starters[10]	-	Leaf infusion for diabetes[82], skin[17], respiration[16, 86], anthelminthic[28]; plant ash - soap[82]
Buxus macowanii	Wood hard, smooth, fine- grained - instruments, tools for ceramics, engravers' blocks [10]	Tinder	-	-
Calodendrum capense (Cape chestnut)	The pale yellow, tough, pliable wood is used for handles[78] and carving[75]	-	-	Soap is made from the oil of crushed, boiled seed[78]
Canthium mundianum (rock turkey-berry)	Hard-wood, fine-grained: tools, implements [10]		-	-
Canthium spinosum (coast turkey-berry)	Yellow, fine-grained, heavy wood[10]	-	Edible fruit [10]	-
Canthium suberosum (cork turkey-berry)	-	-	-	-

Celtis africana (white stinkwood)	Young branches and coppice shoots are popular implement handles[78], wood is sought after for carvings[78]	-	Fruit eaten by Suiei Ndorobo hunter gatherers in Mathews Range, Northern Kenya[29]. Edible fruits for birds, baboons and monkeys; sweet with thin flesh. Older leaves for shade and fodder[78]	Bark decoction drops for eyes/ears[5], bark tea for throat infections[19], bark decoction for syphilis[38]; Leaves for rheumatism, Ethiopia[84, 85], bark steam or smoke, protection-ritual [43], branch sticks protection-ritual, Venda[45], Xhosa[68], Wood & crocodile fat – protection (lightning)[10]
Chionanthus foveolatus (pock-ironwood cf.)	Hard-wood, strong, heavy.	-	Edible fruit – wildlife[10]	-
Clerodendrum glabrum (tinderwood)	The white to pale brown, hard, wood is used for carvings/ poles[75]	Tinder-wood is used to start fires; firesticks[75]	-	Medicinal leaves treat a wide-range of ailments[75]; root or bark ash applied to broken bones[5], also as insect repellent on wounds[82]
*Cliffortia repens**	-	Tinder-wood[33].	-	-
*Cola natalensis**	Hard wood - sticks.	-	-	-
Commiphora marlothii (paper-bark corkwood)	Light, textured wood, bark like paper[15].	-	Edible fruit, moisture from roots[75]	Aromatic resin is produced when the bark is cut or dislodged, in most *Commiphora* spp. (Greek: 'kommi' – gum, 'phero'- to bear). *C. myrrha* produces resinous myrrh and *C. gileadensis* produces healing balm [15, 71].
Commiphora schimperi (glossy-leaved corkwood)	Bark paper[75]	Twigs used to start fire by friction[41, 75]		Resinous leaves[15]. Bark medicinal[75]

Cordia caffra (septee tree)	Soft-wood, contrasting light/ dark: carrying sticks, poles, boards[75]	Friction, firesticks[10]	Edible fruit, not tasty[75]	Leaves medicinal [75]
Croton sylvaticus *				Bark (fish-poison) and leaves poisonous, medicinal use for fever, respiratory ailments [10]
Cryptocarya liebertiana (tropical wild quince)	-	-	-	Medicinal bark: a substitute for the anti-inflammatory, volatile snuff and anodyne smoke of *Ocotea bullata* [75]
Cryptocarya wyliei (red-haired wild quince)			Edible fruit[10], thin flesh, not tasty [75]	
Cunonia capensis *	Fine grained, hard, heavy: boards [10]	-	-	Herbal medicine for nervous complaints [10]
Curtisia dentata (assegai)	Hard, elastic wood[75], carvings, poles, boards [10]	-	Edible fruit is bitter[75]	Bark: gastro-intestinal disorders[4, 8, 18, 57, 61]. The bark tannins and fruit are medicinal[75,78]; antiseptic tannins form protective layers on membranes; leaf tri- terpenoids are antimicrobial [78]
Cussonia paniculata (mountain cabbage tree)	Soft, light wood: carvings[75]			Smoke from the stem is used to treat rheumatism (Pedi), an enema treats endo-parasite[82]
Cussonia spicata (cabbage tree)	Hollow, split stems are used as trays[75]	-	Subterranean, succulent roots provide moisture[78]	Bark, leaves & roots: antibacterial/anti-inflammatory[5, 44]. Roots: poisonous [75] or medicinal[78] - malaria, digestive/ reproductive system ailments[10]
Diospyros austro-africana (fire-sticks star apple)	-	Wood used to start fire by friction[15]		-

Diospyros lycioides (blue-bush)	Hard roots [10]	-	Edible fruit [10]	Roots are frayed as toothbrushes[75]. A yellow-brown dye from roots is antibacterial and a purgative [10]
Diospyros mespiliformis (jackal-berry)	Dark heartwood, used for implements [10]	-	Edible fruit: fresh, jam or brew[15]. Basarwa (bushmen) use fruit as bait to trap birds and small mammals[66].	Medicinal leaves, twigs, bark: antiseptic[15]. Fruit, seeds, bark, roots[5]; boiled bark steam inhaled for headaches[12], bark & leaves: anti-mycotic[13], bark powder: wounds & scabies[26]; roots: abdominal pains [48]; bark: gastro-intestinal disorders[46], bark in hot baths for ailing infants, smoke/ bath with trunk barks for coughs[9]
Dombeya rotundifolia (wild pear)	The heavy, tough, fine textured wood is used for handles, carvings [10], bows. The inner bark is used as twine [15, 78]	Frost and fire resistant[10]	Browsed by game[75] and attractive to bees, this is a honey tree [78]	Wood, bark[82] and roots are herbal medicines[75]. Bark infusion: circulation/ digestion ailments [10, 78]. Root infusion: colic[78], diarrhoea[67] and dystentry (anthelminthic) [53]; roots: infertility[45]
*Dovyalis rhamnoides**	Wood heavy, hard, fine-grained [10]		Tasty fruit, jelly preserve [10]	
Ekebergia capensis (Cape ash)	Soft, fine-grained: carved [10]		Food plant of edible *Bunea alcinoe*, (Emperor moth) caterpillars [10]	Bark: anodyne[45], dysentry[5, 57]; bark poultice: wounds[24]; leaves: respiratory infections[86, 88]; root decoction: headache[30]
Erica caffra (water-tree erica)	-	-	-	-

Euclea crispa (blue guarri)	-	The branches are used to extinguish fires[75]. Wood is avoided for fuel in Maputaland [10]	Bark and leaves are browsed by black rhino[75]. The edible fruits are not very palatable[75]	Chewed twigs: toothbrushes; roots, bark & fruit: phyto-medicines; roots: dark brown dye[75]
Euclea natalensis (hairy guarri)	Hard wood.	Avoided as firewood in KZN [10]	fruit	Twig toothbrushes. Root smoke: hypnotic. Root dye used as a stain and as an anthelminthic[10]. Edible fruit; wood tannin/dye: black, mats; vertebrate poison; medicinal bark [23]; anti-plasmodial[14]; drug-resistant *Mycobacterium tuberculosis*/TB [40] gynaecological ailments[70].
Eugenia erythrophylla (large-leaf myrtle)	-	-	Fruit is edible to birds and genets [10]	-
Faurea saligna (willow beechwood)	Strong, durable wood, attractive grain, can be worked when green, carved, used as poles [10]	Good firewood, although tree is fire-resistant [10]	-	Bark is used for tanning in Zimbabwe[82]; red dye from wood soaked in water [10]
Ficus burkei (common wild fig)	White, light wood. Fibre mats[75]		Edible figs[75]. Leaf relish: edible, tonic[25]	Leaves and bark used as antiseptic in several African countries. Bark: medicinal [82]; leaves anti-malarial/anti - *Plasmodium falciparum* [21, 31]; leaves: shistosomiasis[6], antimycotic[52]; roots: antiseptic[13]; tree: Maasai fertility rites[51]
Ficus ingens (red-leaf rock fig)	-	-	Figs are edible to wildlife[10]	Poisonous leaves, cause nervous disorders in animals, even death[75]; Bark decoction: lactogenic[82]; bark: anaemia[76].

Ficus lutea (giant leaved fig)	Bark fibre cloth[75] or twine[10]		Edible figs: birds & animals[75]	Latex poison: bird lime[75]
Ficus sur (broom cluster fig)	Drums, mortars, carved wood[75]; rope from the inner bark[78]	Forms the base-wood when making fire by friction using sticks; the upper, drill-stick is usually *Grewia* sp.[78].	Young leaf relish and dried or fresh figs are eaten (jam)[75]	Latex is used as bird lime or medicine [10] Leaves & bark: antiseptic[82], lactogenic[28]; anti- diarrhoeal[68]; latex used against ecto-parasites, ticks[81]; roots: infertility, anti-abortifacient[70]; leaves: fertility[37]
Gardenia volkensii (bushveld gardenia)	Hard, heavy, fine-grained wood, carved[75]	Smoke used in fields[75]	Edible fruit [10]	Roots and fruits used medicinally for several ailments. Protected near villages as it wards off lightening[75]; a charm [10]
Grewia bicolor (white raisin)	Bark fibre, wood handles and sticks [10]	-	Edible fruit and tea leaves[75]	Bark medicine[75]; twig toothbrushes[11]; root infusion: diarrhoea[13, 67]; carbonized stems, medicinal[1]; shafts & sticks; leaf smoke: cleansing ceremonies[73]
Grewia flava (velvet raisin, brandy-bush)	Hard, fine-grained wood [10], strong, elastic stems used as bows[41]; short, straight stems as used as arrow shafts, the larger, longer stems as used as walking sticks[65]. Bark makes strong fibre rope [75, 78]	Firesticks *Grewia flava* rolling stick and *Commiphora* sp. base, were carried in the quiver to make fire during the hunt by the Ju/wasi, Nyae Nyae, Namibia[41]. Fire started by friction, by drilling *Ficus sur* wood with *Grewia* sp. sticks[78]	Edible fruit, fresh/dried; drink /porridge[75, 78]	Frayed- twig toothbrushes[75]; plant: anti-mycotic[13], root infusion: kidney/back-pain[26], antiseptic[72, 74]
Halleria lucida (tree-fuchsia)	Spear shafts[15]	Firesticks[78]	Edible fruit[75]	Leaf / root infusion: ears[78]. Burnt wood, crocodile fat[10] and *Rhamnus prinoides* hedge: protection[15]

Harpephyllum caffrum (wild-plum)	Pale red-brown wood is used for general purposes[75]	Good fuel wood [10]	Edible fruit[75]	Bark decoction is used as a blood (STD) purifying emetic[78]
Heteropyxis natalensis (lavender tree)	Hard, fine-grained wood [10]	-	-	Aromatic leaves are used medicinally as herbal tea lavender [10]
Hippobromus pauciformis (false horse-wood)	-	-	-	Leaf sap: ophthalmic treatment; leaf poisonous; roots very poisonous; wood and leaves are strongly scented, resinous and oily[82]. Used in veterinary treatments for stock animals by small scale farmers - roots: diarrhoea[18, 49], cough[28].
Leucosidea sericea (ouhout)	Poles [10]	Good firewood[75] slow burning, a fire-starter[10, 79, 80]		A medicinal plant [10]. An ophthalmic leaf paste is made (Zulu)[82]
Maytenus peduncularis (Cape blackwood)	Black heartwood fighting sticks, knob-sticks and carved [75]	-	-	-
*Mimusops obovata**	Timber[75], boards, poles, knob-sticks and fish traps [10]		Edible fruit (jelly, wine)[82]	Bark: medicinal[75]
Morella pilulifera (broad- leaf waxberry)	-	-	Bees visit flowers [10]	Waxy oil from fruit [10]
Mystroxylon aethiopicum (kooboo-berry)	Fighting sticks and utensils[10]	Fuel[10]	Edible fruit sour/bitter[15]	Bark: brown dye, herbal medicine[10] for stomache ache, anaemia and coughs[23] anthelminthic[82]; leaf tea/ leaf bird-line[51]
Nuxia floribunda (forest-elder)	Yellow, hard, heavy wood for poles, carved [75]	-	-	Bark has tannins; medicinal[10]

Ochna serrulata (carnival ochna)	-	Tinder[10]	-	Medicinal roots treat infections of bones and alimentary canal [75, 10]
Olea europaea ssp. *africana* (wild olive)	Timber is richly figured brown and yellow, attractive, hard and heavy. Wood is carved [75], durable posts[78] Spear handles[11]	Firewood: a good burner, with little smoke[20, 51], used in ceremonies[11]	The edible fruit is bitter or sweet on various trees. Tea is made from leaves[10]	Oleuropein and oleicein in leaves are antispasmodic and antioxidant, lowering blood pressure, and relieving fever[78]. A leaf decoction of treats throat infections[78]. A bark infusion treats colic[75] Leaf snuff stops nose-bleeds[78]. Leaves produce ink[78]. Bark powder for eyes, bark infusion for itchy skin rash[34]. Bark: antimicrobial, sap used for bone-setting[32] bark & roots: headaches [27] leaf infusion: eye lotion[28, 42] charcoal a milk preservative, Maasai [60], bark, leaves, roots treat diarrhoea[57], toothbrush[11]
Pappea capensis (jacket plum)	Hard wood is used for sticks [10]	-	Edible fruit[10]	Seed kernel viscous oil is medicinal, a purgative[82]. The oil treats skin and eye infections[10]. Root infusion: enema[82], fruit: diarrhoea[67]; bark infusion: digestion[22, 29], plant extracts [51].
Pavetta eylesii (flaky-bark brides-bush)	-	-	-	-
Pittosporum viridiflorum (cheesewood)				Medicinal bark used for digestion, pain, fever and as an aphrodisiac; bitter, tastes like licorice[10]

Protea caffra (common sugarbush)	-	Used as fuel in Lesotho[82]	-	Bark has tannin [82]. Bark treats diarrhoea and chest ailments[10]. Bark and fruit: dizziness[45]; root barks: for diarrhoeae[27].
Protea roupelliae (silver sugarbush)	-	-	-	-
Psydrax obovata (Quar)	Wood hard, heavy, fine-grained, aromatic, fences, huts	Fuel[75]		
Ptaeroxylon obliquum (sneezewood)	Timber is durable and water-tight[78]. Used as boards, poles[75, 78]	Excellent fuel-wood., with flammable resin[75]	Edible fruit[75]	Phenolic compounds. Bark and wood snuff treat headaches and sinus. Wood blocks repel insects. Resin is used to treat warts and ticks[77] Sap: stomach ache[64], wood: used against ticks[28], leaf wash for wounds, bark paste for wounds[69]
Rapanea melanophloeos (Cape-beech)	Wood carved[10]		Edible fruit[10]	Bark used as an expectorant and an emetic[15]. Used for protection[10]. Bark: anodyne, tonic[3] mouthwash or tooth-ache remedy[12], leaves: antimicrobial[13].
Rhamnus prinoides (shiny-leaf)	Wood hard			Medicinal wood treats skin and respiratory ailments, used in rituals for protection
Rhoicissus rhomboidea (glossy forest grape)	Rope is made from stems[10]	-	Edible fruit for people and birds[10]. Roots are edible[75]	The medicinal roots[75], contain anti-inflammatories for digestive system ailments[77]
Rothmannia capensis	Hard, pliable: implement handles [1, 75] engraving[2]	Hot fire[78]	Edible fruit: animals[78]	Fruit: wounds, burns; powdered root: leprosy & rheumatism[78]

Sclerocroton integerrimus (duiker- berry)	The hard, heavy, durable wood is used as poles, boards and carved [10]	-	-	Antiseptic, clear latex is a dental and cough treatment[10] Fruit extract is used as a black ink and for tanning[10]
Searsia burchellii -type (kuni bush)	branches once used by the San for bows[75]			
Searsia chirindensis (red currant)	Hard, heavy: furniture[75]		Edible fruit: birds and animals[78]	Bark medicinal[75]
Searsia dentata (nana-berry)			Edible fruit[75]	
Searsia erosa - type (broom karee)	Branches and leaves used as brooms, thatching[75]			medicinal, magical
Searsia leptodictya (rock karee)			Fruit beer[75]	Medicinal[75]
Shirakiopsis elliptica (jumping-seed tree)	The tough, soft, light, white wood is for instruments[75]	Wood is burnt as firewood and charcoal [75]	-	Tannins and alkaloids occur in the whole plant. The poisonous and purgative, clear latex is used as bird lime, for body markings and in arrow poison of *Acokanthera schimperi*, oubain, in East Africa. Bark extracts treat food-poisoning, caused by *Campylobacter jejuni*. It is an anthelminthic of the skin and digestive system. Root bark infusion: a treatment for ticks[81], leaf vermifuge[54], leaves: abdominal complaints, roots: snake bite[7], paludism (malaria) [47].

Spirostachys africana (tamboti)	Hard, heavy, contrasting light and dark wood is used for staves, carved and as poles [77]	Phorbol esters make the sawdust and latex an extremely hazardous class 1a cellular poison[83]. The wood is avoided as fuel for cooking; fumes cause food poisoning [82]		*S.africana* is an arrow and fish poison [82], latex provides a treatment for dental and ophthalmic infections, the antimicrobial bark[50] is used as a purgative treatment for digestive ailments[63] and as a powder for dermatitis. Smoke is inhaled for respiratory tract infections, although it causes headaches[77]. Smoke and wood blocks are insect repellent[45]. Wood & bark used for coughs, fever and bleeding gums, smoke inhaled[5]. Latex: bait dipped for hunting; bark: infusion for wound[16].
Syzigium cordatum (waterberry)	Hard, heavy, fine-grained, water-tight wood is pale red-brown or grey[75]	Good [82]	Edible fruit [82]	Various medicinal uses[82] Powdered bark is fish poison, sprinkled on water by Bemba. Fruit has medicinal and ritual uses[75]
Tabernaemontana ventricosa *	Wood planks[75]	Fire resistant bark[75]	Edible fruit[75]	Sap used as bird lime. Bark treats fever[75]

Tarchonanthus camphoratus (wild- camphor)	Fine-grained: walking sticks, carved[78]	Firewood[78]		Camphor fragrance[82] Smoke from burning green branch, inhaled for sinusitis and headaches[78] (Southern Sotho)[82]. Plant is repellent to insects [58, 59]. Wood splinters cause sores which are difficult to heal[82]. Leaf poultice for respiratory ailments. Leaf infusion for alimentary canal disorders[78]. Insect repellent[82]; leaves: bronchitis, asthma [35, 39, 62], infections. Branches burned, smoke inhaled (Sotho), headaches, asthma, toothache[27]; leaves: bed in home or bush, fragrance and insect-repellent (bed-bugs),leaf relish, fire-wood, deodorant and anti-perspirant (Maasai, Kenya) [11]
Teclea gerrardii (flaky-bark or Zulu cherry orange)	-	-	Edible fruit[10]	Aromatic leaves are pungent[10]
Trema orientalis (pigeonwood)	Sticks, boards [75]		Leaf relish[75]; edible fruit: Animals[75]	Fruit: medicinal. Bark tanning[75] ; waterproof fishing lines, contact dermatitis[82].
Vangueria madagascarensis (bush medlar)			Edible fruit[75]	
Vangueria randii (Natal bush medlar)	-	Avoided as firewood[10]	Edible fruit[75]	-

Vitex rehmannii (pipe-stem fingerleaf)	Hard wood, termite resistant, used to make stools and as handles[15]. Young stems with soft centres are used as pipes[75]	Sought after[10]	-	Aromatic leaves, with antimicrobial properties[75] relieves abdominal pains[15]
Ximenia caffra (sourplum)	-	-	Edible fruit, high in vitamin C and potassium[10]	-
Ziziphus mucronata (buffalo-thorn)	Wood is elastic, hard and tough[82]	-	-	The leaf and bark is powdered, used as an emetic, for various medicinal purposes. Leaf poultice is used as an antiseptic for boils and swellings[82]

APPENDIX D CONTINUED

APPENDIX D CITATIONS	
1	Adjanohoun *et al*. 1980
2	Amri and Kisangau 2012
3	Amusan *et al*. 2002
4	Appidi *et al*. 2008
5	Arnold and Gulumian 1984
6	Bah *et al.* 2006
7	Bekalo *et al.* 2009
8	Bisi-Johnson 2010
9	Bonnefoux undated
10	Boon 2010
11	Bussmann *et al*. 2006
12	Chinemana *et al.* 1985
13	Chinsembu and Hedimbi 2010
14	Clarkson *et al.* 2004
15	Coates- Palgrave 2002
16	Corrigan *et al.* 2011
17	de Wet *et al*. 2013
18	Dold and Cocks 2001
19	Dyubeni and Buwa 2012
20	Esterhuysen and Mitchell 1996
21	Falade *et al*. 2014
22	Glover *et al.* 1966
23	Grace *et al*. 2002
24	Grierson and Afolayan 1999
25	Gueye and Diouf 2007
26	Hedberg and Staugärd 1989
27	Hutchings and van Staden 1994
28	Hutchings *et al*. 1996
29	Ichikawa 1987
30	Jäger *et al*. 1996
31	Jansen *et al.* 2010
32	Kareru *et al.* 2007
33	Killick 1990
34	Kipkore *et al.* 2014
35	Kling 1923
36	Kokwaro 1987
37	Koné and Atindehou 2008
38	Lacroix *et al.* 2011
39	Laidler 1928
40	Lall and Meyer 1999
41	Lee 1979
42	Lindsay and Hepper 1978
43	Lulekal *et al.* 2007
44	Luseba *et al.* 2013
45	Mabogo 1990
46	Mahwasane *et al*. 2013
47	Mainen *et al.* 2009

48	Maryoyi 2011
49	Masika *et al.* 2000
50	Mathabe *et al*. 2008
51	Maundu *et al.* 2001
52	Moshi *et al.* 2009
53	Muthee *et al.* 2011
54	Nalule *et al*. 2011
55	Nanyingi *et al.* 2008
56	Okello *et al*. 2010
57	Olajuyigbe and Afolayan 2012
58	Omolo *et al*. 2005
59	Omolo *et al*. 2006
60	Onyango *et al*. 2014
61	Otang *et al*. 2012
62	Pappe 1847
63	Paulsen *et al*. 2012
64	Ribeiro *et al*. 2010
65	Rodin 1985
66	Roodt undated
67	Semenya and Maroyi 2012
68	Simon and Lamla 1991
69	Soyelu and Masika 2009
70	Steenkamp 2003
71	Steyn 2003
72	Sullivan 1986
73	Timberlake 1987
74	van der Merwe *et al*. 2001
75	Van Wyk and Van Wyk 2013
76	Van Wyk 1974
77	Van Wyk *et al.* 2009
78	Venter and Venter 2002
79	Wadley 2001
80	Wadley and Laue 2000
81	Wanzala *et al.* 2012
82	Watt and Breyer-Brandwijk 1962
83	Wink and Van Wyk 2008
84	Yineger and Yewhalaw 2007
85	Yineger *et al.* 2008
86	York *et al.* 2011
87	Zerabruk and Yirga 2012

Appendix E

The environmental requirements of trees in BYA2(i) and SPCA ([1]Coates-Palgrave 2002; [2]Boon 2010; [3]Venter & Venter 2002; [4]Van Wyk & van Wyk, 2013). Plant distribution is given for nature reserves between 29 to 30°S and 30 to 32°E ([5]Boon 2010; [6]pers. comm. Richard Boon, October, 2014), for Springside Nature Reserve [7](Metcalf 2013) and Hawaan Forest [8](Sutherland 2014). Information is given for trees near Sibudu [9](Sievers, 2013) and in the Coastal Forest [10](Musina & Rutherford, 2006). Plants present in the nature reserves near Sibudu are shaded i.e. "in the grid" (Boon, 2010), in reserves near the coast and therefore could grow near Sibudu. Plants which occur in BYA2i but not in SPCA are marked with an asterisk.

Scientific name	Habit	Habitat	Distribution
Acacia spp.	Climber, tree or scrambler: *A.ataxacantha:* scrambler, *A.karoo* tree (7m), *A.kosiensis:* tree (17m), *A.kraussiana*: climber (15m), *A.natalitia*: tree (8m), *A.robusta*: tree (20m), *A.schweinfurthii*: scrambler	*Acacia robusta*: river valleys, savanna , wooded grassland.[2]	*Acacia robusta* occurs near Sibudu.[9] *A.kosiensis, A. kraussiana, A. natalitia* are common in the Coastal Forest[10] *A. ataxacantha, A.karoo, A.kraussiana* & *A. schweinfurthii* occur in Hawaan Forest[8].
Afrocarpus spp., yellowwood. *A. falcatus* (small-leaf/Outeniqua), *P. henkelii* (drooping-leaf), *P. latifolius* (real/broad-leaf).	Tall trees: *A. falcatus* (25-40 m) *P. henkelii* (25-35 m) *P. latifolius* (30 m)[2]	*A. falcatus*: from coast to mountains, in temperate forest. *P. henkelii*: in moist, inland forest, common in Drakensberg, *P. latifolius*: straight in forest, stunted when exposed.[2]	*A. falcatus*: Western Cape to Ethiopia, *P. henkelii*: Eastern Cape to KZN, *P. latifolius*: Cape Peninsula to Tanzania. *P. latifolius*, *A. falcatus* and *P. henkelii* occur in grid.[2] *P. latifolius* occurs in Springside NR.
Bersama lucens cf (glossy white ash)	Small tree (to 9m) or shrub.[2]	Forest, thicket, bushveld, to 1 525 m.[2]	From Eastern Cape, Mpumalanga to Mocambique;[2] Springside NR[7]
Burkea africana cf. (wild seringa)	A deciduous, medium tree,[4] 8–10 m.[1]	In bushveld, on deep, sandy soil.[4]	From Limpopo, Zimbabwe, Mocambique, Botswana, to Namibia.[1, 6]
Canthium mundianum (rock turkey-berry)	A deciduous shrub or small tree, 7 m.[2]	In groves, forest, scrub, rocky outcrops & along the coast.[2]	Present in KZN between 29 to 30°S and 30 to 32°E;[2]

Scientific name	Habit	Habitat	Distribution
Canthium spinosum (coast turkey-berry)	Small tree, to 4 m.[2]	Forest, margins, bushveld, thicket, rock outcrops, coastal areas, to 700 m.	Eastern Cape to KZN; present[2] in KZN between 29 to 30°S and 30 to 32°E.
Canthium suberosum cf. (cork turkey-berry)	A shrub or small tree with upswept branches,[1] corky bark, [8] m.[2]	Favours sandstone, on scarp forest margins, rock outcrops and cliff tops, altitude + 250-400 m. [2]	In KZN, common in Pondoland centre of endemism [2] and Limpopo.[1] In Krantzkloof Nature Reserve, Inanda Mountain, Vernon Crookes NR. Quite rare in Durban. Was possibly more common before habitat transformation. [6]
Chionanthus foveolatus (pock-ironwood)	A small to tall tree.[2]	In forest and thicket, from coast to mountains.[2]	From western Cape to Mocambique and Zimbabwe Present in KZN between 29 to 30°S and 30 to 32°E[2] but only *C. peglerae* is in Hawaan Forest.[8]
*Cliffortia repens** (Drakensberg rice-bush)	Shrub, to 2m.[2]	On rocky slopes, stream banks, wet areas, to 2 250 m. [2]	E Cape – NE RSA.[2] Present in KZN between 29 to 30°S and 30 to 32°E[2]
Commiphora marlothii (paper-bark corkwood)	A small to medium sized tree, thickset with a heavy bole and branches, 13 m. [1]	Usually on rocky koppies or stony hill slopes, sometimes in woodland.[1]	*C. marlothii* occurs in Northern South Africa, Zimbabwe.[1] *C. harveyi* & *C. woodii* occur near Sibudu.[9]
Commiphora schimperi cf. (glossy-leaf corkwood)	Deciduous shrub or tree, to 6 m.[2]	In bushveld & thicket.[2]	From Maputaland to tropical east Africa.[2] Present in
*Cordia caffra** cf. (septee tree)	Shrub/ tree.[8]	Forest, bushveld.[8]	E Cape - NE RSA,[8] on Durban coast,[12] Hawaan Forest.[14]
Cryptocarya liebertiana (tropical wild quince) (may be hybrid *C.woodii* x *C.latifolia*)	Evergreen, medium to large tree 10 – 35 m.[1]	Evergreen forest.[1]	From Zimbabwe to east Africa,[2] in Durban Berea and Nkandla,[2] but *C. woodii* occurs near Sibudu and in Springside NR.

Cryptocarya wyliei cf. (red wild-quince)	Shrub or small tree, 6(-12 m)	In sandstone soils, in scarp forest & margins, on rock outcrops, to 1 350 m.	Scattered through eastern Cape and KZN.[2] Present on the northern edge of the distribution grid: 29 to 30°S and 30 to 32°E .[2]
Cunonia capensis * (red-alder)	Tall, evergreen tree, to 30 m.[2]	Temperate climate, cool, moist summers. In moist forest, near water.[2]	Western Cape, KZN. Present in KZN between 29 to 30°S and 30 to 32°E[2]
Curtisia dentata (assegai)	Tree to 15 (-20 m).[2]	Uncommon: in moist forest, from coast to high altitude.[2]	Western Cape, to Zimbabwe & Mocambique.[2]
Cussonia paniculata (ssp. *sinuata,* Karoo and ssp. *paniculata,* mountain cabbage tree)	Small tree to 6 m.[2]	On rocky outcrops, mountains, bushveld.[2]	Interior to 2 000 m, but *C. zuluensis* at Sibudu, *C. nicholsonii* in Springside NR.
Cussonia spicata (cabbage tree)	Small to medium tree to 10 (-15 m)[2]	Forest margins, wooded grassland, rocky outcrops; coast to mountains.[2] Frost tender, evergreen.[4]	Western Cape to tropical Africa,[2] present in KZN between 29 to 30°S and 30 to 32°E[2]
Deinbollia sp. (*oblongifolia* cf.) (dune soap-berry)	Briefly deciduous shrub or small tree, to 9 m.[2]	Forest, bushveld, dune bush, to 600 m.[2]	Eastern Cape to Mocambique,[2] present in KZN between 29 to 30°S and 30 to 32°E,[2] *D. oblongifolia* in Hawaan Forest.
*Diospyros austro-africana** (fire-sticks)	Shrub/small tree.[8]	Rocky slopes.[8]	Drakensburg [3] Present in KZN between 29 to 30°S
Diospyros lycioides (bluebush star-apple) The four sub-species are:[1] ssp. *Lycioides* (bluebush), ssp. *guerkei* (quilted bluebush), ssp. *nitens* (silver bluebush) and ssp. *sericea* (eastern bluebush).[2]	A shrub 2– 3 m, or small tree, 6 m.[1]	The ssp. *lycioides* occurs in bushveld, forest margins and grassland, (in groves), ssp. *guerkei* in rocky areas (quartizite), ssp. *nitens* in rocky outcrops and grassland, (in colonies), ssp. *sericea* in tropical areas.[2]	The subspecies *sericea* has a sub-tropical distribution, KZN, E. Cape - Zimbabwe;[2] ssp. *sericea* is common in a number of nature reserves, e.g. Krantzkloof [6] and Springside[7] Nature Reserve. It should occur near Sibudu.[6] (The ssp. *lycioides* is widespread in the drier areas of southern Africa,[1] ssp. *guerkei* : N-W KZN, N RSA;[2] ssp. *nitens* : W KZN, Limpopo[1]) *D. natalensis* occurs near Sibudu.[9]

Diospyros mespiliformis (jackal-berry)	A deciduous shrub to large, semi- tree, to 25 m.[2]	Along rivers and dry areas, on termite mounds.[2]	Swaziland to Namibia, widespread in tropical Africa.[2] Not in Hawaan or Springside.[6]
Dombeya rotundifolia (wild pear)	A deciduous, small tree, 5 (-10) m.[2]	In bushveld, open woodland, on hillsides.[2]	*D. tiliacea* occurs near Sibudu.[9] KZN to tropical Africa,[2] Ethiopia.[3] Common in valley bushveld areas around Durban[2], should occur near Sibudu.[6]
Ekebergia capensis (Cape ash)	Semi-deciduous tree, medium to tall, to 20 (-35 m).[2]	In forest, riverine vegetation, bushveld.[2]	From western Cape to Sudan, Ethiopia.[2] Present in KZN between 29 to 30°S and 30 to 32°E,[2] in Springside NR. *E. pterophylla* occurs near Sibudu.
Erica caffra (water-tree Erica)	Evergreen shrub or small tree, to 4 m.[2]	On cliffs, rock outcrops, along water-courses; coastal scarp to 2 500 m.[2]	From KZN to the Cederberg mountains, western Cape.[2] Present in Krantzkloof NR and probably at other mesic, south-facing sites, on krantz or forest margins[6]
Euclea crispa (blue-guarri)	Shrub to medium tree, to 8 (-20 m)[2]	Forest margins, bushveld, grassland, in pure stands.[2]	Present in 29 to 30°S and 30 to 32°E. [2] *E. natalensis*
Eugenia erythrophylla (large-leaf myrtle)	Small to medium tree, to 6 m (-15 m)[2]	Scarp forest, on sandstone in Pondoland.[2]	*E. natalitia* & *E. sp.nov.* (rare endemic) occur near Sibudu.[9] *E. capensis* in Hawaan, *E.natalitia* (common forest myrtle) in Springside NR.
Faurea saligna (boekenhout)	Semi-deciduous tree, to 10 (-20 m).[2]	In woodland, young forest, well-drained soil, stony hillsides, low to medium altitude. In large groves, indicates "sour-veld",	From KZN to tropical Africa.[2] Not near the coast: absent from Hawaan Forest and Springside Nature Reserve.

Ficus burkei (common wild fig)	Evergreen, briefly deciduous tree, large, to 18 (- 40 m).	Savanna & forest	Eastern Cape to tropical Africa.[2] Present in 29 to 30°S and 30 to 32°E. [2] (*F. glumosa, F. ingens, F. lutea, F. natalensis, F. polita, F. sur, F. thonningii)* - Sibudu.[9] (*F. burtt-davyii* & *F. natalensis*) - *Hawaan* Forest. (*F. lutea* & *F. sur*) - Springside NR
Gardenia volkensii (bushveld gardenia)	A deciduous, small, rigid tree, arching branches, 10 m.[2]	In open woodland and bushveld.[1]	From KZN to tropical Africa.[2] Present on the NORTHERN EDGE OF GRID 29 to 30°S and 30 to 32°E.[2] but not in Hawaan or Springside.
Grewia bicolor (white raisin)	Shrub or small tree, to 9 m.	In dry bushveld, woodland, at low altitude.	Present on the northern edge of grid 29 to 30°S and 30 to 32°E. [2] (*G. lasiocarpa, G. occidentalis*) – Sibudu;[9] (*G. caffra, G.occidentalis*) – Hawaan[8]; (*G. lasiocarpa)* – Springside[7].
Grewia flavescens cf (sandpaper raisin)	Shrub to 5 m.[2]	Bushveld & thicket, to 1 525 m.[2]	Northern Zululand, to tropical Africa and India.[2]
Halleria lucida cf (tree fuschia)	Tree, 12 m.[2]	Forest margins, rock outcrops.[2]	Widespread; in Springside NR[7].
Heteropyxis natalensis (lavender tree)	A semi-deciduous to evergreen tree, 15 m.[3]	On rocky hills and mountainsides, in woodland or wooded grasslands, occasionally on forest margins,[3] in riverine fringes.[1]	From KZN to Zimbabwe.[3] Common in valley bushveld parts of Durban. Should occur near Sibudu 2, 6
Kigelia africana cf. (sausage-tree)	Briefly deciduous tree, to 15 (-25 m).[2]	On bushveld watercourses.[2]	Present on north western edge of grid 29 to 30°S and 30 to 32°E. [2]
Kirkia acuminata cf. (white Kirkia)	Medium, deciduous tree, 6 (-15) m.[1]	In woodland, at medium to low altitude, on rocky ridges and outcrops.[1]	Far-northern SA to Zimbabwe, in northern Namibia.[1] Not in KZN.[2] Absent from Hawaan & Springside.

Leucosidea sericea (ouhout)	Small tree, to 9 m, straggling.[2]	Pioneer at high altitude, near water, in scrub forest, grassland.[2]	Does not grow anywhere near the coast: absent from Hawaan & Springside,
Loxostylus alata cf. (tarwood)	Small tree, to 10 m.[2]	Sandstone rock outcrops, forest margins, to 1 350 m.[2]	From eastern Cape to KZN. Present in grid.[2] Absent from Hawaan & Springside.
Maytenus albata cf. (grey koko-tree)	Shrub or tree to 6 (-20m).[2]	High altitude forest and margins.[2]	Eastern Cape to Sekhukhune & Waterberg, Limpopo, also Mpumalanga.[2] Present in grid, NORTH WESTERN CORNER.[2] *M. mossambicensis* in Springside, *M. undata* in Hawaan Forest.
Maytenus peduncularis (Cape-blackwood)	Small to tall tree, to 13 (-25 m).	In forest, on margins.	Eastern Cape to KZN, widespread.[2] Present in grid.[2] Absent from Hawaan & Springside.
Morella pilulifera (broad- leaf waxberry)	Shrub or small tree to 10 m.[2]	At high altitude, forest edges, grassland, rocky places.[2]	Eastern Cape to Malawi. Present in grid.[2] Absent from Hawaan & Springside.
Nuxia floribunda (forest-elder)	An evergreen, variable shrub or tree, to 20 m;[2] often gnarled.[1]	In evergreen forest, on margins[1] and in bush clumps.[2]	From Knysna, western Cape, KZN to Zambia and Malawi.[2] Present in the grid, it grows in the Vernon Crookes NR, but not near the coast.[6] Absent from Hawaan or Springside.
Ochna serrulata (carnival Ochna)	A densely branched shrub or small tree, [4] 2 m.[2]	Along forest edges, scrub forest, coastal grassland, bushveld, Fynbos, [4] coast to 1 800 m.[2]	*O. natalitia* occurs near Sibudu.[9] From western Cape, KZN to Limpopo province.[2] (P) Common species on the Kloof scarp.[6] Springside NR.[7]
Olax dissitiflora cf (small-fruit Olax/ small false-sourplum)	Small, deciduous shrub, tree to 12 m.	In hot, dry savanna.	In Maputaland, (far northern KZN), to Tanzania and Madagascar. Absent from Hawaan and Springside.
Olea europaea ssp. *africana* (wild olive)	Tree, 14 m.	On forest margins, bushveld, rocky hillsides, near watercourses,[2] on termitaria.[1]	From South Africa (including KZN) to Ethiopia.[2] Present in the grid, in the Umgeni River valley, not near the coast.[6] *Olea woodiana* is in Hawaan Forest.

Olinea ventosa cf. *(=cymosa)* (hard-pear)	Tree, to 25 m.[2]	Evergreen forest, margins, coastal scrub, rocky hillsides.[2]	Western Cape to Eastern Cape.[2] Not in KZN.[2] Not in Hawaan or Springside. *Olinia emarginata* (mountain hard-pear) and *O.radiata* (forest hard-pear) occur in KZN.[2]
*Pappea capensis** (jacket plum)	Tree, to 13 m.[2]	In bushveld, grassland, on termitaria.[2]	Western Cape to tropical Africa.[2] Present in grid.[2]
Parinari curatellifolia cf (mobola plum)	Shrub or tree, to 15 m.[2]	Bushveld, wooded grassland, to 1 500 m.[2]	Not in KZN.[2] Not in Hawaan or Springside.
Pavetta eylesii cf. *Rubiaceae* (flaky bark)	Shrub or small tree, 3-6 m.[1]	Sandveld, woodland, rocky outcrops, in shade of bush clumps.[1]	Northern SA, Zimbabwe.[1] Not in KZN.[2] *P. bowkeri* occurs near Sibudu; *P.capensis* in Hawaan, *P. lanceolata* in Springside.
Peltophorum africanum cf. (African wattle)	A deciduous tree, 9 (–14) m.[2]	In bushveld and open woodland, low to medium altitude.[1]	From northern KZN to tropical Africa.[2] Absent in grid.[6]
Pittosporum viridiflorum cf (cheesewood)	Tree, to 15 (- 20 m). [2]	Forest, margins, rock outcrops, bush clumps, to 1 800 m.	Western Cape to tropical Africa and Yemen.[2] Present in grid.[2] Not near the coast: absent from Hawaan and Springside NR.
Protea caffra (common sugarbush)	Multi-stemmed bush or single- stemmed tree, to 8 m.[2]	Coast to 2 300 m., common on south facing slopes. Most widespread Protea in SA.[2]	Eastern Cape to Limpopo.[2] Present in grid;[2] in Springside NR.[2]
Protea roupelliae (silver sugarbush)	Common tree to 8 m.[2]	In pure stands, small groups, protea veld, on rocky slopes.[2]	Eastern Cape to Zululand, to 2 400 m in Drakensberg.[2] Lesotho to Limpopo.[2] Present in grid,[2] but, absent from Hawaan and Springside NR.
Psydrax obovata cf. *(=Canthium obovatum)* (quar)	Medium to large tree to 12 (-20) m.	Forest margins, rock outcrops, a pioneer on coastal dunes, to high altitude.	*P. locuples occurs near Sibudu.*[9] Present in grid,[2] in Hawaan Forest.
*Rapanea melanophloeos** cf. (Cape-beech)	Small to tall, evergreen tree, to 20 m.[2]	Forest margins, bush clumps, often damp places, often pioneer, coast to mountains.[2]	Western Cape to tropical Africa, present in grid.[2]

Rauvolfia caffra cf. (quinine tree)	Evergreen, briefly deciduous, tree, to 30 m.[2]	In forest, (riverine/ swamp) & woodland, to 1 400 m.[2]	Eastern Cape to tropical Africa.[2] Present in grid,[2] in Springside NR.
Rhamnus prinoides cf . (glossy leaf)	Scrambling tree, to 8 m.[2]	Forest margins and stream banks. In drier scrub. At high altitude.	Western Cape to Ethiopia.[2] Present in grid,[2] but absent from Hawaan and Springside.
Rhoicissus rhomboidea (glossy forest grape)	Canopy climber to 20 m.	In forest margins, to 1 600 m.[2]	Eastern Cape to Mocambique.[2] Present in Hawaan Forest. *R. digitata, R. tomentosa* & *R. tridentata*
Rothmannia capensis *cf. (common rothmannia)	Tree.[3]	Forest, bushveld.[3]	W Cape, KZN - Botswana.[8] Present in Hawaan Forest;[8] Krantzkloof, near Durban.[12]
Sclerocroton integerrimus (duiker-berry)	A deciduous, small to medium, hard wood, tree, 2–10 (–15) m.[5]	A pioneer on forest margins, in wooded grassland, coast to 460 m.[4]	From KZN south coast, to Swaziland, Mpumalanga, (where marginal) to southern Mocambique.[1] Very common tree on the coast and into valley bushveld and dry scarp forest margins.[6] Hawaan Forest.[8]
Searsia burchellii cf. (Karoo kuni-bush)	Shrub, to 5 m.[1]	Rocky hills, arid, interior.[1]	North western Cape.[1] *S. burchelli* is absent from KZN.[2] *S. chirindensis, S. gueinzii* & *S. pentheri occur* near *Sibudu.* [9] *S. nebulosa* is common in the Coastal Forest [10]
Searsia dentata cf. (nana-berry)	Deciduous shrub, or small tree to 2 (-5m).[2]	Forest margins, scrub forest, rock outcrops, streams. Widespread to 2 500 m. [2]	Eastern Cape to Limpopo, Zimbabwe.[2] Present in grid;[2] Springside NR.
Searsia divaricata cf. (mountain kuni-bush)	A deciduous, multi-stemmed shrub, to 3 m.[2]	In scrub, among rocky outcrops and at cliff bases, to 2 500 m; reaches the highest altitude of any *Searsia* spp.[2]	Foothills of KZN Drakensburg, Lesotho, Eastern Cape, OFS.[2]
Searsia erosa cf. (broom karee)	Branched shrub or tree, 3-4 m.[1]	In karoo, on rocky outcrops, on koppies.[1]	Eastern Cape, Lesotho.[1] Not in KZN.[2]

Searsia leptodictya cf. (rock/mountain karee)	Shrub, small tree, 3-4 m.[1]	Open woodland, bushveld, forest margins, hillsides, rocky places.[1]	From Swaziland, Free State, Mocambique to Malawi.[2] Not in KZN.[2]
Shirakiopsis elliptica (jumping-seed tree)	A deciduous, medium to tall, soft wood tree, 12 (– 20) m.[5]	In wooded ravines, common at the canopy edge of evergreen forest, a canopy tree in swamp forest.[5]	Eastern Cape, KZN to tropical Africa.[1] Common in scarp forest;[6] Hawaan Forest.[8]
Sophora inhambanensis cf. (coast-bean bush)	Pioneer shrub or small tree, to 4 m.[2]	On coastal dunes.[2]	From Maputaland to Kenya. Absent from Hawaan and Springside, there is an outlier near Durban.[2]
Spirostachys africana (tamboti)	Medium, deciduous tree to 10 (-16 m).[2]	Dense stands, valley bushveld, rivers, brackish, poorly drained soils, warm, dry areas.[2]	North eastern Cape to tropical Africa. Common, widespread in KZN. In grid.[2] Absent from Hawaan and Springside.
Sterculia rogersii cf. (squat star-chestnut)	Deciduous tree, to 12 (-18 m).	Deep soils, rocky ridges, bushveld.	Northern Swaziland to Mpumalanga.[2] Absent from Hawaan and Springside.
Tarchonanthus camphoratus (= *T.littoralis* (coast camphor bush) and *T.parvicapitulatis* (small-head camphor bush)[2]	Shrub to tree, to 8 m.	*T. littoralis*: coast to 700 m, dunes, hills, rivers *T. parvicapitulatus*: inland to 1 850 m, forest, bushveld.	*T. littoralis* : W Cape - S KZN. *T. parvicapitulatus*: KZN - Zimbabwe.[2] In grid,[2] but absent from Hawaan and Springside.
Terminalia phanerphlebia cf. (Lebombo cluster-leaf)	Shrub or small tree, to 10 m.[2]	Bushveld, rocky hillsides.[2]	Zululand to Mocambique.[2] Absent from Hawaan and Springside.
Trichilia dregeana cf (forest Natal mahogany)	Evergreen tree to 20 (-35) m.	In moist forest.[2] (*T. emetica* occurs in drier areas, riverine, open woodland, coastal areas.)[2]	Eastern Cape to tropical Africa.[2] (*T. emetica*, Natal mahogany, occurs near Sibudu,[9] from Durban to tropical Africa.[2])
Trimeria grandifolia cf. (wild mulberry)	Shrub or small tree, to 10 m.	Forest, margins.	Knysna to Mocambique.[2] Present in grid[2]; in Springside
Vangueria madagascarensis cf. (Bush medlar)	Shrub or small tree, 1-5 m.[1]	Bushveld, coastal bush[4]	Not in KZN.[2] *V. infausta* & *V. randii* ssp. *Chartacea* occur near Sibudu.[9]

Vitex rehmannii *cf. Lamiaceae	Shrub, small tree, to 9m[1], drooping.[3].	In bushveld, stony hillsides, rocky outcrops, deep sand.[3]	Limpopo.[1] In KZN, mostly in Tugela R. basin, probably in Lebombo mountains
Ximenia caffra * (sourplum)	Small, deciduous tree, a hemi- parasite.[2]	Savanna, wooded grassland.[2]	Central KZN to tropical Africa.[2] Present in grid.[2] Absent from Hawaan and Springside.
Ziziphus mucronata (buffalo-thorn)	Tree, to 10 (-20) m. [2]	Small and deciduous in bushveld.[2] Large, evergreen in coastal forest.[2] At low altitude in KZN.[2]	South Africa to Arabia.[2] Present in grid;[2] in Hawaan Forest.

Appendix F

The plants from BYA2(i), SPCA and MOD are arranged in Forest (Mucina and Geldenhuys, 2011; Mucina *et al*., 2011) and Savanna Biome (Rutherford et al., 2011) vegetation units - the KZN Coastal Belt (CB 3)(Mucina et al., 2011), Scarp Forest (FOZ 5), Northern Coastal Forest (FOZ 7), Southern Mistbelt Forest (FOZ 3) and Northern Afrotemperate Forest (FOZ 2), Ngongoni Veld (SVs4) and KZN Sandstone Sourveld (SVs 5), Savanna Bushveld and Fynbos (Rebelo et al. 2006).

Habit	**Plant species (n=154)**	**BYA2(i) (n=69)**	**SPCA (n=110)**	**MOD (*n*=60)**	**Present**
CB 3	*Apodytes dimidiata*		*		*
CB 3	*Bauhinia galpinii*			*	absent
CB 3	*Bersama lucens*		*		absent
CB 3	*Buxus macowanii*	*			absent
CB 3	*Canthium mundianum*	*	*	*	absent
CB 3	*Canthium spinosum*	*	*		absent
CB 3	*Canthium suberosum*	*	*	*	absent
CB 3	*Canthium* sp.	*			*Canthium ciliatum, C. inerme*
CB 3	*Carissa macrocarpa*		*		*
CB 3	*Volkameria glabra*	*	*	*	*
CB 3	*Cola natalensis*	*			*
CB 3	*Commiphora schimperi*		*		absent
CB 3	*Cordia caffra*	*	*	*	absent
CB 3	*Croton sylvaticus*	*			*
CB 3	*Cryptocarya woodii*	*	*		*
CB 3	*Cunonia capensis*	*			absent
CB 3	*Dalbergia obovata*			*	*
CB 3	*Deinbollia* sp.		*		absent
CB 3	*Diospyros natalensis.*		*		*
CB 3	*Diospyros villosa*			*	absent
CB 3	*Diospyros whyteana*			*	absent
CB 3	*Dombeya rotundifolia.*	*	*	*	absent
CB 3	*Dovyalis rhamnoides*.	*			*
CB 3	*Ekebergia capensis*	*	*		*absent (Ekebergia pterophylla* occurs*)*
CB 3	*Empogna lanceolata*		*	*	* (and *Tricalysia capensis*)
CB 3	*Euclea crispa*		*	*	absent
CB 3	*Eugenia erythrophylla*		*		absent (*Eugenia natalitia* occurs)
CB 3	*Ficus burkei*		*	*	** (*and *Ficus glumosa, F. natalensis, F. polita)*
CB 3	*Ficus ingens*		*		*
CB 3	*Ficus lutea*	*	*	*	*
CB 3	*Ficus sur*		*		*
CB 3	*Heteropyxis natalensis*		*	*	absent
CB 3	*Hippobromus pauciflorus*	*	*		*
CB 3	*Kigelia africana*		*		absent

Habit	Plant species (n=154)	BYA2(i) (n=69)	SPCA (n=110)	MOD (*n*=60)	Present
CB 3	*Loxostylus alata*		*		absent
CB 3	*Maytenus peduncularis*		*		absent
CB 3	*Mimusops obovata*	*		*	*
CB 3	*Mystroxylon aethiopicum*	*	*	*	*
CB 3	*Nuxia floribunda*	*	*	*	absent
CB 3	*Ochna serrulata*		*	*	absent
CB 3	*Ochna sp.*	*			*Ochna natalitia* occurs
CB 3	*Pappea capensis*	*	*	*	absent
CB 3	*Peltophorum africanum*		*	*	absent
CB 3	*Protorhus longifolia*		*	*	absent
CB 3	*Psydrax obovata*	*	*		absent (*Psydrax locuples* occurs)
CB 3	*Rapanea melanophloeos*	*	*		absent
CB 3	*Rauvolfia caffra*		*		absent
CB 3	*Rhoicissus rhomboidea*		*	*	absent (*Rhoicissus digitata* and *R. tomentosa* occur)
CB 3	*Rothmannia capensis*	*		*	*
CB 3	*Sapium/ Spirostachys type*		*		absent
CB 3	*Sclerocroton integerrimus*	*	*	*	absent
CB 3	*Searsia dentata*	*	*		absent
CB 3	*Searsia rehmanniana*			*	absent
CB 3	*Shirakiopsis elliptica*	*	*	*	absent
CB 3	*Spirostachys africana*	*	*	*	absent
CB 3	*Syzygium cordatum*		*	*	*
CB 3	*Syzygium* sp.		*		absent
CB 3	*Tabernaemontana*	*			*
CB 3	*Terminalia phanerophlebia*		*		absent
CB 3	*Trema orientalis* cf.	*	*	*	*
CB 3	*Trichilia dregeana*		*		absent
CB 3	*Vangueria randii*	*	*	*	*
CB 3	*Virgilia oroboides*		*		absent
CB 3	*Ximenia caffra*	*	*		absent
CB 3	*Zanthoxylum davyi*		*		*
CB 3, FOZ 3	*Searsia chirindensis*	*	*	*	*
CB 3, FOZ 3	*Allophylus dregeanus*	*	*	*	*
CB 3, FOZ 3	*Chionanthus foveolatus*		*		absent
CB 3, FOZ 3	*Dombeya tiliacea*			*	*
CB 3, FOZ 7	*Brachylaena discolor*	*	*	*	*
CB 3, FOZ 7	*Kiggelaria africana*			*	absent
CB 3, FOZ 7	*Searsia* sp.	*	*		*Searsia gueinzii*, *S. pentheri*
CB 3, Savanna bushveld	*Grewia flavescens*		*		absent

Habit	Plant species (n=154)	BYA2(i) (n=69)	SPCA (n=110)	MOD (*n*=60)	Present
CB 3, Savanna Bushveld	*Gardenia volkensii*	*	*	*	absent
CB 3, Savanna bushveld	*Grewia bicolor*		*		absent (*Grewia lasiocarpa, G. occidentalis*)
CB 3, Savanna bushveld	*Grewia flava*		*		absent
CB 3, SVs 4, Savanna Bushveld	*Acacia* spp.	*	*	*	*Acacia robusta*
CB3	*Cryptocarya liebertiana*	*	*		absent
Forest: E. Cape	*Olinia ventosa*		*		absent
FOZ 2	*Cliffortia repens* Drakensberg	*			absent
FOZ 2	*Diospyros austro-africana*	*	*	*	absent
FOZ 2	*Leucosidea sericea*	*	*		absent
FOZ 2	*Morella pilulifera*	*	*		absent
FOZ 2	*Pittosporum viridiflorum*	*	*		absent
FOZ 2	*Protea roupelliae*		*		absent
FOZ 2	*Rhamnus prinoides*	*	*		absent
FOZ 2, 3, 7	*Halleria lucida*	*	*	*	absent
FOZ 2, FOZ 3	*Afrocarpus/ Podocarpus* sp.	*	*		absent
FOZ 2, FOZ 3	*Celtis africana*	*	*	*	*
FOZ 3	*Calodendrum capense*	*	*		*
FOZ 3	*Curtisia dentata*	*	*		absent
FOZ 3	*Cussonia paniculata*		*	*	absent
FOZ 3	*Hypericum* sp.		*		absent
FOZ 3	*Olea europaea* ssp. *africana*	*	*	*	absent
FOZ 3	*Trimeria grandifolia*		*		absent
FOZ 3	*Vitex rehmannii*	*	*		absent
FOZ 3	*Vitex* sp.		*		absent
FOZ 3, FOZ 5	*Ptaeroxylon obliquum*	*	*	*	*
FOZ 5	*Cussonia*zuluensis*		*		*
FOZ 5	*Erica caffra*	*	*	*	absent
FOZ 5	*Erica* sp.		*		absent
FOZ 5	*Commiphora harveyi*		*		*
FOZ 5	*Cryptocarya wyliei*	*	*		absent
FOZ 5	*Harpephyllum caffrum*	*	*	*	*
FOZ 5	*Strychnos henningsii*		*		present
FOZ 5, FOZ 7	*Englerophytum natalense*		*		*
FOZ 7	*Diospyros lycioides*		*	*	absent
FOZ 7	*Euclea natalensis*		*		*
FOZ 7	*Maytenus albata*		*		absent

Habit	Plant species (n=154)	BYA2(i) (n=69)	SPCA (n=110)	MOD (*n*=60)	Present
FOZ 7	*Sideroxylon inerme*		*		*
FOZ 7	*Sophora inhambanensis*		*		absent
FOZ 7	*Tarchonanthus parvicapitulatus*		*		absent
FOZ 7	*Teclea gerrardii*		*		absent
FOZ 7	*Trichilia emetica*		*	*	*
FOZ 7	*Searsia divaricata*		*	*	absent
Savanna Bushveld	*Afzelia quanzensis*			*	absent
Savanna Bushveld	*Bridelia mollis*			*	absent
Savanna Bushveld	*Burkea africana*		*	*	absent
Savanna Bushveld	*Commiphora marlothii*	*	*	*	absent
Savanna Bushveld	*Diospyros mespiliformis*		*	*	absent
Savanna Bushveld	*Kirkia acuminata*		*		absent
Savanna Bushveld	*Olax dissitiflora*		*		absent
Savanna Bushveld	*Parinari curatellifolia*		*		absent
Savanna Bushveld	*Pavetta eylesii*	*	*		absent (*P. bowkeri*)
Savanna Bushveld	*Pterocarpus rotundifolius*			*	absent
Savanna Bushveld	*Searsia leptodictya*	*	*		absent
Savanna Bushveld	*Sterculia rogersii*		*		absent
Savanna Bushveld	*Vangueria madagascarensis*	*	*	*	absent (*V. infausta*)
Savanna widespread	*Searsia lancea*			*	absent
SVs 4	*Cussonia spicata*		*		absent
SVs 4	*Ozoroa paniculosa*			*	absent
SVs 4	*Ziziphus mucronata*	*	*		absent
SVs 5	*Faurea saligna*	*	*		absent
SVs 5	*Protea caffra*	*	*		absent
SVs 5	*Protea* sp.	*			absent

Note on the referencing: Forest (Mucina and Geldenhuys 2011; Mucina et al. 2011) and Savanna (Rutherford et al. 2010) Biomes, occur in the region where Sibudu is situated today. The Forest Biome includes the Afrotemperate and Subtropical Forests (Mucina and Geldenhuys 2011). The Indian Ocean Coastal Belt (Subtropical Coastal Forest Biome) includes the KwaZulu-Natal Coastal Belt (Mucina et al. 2011). The Savanna Biome includes plants from the Savanna Lowveld and Sub-Escarpment (Rutherford et al. 2011). The Grassland Biome is present (Mucina et al. 2011).