



Furnaces, hearths, rituals, and construction: investigating the utilisation of woody plant species at the Early Iron Age site of Ndondondwane by means of identifying archaeological charcoal

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Received: 26 February 2023 / Accepted: 11 July 2023 / Published online: 10 August 2023
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Abstract

Ndondondwane, an Early Iron Age settlement situated on the banks of the Thukela River, KwaZulu-Natal, South Africa, provides a unique record of a single, short-term occupation (c. 1300 to 1200 years ago). Several areas associated with different activities had been previously excavated and analysed, yielding various scenarios for the cultural and social organisation of the settlement. Three phases of occupation or cultural horizons have been identified and this paper largely explores the charcoal assemblage from the middle cultural horizon, during the settlement's maximum extent of occupation. Charcoal was analysed from the central part of the site, represented by a livestock byre (kraal), a meeting place, and a craft production area; as well as the peripheral areas including three domestic middens and a charcoal preparation area. Archaeological charcoal specimens were examined using reflective light microscopy to observe the characteristic anatomical features needed to determine the taxonomic group they represent and subsequently identified by direct comparison with a modern charcoal reference collection and published archaeological charcoal studies. Charcoal was identified as belonging to 15 families, 23 genera, and 29 species of trees with known fuel, construction, and medicinal uses. There was a preference for wood previously known as *Acacia*^{*}, indicating that this genus was readily available and prolific in the surrounds of the site. Ndondondwane has been extensively investigated in terms of the archaeology, and this together with the anthracology data provides further insight into Early Iron Age settlement location-specific activities, cultural practices, and reasons for abandonment.

Keywords Anthracology · Macrobotanical remains · South Africa · Wood use

Introduction

Charcoal is often the most abundant macrobotanical remnant recovered from archaeological deposits associated with past human settlements of all ages. Typically it has been used as a resource for radiocarbon dating. However, as the microscopic anatomical properties of wood are preserved even after burning, it is possible to identify the taxonomic group of trees from which the charcoal was originally derived. In the past decade or so, anthracology, or the science of identifying archaeological charcoal, has gained global popularity in archaeological and palaeoecological fields (Ludemann and Nelle 2017). Nowadays, the charcoal data have a much wider application, including the reconstruction of past vegetation, thereby enabling inferences as to climatic and other environmental conditions prevalent at the time, to be made. A number of studies have assessed the use of charcoal for palaeovegetation reconstruction (for example, Asouti and Austin 2005; Théry-Parisot et al. 2010; Dotte-Sarout et al.

*The previous classification of the genus *Acacia* will be followed, except where the species is named, in which case the revised generic nomenclature will be used.

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2015; Allue et al. 2017; Puech et al. 2021), allowing environmental changes to be tracked over time in sites showing significant stratification. In South Africa, analysis of charcoal, mainly from Late or Middle Stone Age archaeological sites, has been successfully carried out primarily for palaeoenvironmental reconstruction (for example, Deacon et al. 1983; Wadley et al. 1992; Esterhuysen and Mitchell 1996; Cartwright and Parkington 1997; Parkington et al. 2000; Allott 2006; Lennox et al. 2015).

How well a charcoal assemblage represents a palaeoenvironment is less clear, as the retrieved samples are remnants of species specifically selected and collected by the inhabitants of the site. Following the principle of least effort (Zipf 1949; Chisholm 1968; Vita-Finzi and Higgs 1970; Shackleton and Prins 1992), it is unlikely that the occupants would have travelled long distances to collect wood, and mainly those species found in close proximity to the site would be represented. Moreover, the collection would be subject to further selection and choice of the inhabitants, based on factors such as their suitability as fuel, usefulness, abundance in the area and ease of collection (Marston 2009). The carbonisation and preservation of the resultant charcoal from burned wood also differ depending on the characteristics of the fire (Braadbaart and Poole 2008). Wood may have been heated to different temperatures and exposed to burning for different lengths of time depending on the purpose of the particular fire, including for cooking, heating, charcoal preparation, and iron smelting and forging. In this way, the individual structural properties of the wood also come into play. For instance, the tendency of some woods to readily turn to ash instead of forming more durable charcoal may influence the range of species identified in an assemblage. Consequently, it is not surprising that woody species diversity identified in a charcoal assemblage does not exactly mirror the vegetation currently surrounding the site. While all of the above considerations are problematic for vegetation reconstruction, a further, and mostly unexplored, application for the taxonomic data that charcoal affords is the insight it can provide regarding the inhabitants' cultural practices, habits, economy, and their relationship to the local environment. In this instance, the inhabitants' selection of species and foraging distances are not constraints on our interpretation of the assemblage.

The technologies and activities in which any society engages are limited by the resources available to them. The large volumes of charcoal recovered from past human occupation sites indicate that woody plant species were of fundamental importance to early societies. The specific properties of different types of wood make certain species more desirable or appropriate for particular tasks or applications. Analysing the charcoal recovered from different locations in past human settlements allows one to determine the woody species used for a wide range of purposes. The identification

of charcoal specimens from separate locations within a site can provide data to better understand the variety of aspects of the inhabitants' way of life.

Evidence suggests that Iron Age communities purposefully selected and utilised different woody species for a variety of applications ranging from the construction of fences and dwellings, cooking, smelting and forging, as well as for ritualistic purposes relating to cultural beliefs (for example, Huffman 1986; Whitelaw 2015; Chikumbirike et al. 2016). Specialised usage of plant species by current societies and those of the recent past allows us to hypothesise that Iron Age settlements were likely to have used specific species of wood for specific purposes, based on the particular suitability of the wood to the task at hand.

The Early Iron Age (EIA) is the time period (A. D. 200 to 900) when the first farming (cultivation and herding) communities settled in southern Africa. Several opposing models for EIA settlements in southern Africa have been proposed, the two most popular being the Central Cattle Pattern (CCP) of Huffman (1990)—which he first described as the Bantu Cattle Pattern (Huffman 1982)—and the Household Mode of Production (HHMP) of Hall (1987). The EIA settlements in southern Africa are believed to follow the CCP, where cattle represent wealth (Huffman 1993). CCPs were characterised by a central byre, grain storage pits, metal working areas, and huts with a central fireplace (Huffman 1993). Distinct zones for gender-specific activities were also a typical feature of these societies. These features are reported to be found together in all EIA sites in southern Africa (Huffman 1990; Whitelaw 1995). However, the CCP organisation in the EIA has been disputed by Maggs and Ward (1984), Hall (1987), and Badenhorst (2009). They consider the CCP to be a Late Iron Age (LIA) phenomenon and that the EIA and Middle Iron Age (MIA) were characterised by individual households in small farming villages, equivalent to the HHMP. Nevertheless, determining the settlement patterns of these archaeological sites gives an insight into the socio-economic structure of these early societies (Whitelaw 1994; Greenfield and van Schalkwyk 2003).

The dominant domestic animals of the EIA were caprines (sheep and goats) (Badenhorst 2010). There is a suggestion that caprine herding is associated with matrilineal descent in the EIA (Badenhorst 2010). During the EIA women played an important role in crop cultivation involving digging sticks and hoes, as well as taking care of the cooking. At this time, construction typically utilised wooden posts and dhaka (Badenhorst 2010), with thorn bushes used for fencing (Klehm and Ernenwein 2016). In contrast, there was a shift towards patrilineal descent in the LIA, dominated by cattle for bridewealth (Badenhorst 2010). Cattle replaced sheep during the LIA and were utilised for ploughing. Stone was introduced in construction and replaced thorn bushes as fencing (Klehm and Ernenwein 2016). The division of

labour based on gender saw men doing most of the bush clearing, fencing, and stock rearing. Wood for construction was collected by men, while woods for fuel, cooking, and other household activities, as well as the edible parts of trees were collected and foraged for by women (for example, Liengme 1981; Corrigan et al. 2011).

Following ceramic typology evidence, the EIA in Kwa-Zulu-Natal (KZN) was initiated by people from the Great Lakes District of central Africa settling in the valleys (Huffman 1986), bringing with them the skillsets of agriculture and iron working. At this stage, settlements were not stratified, and it seems that communities in the valley comprised scattered independent, individual households, or small groups about 5 km distant (Greenfield and van Schalkwyk 2008). Iron work was conducted away from the households, probably by men. In the latter half of the first millennium, during the Ndongondwane phase of the EIA, there were thriving village sites with evidence of ceramic manufacturing, iron smelting and forging, rituals, and ivory work (Maggs 1984). KwaGandaganda, one of the largest settlements in the valley, may have had centralised control over iron and ivory production (Miller and Whitelaw 1994).

The Lower Thukela River Valley (one of many west–east flowing rivers), in KZN, has been recognised as an area of intensive EIA settlement (Maggs 1984; van Schalkwyk 1991; Loubser 1993; Whitelaw 1994). Chronology of the area is well defined in terms of artefacts (for example, ceramic typology) and radiocarbon dating. It is rich in archaeological evidence for EIA mixed farming settlements and to date, 24 settlements have been identified in the valley and even more may yet be discovered (Greenfield and van Schalkwyk 2008). As a result, the area has been extensively surveyed and excavated and much of the general culture historical sequence has been researched, including the definition of time periods or traditions based on the typology of the ceramic decoration and the settlements in which the pottery was found. Msuluzi (A. D. 500 to 750) was the earliest and longest tradition to appear in the valley; Ndongondwane (A. D. 750 to 850) represents the pinnacle of EIA culture in the region, marked by great population expansion inland; and Ntshekane (A. D. 850 to 1000) marks the end of the EIA sequence in the valley (Maggs and Michael 1976; Maggs 1980, 1984).

The population in the Lower Thukela River Valley grew fivefold during the Ndongondwane phase, but appears to have collapsed in the Ntshekane phase at the end of the EIA, signalling the start of the MIA. The valley was abandoned during the MIA, and by the LIA (in the 2nd millennium) these early farmers had moved to the escarpment grasslands above the valley bottom (Maggs and Ward 1984; Greenfield and van Schalkwyk 2008). It is not yet clear as to why there was such a dramatic shift in settlement pattern at the end of the EIA, but an unpredictable climate and spread of diseases

such as malaria and tsetse fly have been suggested as a cause (Huffman 1994).

During the EIA, societies used wood for cooking, heating, building structures (huts, byres), making tools, as well as for medicinal and ritual purposes. In addition, wood was also used for firing ceramics and producing charcoal for use in iron smelting, forging, and smithing. The high demand and resultant harvesting of wood must have impacted the biodiversity and landscape in the area (Kay and Kaplan 2015).

Regional setting and history of research at Ndongondwane

The EIA site, Ndongondwane (28°53'40"S, 31°01'42"E), is located on the north-eastern bank of the Thukela River in the Lower Thukela River Basin, KZN, South Africa (Fig. 1). Ndongondwane is unique among the many EIA settlements in this area as it represents a single, short-term occupation of no more than 150 years within the time period A.D. 750 to 950. This is evidenced by the occupation only extending over a single ceramic phase, based on the typology of the recovered ceramics (Maggs 1984; Loubser 1993; van Schalkwyk et al. 1997; Fowler and Greenfield 2009). Consequently, it is the type site for the Ndongondwane phase of the KZN, EIA sequence (Maggs 1984). As most other EIA sites in the Lower Thukela River Basin include more than one ceramic phase (for example, Maggs and Ward 1984; van Schalkwyk 1991; Whitelaw 1994), it is assumed that Ndongondwane was never reoccupied, minimizing the possibility of contamination from later settlements.

Initial investigations conducted by Tim Maggs in April 1978 (Maggs 1984) revealed a well-preserved settlement with abundant remains, indicating a new ceramic phase within the EIA sequence. Maggs recognised the site as being unique and important and recommended further more extensive excavations. These were conducted by J. Loubser from December 1982 to May 1983 (Loubser 1993, 1998) and revealed spatially discrete activity areas, including those for ivory and iron working as well as others for ritualistic ceremonies. The likelihood of a single occupation made Ndongondwane a suitable test case for reconstructing the social and economic organisation or structure of EIA settlements in southern Africa. This led to a collaborative effort by a Canadian–South African team, and from 1995, excavations were conducted over 3 years, directed by Haskel J. Greenfield and Len O. van Schalkwyk (for example, van Schalkwyk et al. 1997; Greenfield et al. 2000). A variety of surface and subsurface pre-excavation reconnaissance techniques were employed as well as different excavation strategies, revealing a more comprehensive picture of the structure and organisation of the site (Greenfield et al. 2000). A substantial accumulation of archaeological cultural material (ceramics, models, masks, ivory, iron artefacts, a furnace,

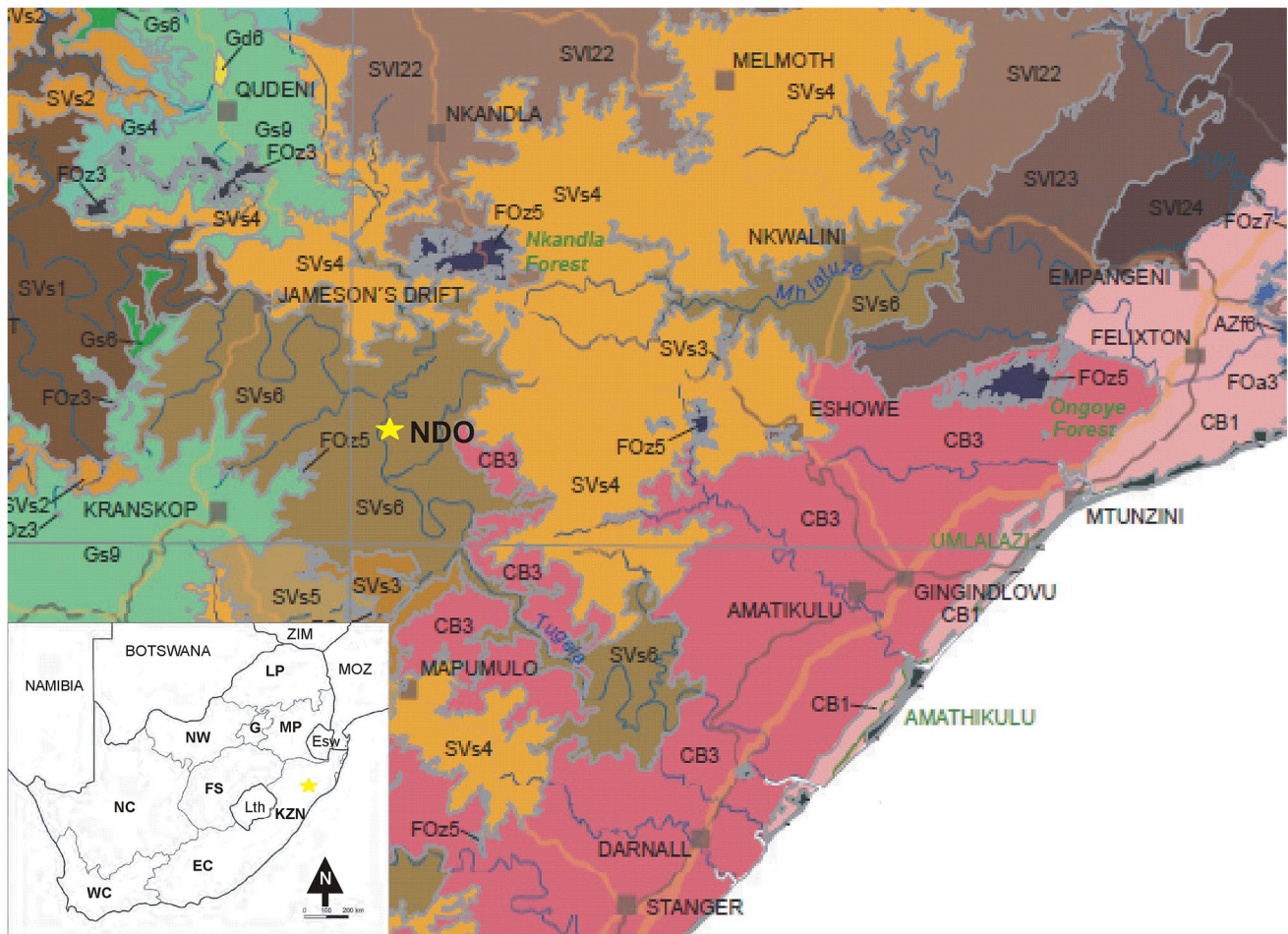


Fig. 1 Modern vegetation distribution map showing the Thukela River Valley and surrounding area with the proximity and location of Ndongondwane (NDO) (adapted from Mucina and Rutherford 2006). Sub-Escarpment Savanna Bioregion: SVs6 Eastern Valley Bushveld (Svs 4 Ngongoni Veld; CB3 KwaZulu-Natal Coastal Belt in the Indian Ocean Coastal Belt Bioregion; Gs9 Midlands Mistbelt Grassland within the Sub-Escarpment Grassland Bioregion; FOz5

Scarp Forest). Inlay shows location of Ndongondwane, Provinces of South Africa and neighbouring southern African countries. EC, Eastern Cape; FS, Free State; G, Gauteng; KZN, KwaZulu-Natal; LP, Limpopo; MP, Mpumalanga; NC, Northern Cape; NW, north west; WC, Western Cape; Esw, Eswatini; Lth, Lesotho; Moz, Mozambique; Zim, Zimbabwe

and shell beads) as well as a large amount of charcoal have been recovered from the site. Provincial Heritage Site protection status was sought and later granted (provincial heritage site number 2608) (Prins and Hall 2013).

As was typical for EIA settlements in the Lower Thukela River Basin, Ndongondwane is located at low altitude, about 200 m above sea level (Loubser 1993), in savanna bushveld vegetation, providing grazing for livestock and wood for fuel and construction (Maggs and Ward 1984). The adjacent river provided water and deep colluvial soils and the flat topography made this area suitable for cultivating sorghum and millet crops, adapted to summer rainfall conditions requiring no additional irrigation. Metal bearing rocks for iron production and clay sediments used for ceramic manufacture were found in close proximity.

The area lies within the Sub-Escarpment Savanna Bioregion and the vegetation is described as Eastern Valley Bushveld (SVs 6) (Mucina and Rutherford 2006). The local vegetation is characterised by *Sclerocarya-Acacia* tree veld (Edwards 1967). This diverse semideciduous, savanna woodland includes many woody taxa. Some of the common wood producing trees are various species of *Acacia*, *Berchemia zeyheri*, *Combretum molle*, *Cussonia spicata*, *Sclerocarya birrea* sub-species *caffra*, *Spirostachys africana*, and *Ziziphus mucronata* (Edwards 1967; Mucina and Rutherford 2006) (Fig. 1).

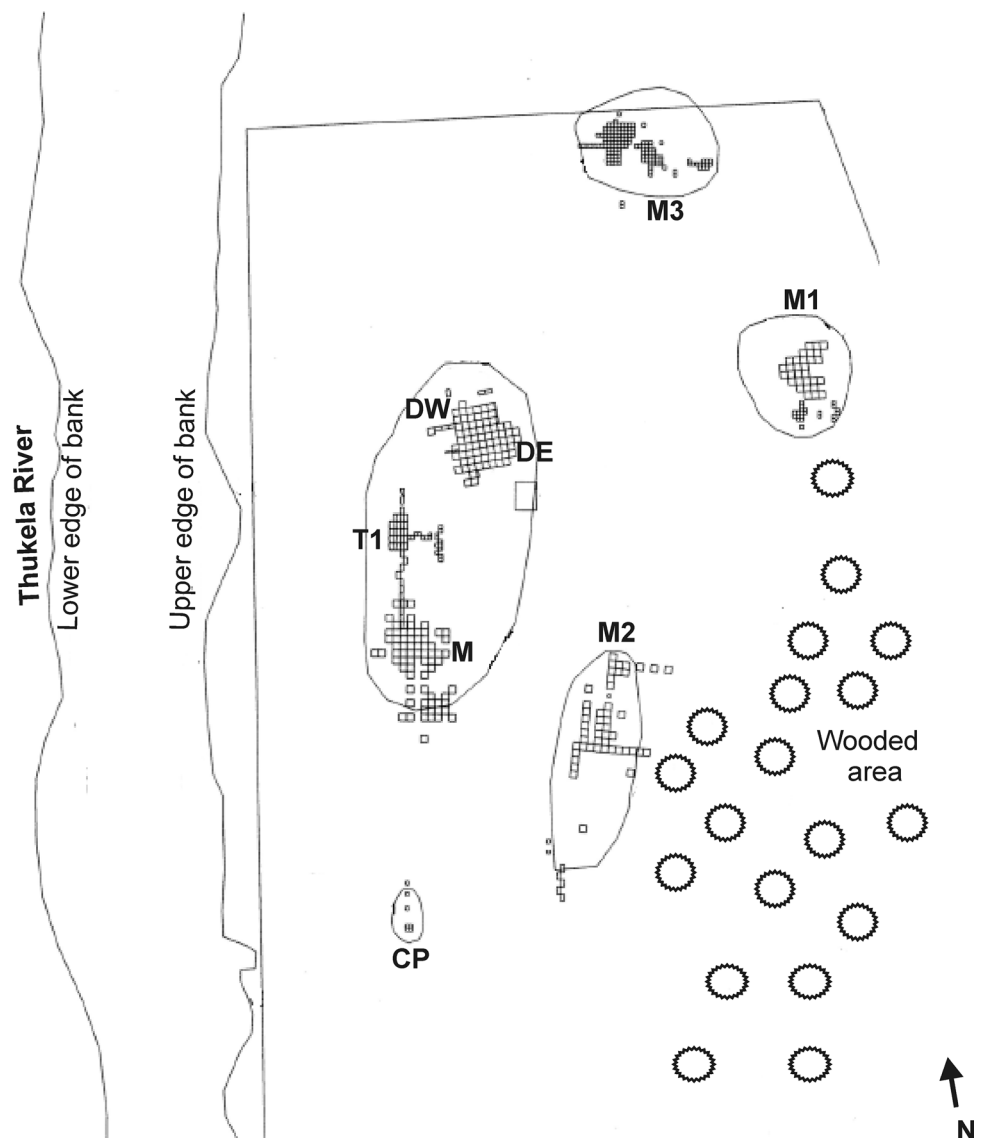
The climate is subtropical with summer rainfall, averaging 450 to 750 mm per year. The average temperature ranges from 19 to 22 °C, but can become hotter during the summer (Mucina and Rutherford 2006).

Ndondondwane is one of the larger settlements in the lower valley. Overall, the site is about 300 m long (north to south) and about 200 m wide (east to west) (Greenfield et al. 2000) (Fig. 2). The settlement has been extensively investigated with respect to spatial organization and structure. A number of spatially separated areas have been excavated and associated with different activities, including areas dominated by either male- or female-specific activities (Maggs 1984; Loubser 1993; Greenfield et al. 1997; van Schalkwyk et al. 1997; Loubser 1998; Fowler et al. 2000; Greenfield et al. 2000; Greenfield and van Schalkwyk 2003; Greenfield and Miller 2004; Greenfield et al. 2005; Fowler and Greenfield 2009).

There are two major activity zones, a central communal zone and a peripheral homestead, and other specialised activity zone (Loubser 1993; Greenfield et al. 2000). The central communal zone comprises three activity areas,

approximately 40 m apart. These include the dung area (incorporating dung east, a cultural activity area, and dung west, a livestock byre), a large hut floor or community meeting place (within transect 1), and an enclosed area associated with cultural craft production (mound area), in which iron forging, ivory work, and ritual activities took place. Due to the presence of hollow ceramic mask pieces and solid ceramic figurines found to be broken and then discarded in the mound area, it was proposed that this was a male assembly area in which initiation ceremonies took place (Loubser 1993; Whitelaw 1994). The peripheral homestead zone is arranged in an arc around the communal zone, about 100 m upslope, across a large open field thought to be utilised for crop cultivation (Greenfield et al. 2005). Three domestic areas (middens 1, 2, and 3) about 70 m apart are situated on the north side of the arc, and a specialised activity charcoal preparation area is located on the far south side (Fig. 2). The

Fig. 2 Site map or plan of Ndondondwane, redrawn from Greenfield and van Schalkwyk (2003). DE, dung east; DW, dung west; T1, transect 1; M, mound area; M1, midden 1; M2, midden 2; M3, midden 3; CP, charcoal preparation area



site incorporates well-established metal working technologies in terms of furnace structure, similar to contemporary furnaces in the region (Maggs and Ward 1984).

The site comprises three stratigraphically superimposed cultural horizons. The lowest, cultural horizon 1 (CH1), representing the founding of the site, is only found in the central communal area and is depicted by the mound and dung areas. The middle, cultural horizon 2 (CH2), signifying the growth and development of the site, is found in all eight spatially discrete excavation areas (Fig. 2). The uppermost, cultural horizon 3 (CH3), is associated with a charcoal preparation area and the mound area and spans the abandonment of the site and the period directly thereafter when people intermittently returned to the site for the purpose of iron smelting (Loubser 1993; Greenfield et al. 2000; Greenfield and van Schalkwyk 2003; Greenfield and Miller 2004).

During the time of CH2, Ndongondwane was organised in a way that combined the CCP (Huffman 1990) with the self-sufficient early farming village model of Maggs (1984) or HHMP of Hall (Greenfield and van Schalkwyk 2003) (Fig. 2).

The mound area yielded a significant amount of dietary remains. Over 100 g of carbonised *Sclerocarya* (marula) nuts were retrieved (Maggs 1984), suggesting that this indigenous fruit also formed a part of the community's diet. Carbonised seeds of *Pennisetum typhoides* (bulrush millet) have been collected. This cultigen was an important grain crop in the EIA and has also been retrieved from other sites in the Thukela Valley (Maggs 1984). Analysis of faunal remains confirmed the domestic nature of the community that relied on mostly sheep and possibly goats as a source of meat and rarely on cattle or wild animals (Voigt and Von den Driesch 1984).

There is evidence that some of the earliest, large-scale, elephant-ivory processing in southern Africa took place at Ndongondwane and other larger settlements in the Lower Thukela River Valley. This is a few centuries before the Limpopo River valley sites were involved in the Indian Ocean trade routes. Ivory procurement was conducted over great distances and very well organised (Coutu et al. 2016).

The Ndongondwane charcoal assemblage was recovered from all contexts and all three cultural horizons. Previously the charcoal from the deepest horizon (CH1) which was only represented by the dung area at the time of analysis was investigated (House and Bamford 2019). The majority of the charcoal was identified to six recognizably different *Acacia* species. Only four other taxa were identified in very low numbers, two *Combretum* species, *Sclerocarya birrea*, and *Searsia pyroides*, indicating a preference for *Acacia* wood.

Here we focus on the charcoal assemblage from the middle horizon, CH2, but also include the charcoal recovered from the charcoal preparation area associated with CH3. An analysis of the charcoal from all eight localities in the

settlement was carried out, with the potential to provide answers to key questions about settlement organisation, wood selection, and use, as well as the relationship with the environment due to the wood-based economy. The location of particular species within the settlement affords an insight into each species' usage and suitability for cooking, heating, ceramic firing, iron forging and smithing, building, and other community activities. Comparison of charcoal data from the cultural horizons could potentially indicate subtle changes in vegetation composition over the period of occupation, possibly suggesting bush clearing for agricultural activities. The presence, location in multiple areas, or absence of local species indicates the inhabitants' preferences and avoidance of available resources. Non-local species potentially point to the importation of desirable species for specific purposes.

Materials and methods

Archaeological charcoal specimens, systematically collected from the middle horizon, signifying the phase of maximum growth and development of the Ndongondwane settlement, known as CH2, were available for examination and identification. These samples were collected during the 1995 to 1997 collaborative excavation of Greenfield and van Schalkwyk (van Schalkwyk et al. 1997; Greenfield et al. 2000). Sediments were dry sieved and then a large quantity of deposits were wet sieved and floated for charcoal recovery. Many sedimentary samples were collected for floatation, but most contained ash that disappeared in the floatation. Only the remnant charcoal was collectible. This is the first analysis and report on the CH2 (and charcoal preparation area from CH3) remains.

Charcoal samples were retrieved from excavation quadrants (1 × 1 m and 2 × 2 m) and separated stratigraphically from eight separate areas in the two activity zones: the central communal zone and the peripheral zone. In the central communal zone, arranged from north to south are the dung area, representing a livestock byre (kraal), comprising (1) dung east (DE) (quadrants Q2, S1, S3, S4, T1, T4, U1, U3, U5, and V4), reportedly a zone of human activity associated with the kraal; (2) dung west (DW) (quadrant R1), the livestock zone of the kraal; (3) transect 1 (T1), including a hut floor, (quadrants A14, A15, A16, A17, B10, B11, B12, B13, B14, B15, B16, B17, C8 to C17); and (4) the mound area (M) (quadrants G7, H11, I7, and I9). Samples from this area, previously analysed and identified by L. van Schalkwyk (Maggs 1984), were included for completeness and these samples were not re-analysed. The mound area was completely excavated by Loubser (1993) and no new specimens were available for collection during the 1995 to 1997 campaigns. The peripheral zone incorporates three domestic middens, (5) midden 1 (M1) (quadrants B3 and

D6); (6) midden 2 (M2) (quadrants Q26 and Q27), and (7) midden 3 (M3), also known as the ivory midden (quadrants A5, B16, D12, H5); and a special activity area, (8) the charcoal preparation area (CP), an area previously called the furnace (quadrant B124). This was a thick and dense concentration of charcoal at the southern periphery of the site spread across 10 m² (Greenfield et al. 2000). This area was also stratigraphically linked to the upper/surface level, CH3.

Since the charcoal samples were packaged according to the site area (e.g., dung east—DE) and the packet number, that notation will be used here, for example, DE110. Most packets contained between 20 and 50 pieces of charcoal and only two packets contained more than 100 pieces (CP221 and T1253). However, a vast amount of charcoal was retrieved, more than a thousand pieces. First, the charcoal samples in each packet were cursorily sorted into types based on easily identifiable morphological features such as vessel size and distribution, as well as ray width and height. Representative sample pieces of each type were examined and suitable pieces showing the transverse section (TS), tangential longitudinal section (TLS), and radial longitudinal section (RLS), needed for identification, were selected for photographing. After analysis, the types were identified and the different species in each packet were recorded. Each separate activity area was analysed separately.

Due to the nature of the charcoal samples (solid chunks), reflective light is required for surface observations of the characteristic anatomical features of wood. Reflected light optical microscopy was the preferred method, with magnifications from $\times 100$ to $\times 500$ required to observe the morphological features. If necessary, the selected charcoal pieces were snapped or fractured to reveal fresh surfaces of the three planes (TS, TLS, and RLS planes) required to exhibit the important wood diagnostic features. Charcoal specimens were mounted onto glass slides with “Prestik” tacky adhesive to make orientation easier and lend stability for viewing, with no further preparation required. An Olympus BX51 microscope equipped with Analysis® software and reflected light objectives was used to examine and photograph samples with extended focal imaging (EFI). Since diagnostic features such as ray cell type, inter-vessel and vessel-ray pits are visible under the light microscope, it was not necessary to use scanning electron microscopy (SEM). Although many anthracologists prefer SEM for identifying and documenting archaeological charcoal specimens, reflected light optical microscopy offers a great time-saving advantage when analysing large assemblages, such as that retrieved from Ndongondwane.

Use was made of existing literature documenting anatomical characteristics of hardwood to assist in identifying the important features (Barefoot and Hankins 1982; Wheeler et al. 1989) and the terminology used follows that of the IAWA Committee (1989).

To assist in the identification of the archaeological charcoal specimens, the observed features were directly compared with those of modern charcoal reference specimens in the Modern Charcoal Reference Collection housed at the Evolutionary Studies Institute at the University of the Witwatersrand. This is a collection of over 500 taxonomically identified, prepared modern charcoal samples, from southern Africa. This means that if a match is found in the collection, it is possible to identify the charcoal to species level. Photographs of specimens were also compared to data from other archaeological charcoal studies (for example, Allott 2005; Kromhout 1975). If an identification was not possible using the Modern Reference Collection, then the computer database for modern woods, Inside Wood, was consulted. Fragments were identified to family, genus, and species level where possible.

The fragile nature of charcoal which often readily fragments during burning and later excavation typically results in numerous pieces from what may have been a single coal. Therefore, the relative abundance of a taxon was determined by its distribution throughout the whole CH2 and not within individual packets or quadrants.

Results

Charcoal samples from CH2 deposits collected from eight separate activity areas (four from the central communal zone, three from the peripheral homestead zone, as well as those from the charcoal preparation area affiliated with CH3), within the Ndongondwane settlement, were subjected to anthracological analysis. CH2 charcoal samples from the mound area (M) have been previously dated to A. D. 867–974, midpoint A. D. 892 (Fowler and Greenfield 2009: pg 351).

In this study 99 packets were examined and the charcoal identified as belonging to 15 families, 23 genera, and 29 species (Table 1). The analysis of the four packets of charcoal samples retrieved from the mound area and identified by L. O. van Schalkwyk (Maggs 1984) has been included (as previously stated) to provide the most comprehensive data set (Table 2). This adds a family, genus, and species to the list, with the identification of *Olea europaea* L. sub-species *africana* (Mill.) P.S.Green.

The largest amount of charcoal was recovered from a domestic midden, midden 3 (M3), where most of the charcoal was identified as *Vachellia karroo*. The human activity area, dung east (DE), associated with the livestock byre or kraal, dung west (DW), contained the second largest amount of charcoal and was also the most species-rich area.

Specimens identified as belonging to the genus previously known as *Acacia* were found in all eight activity areas, and by far outnumbered the other identified taxa, comprising

Table 1 Characteristic anatomical features and identification of charcoal samples from Ndongondwane cultural horizon 2

Family	Taxon	Porosity	Vessels		Parenchyma		Rays		Fibres	Crystals	Special features	Ref				
			Distribution	Diameter (µm)	#/mm ²	Pits, thickening	Para-tracheal	Apo-tracheal					Width (in cells)	Height (µm)	#/mm	Ray cells
Anacardiaceae	<i>Harpophyllum caffrum</i> Benth	Diffuse	1–4 rm	100	<40	Small, alternate,	Scanty or absent	Absent	1–2 seriate	300–400	4–12	Proc square	Thin, septate	-	Tyloses	A 2; K 110
Anacardiaceae	<i>Sclerocarya birrea</i> (A.Rich.) Hochst. ssp <i>caffra</i> (Sond.) Kokwaro	Diffuse	1–2 rm	100–150	<20	Small, alternate	Scanty or absent	Rare	2–3(5) seriate	200–350	12	Proc square	Thin-medium, septate	In square ray cells	Tyloses may be present	A 15; K 155
Anacardiaceae	<i>Searsia rehmanniana</i> (Engl.) Moffett	Diffuse	≤4 rm	50	<40	Small, alternate,	Scanty or absent	Absent	1(-2) seriate	300–500	>12	Proc.squ upright	Thin, septate	-	Radial canals; tyloses	A14; K152
Apocynaceae	<i>Rauvolfia caffra</i> Sond	Diffuse	Solitary	125	40	Small, alternate	-	Diffuse in aggregates	2–5 seriate	400	4–12	Proc square, upright	Thick, septate	-	Latex; sheath cells	A21; K150
Araliaceae	<i>Cussonia spicata</i> Thunb	Diffuse	1–2 rm	50–100	±20	Medium, alternate,	Rare/absent	Absent	1–5 seriate	200–400	12	Proc squ upr	Thin	-	-	A23; K87
Capparidaceae	<i>Boscia albitrunca</i> (Burch.) Gilg & Gilg-Ben	Diffuse	>4 rm, clusters	50	>40	Small, alternate	Vascentric confluent	Absent	2–3 seriate	<300	4–12	Proc -	Medium, septate	-	Ray cells	K62
Combretaceae	<i>Combretum apiculatum</i> Sond	Diffuse	Solitary	50	20–40	Minute, alternate	Aliform	Absent	Uniseriate	150–200	>12	Proc squ	Thick, septate	Abundant in parench	Incl. phloem diffuse	A40; K77
Combretaceae	<i>C. erythrophyllum</i> (Burch.) Sond	Diffuse	Solitary	100	10–20	Minute, alternate	Vascentric confluent	Absent	Uniseriate	150–200	>12	Squ	Thick, septate	-	Incl. phloem diffuse	A41; K78
Combretaceae	<i>C. kraussii</i> Hochst	Diffuse	Solitary	100	20–40	Minute, alternate	Aliform confluent	Absent	Uniseriate	<200	>12	Proc squ upr	Thick, septate	Few in ray and parench. cells	Phloem not recorded	A43; K80
Combretaceae	<i>C. molle</i> R.Br. ex G.Don	Diffuse	Solitary	<100	10–20	Small, alternate	Aliform confluent	Absent	Uniseriate	>200	>12	Proc squ upr	Medium, bordered pits	Abundant in ray cells	Incl. phloem diffuse	A44
Ebenaceae	<i>Diospyros lycioides</i> Desf	Semi-ring	1–5 rm	<50	>40	Minute, alternate	Scanty	-	Uniseriate	<500	>12	Upr	Thin	-	-	A49; K89/90
Euphorbiaceae	<i>Croton sylvaticus</i> Hochst	Diffuse	2–4 rm	100	20–40	Small, alternate	Scanty	Diffuse	1–2 seriate	>600	>12	Procsqu 4-upr	Thin, septate	-	-	A63; K83

Table 1 (continued)

Family	Taxon	Porosity		Vessels		Parenchyma		Rays		Fibres		Crystals	Special features	Ref		
		Distribution	Diameter (µm)	#/mm ²	Pits, thickening	Para-tracheal	Apo-tracheal	Width (in cells)	Height (µm)	#/mm	Ray cells				Fibres	
Euphorbiaceae	<i>Spirostachys africana</i> Sond	> 4 rm	< 100	± 40	Medium, alternate, bordered	Absent	Diffuse or 1–2 banded	Uniseriate	200–300	> 12	Proc squ	1-squ/upr	Medium, bordered pits	Prismatic in ray cells	Latex	A71; K157
Fabaceae	<i>Schofia brachypetala</i> Sond	1–3 rm	100–150	10–20	Small, alternate, vestured	Scanty	–	2–4 seriate	200–300	4–12	Proc wide	–	Thin, septate	–	Vestured pits	A187; K154
Fabaceae	<i>Acacia</i> type 1 <i>Sen-egalia caffra</i> (Thunb.) P.J.H.Hurter & Mabb	Solitary	100–150	5–10	Minute, alternate, distinct borders, vestured	Vascentric to aliform	Absent	2–3 seriate	100–250	10–12	Proc narrow	–	Medium	–	Vestured pits; gum sels	A190; K40
Fabaceae	<i>Acacia</i> type 2 <i>Vachellia karroo</i> (Hayne) Banfi & Glasse	1–2 rm	± 100	15–20	Medium, alternate, distinct borders, vestured	Vascentric – aliform to confluent	Absent	4(–8) seriate	300–800	4–12	Proc narrow	–	Thick	Few small crystals in ray & vast-parench. cells	Vestured pits; gum sels	A192; K43
Fabaceae	<i>Acacia</i> type 3 <i>V. robusta</i> (Burch.) Kyalan-galiwa & Boatwright	Solitary	100–125	5–10	Small, alternate, distinct borders, vestured	Confluent	> 4 banded	4–6	< 500	4–12	Proc narrow	–	Thick, long	–	Parench. storied	A194; K45
Fabaceae	<i>Acacia</i> type 4 <i>V. sieberiana</i> (DC.) Kyal. & Boatwr	Solitary (or 1–2 rm)	100–200	10–15	Medium, alternate, distinct borders, vestured	Vascentric to confluent	–	10–12	> 500	4–12	Proc narrow	–	Medium	–	Gum in vessels	A195; K46
Fabaceae	<i>Acacia</i> type 5 <i>Vachellia</i> sp.	1–4 rm; clusters	80–120	10–15	Small, alternate, distinct borders, vestured	Aliform to confluent	Banded present	2–6	200–400	4–12	Proc narrow	–	Thin to thick	Chains in parench	Parench. storied	A196; K44, 47
Lauraceae	<i>Cryptocarya woodii</i> Engl	4–6 rm	± 50	± 40	Minute, alternate	Scanty	–	1–5 seriate	200–300	12	Proc squ upr	Upright	Medium, septate	–	–	A81; K84
Phyllanthaceae	<i>Bridelia micrantha</i> (Hochst.) Bail	1–4 rm	100	> 40	Minute, alternate	Scanty	Absent	1–2(–3) seriate	300	≤ 12	Proc squ upr	–	Thin, septate	–	–	A60; K64
Rhamnaceae	<i>Berberimia zeyheri</i> (Sond.) Grubov	1–4 rm, clusters	20–40	> 80	Small, alternate, bordered	Absent	1–2 banded	1–2(–3) seriate	200	> 12	Proc	1-upr	Thick	Prismatic in ray cells	–	A119; K59

Table 1 (continued)

Family	Taxon	Porosity	Vessels		Parenchyma			Rays		#/mm	Ray cells		Fibres	Crystals	Special features	Ref
			Distribution	Diameter (µm)	#/mm ²	Pits, thickening	Para-tracheal	Apo-tracheal	Width (in cells)		Height (µm)	Body				
Rhamnaceae	<i>Ziziphus mucronata</i> Willd	Diffuse	2–4 rm	<100	>40	Small, alternate, bordered	Vasicentric (aliform-confluent)	–	Uniseriate	200–300	>12	Procsqu	Thick	In ray cells	–	A121; K172
Rubiaceae	<i>Breonadia salicina</i> (Vahl) Hepper & J.R.I. Wood	Diffuse to diagonal	Solitary	>100	>40	Small, alternate	Absent	Absent	1–3 seriate	>500	>12	Proc squ	Thick	–	–	K50
Rutaceae	<i>Catodendrum capense</i> (L.f.) Thunb	Diagonal	2–4 rm	<100	>40	Small, alternate	Vasicentric-aliform confluent	Absent	1–5 seriate	300–400	4–12	Proc	Medium, few septate, long	–	Tyloses, fusiform parench	A143; K68
Rutaceae	<i>Ptaeroxylon obliquum</i> (Thunb.) Radlk	Diffuse	>4 rm	50	>40	Minute, alternate	Absent	Absent	Uniseriate	>100	>12	Proc	Thin	–	Resin or gum	A118; K146
Rutaceae	<i>Zanthoxylum capense</i> (Thunb.) Harv	Diffuse	1–3 rm	<50	>40	Medium, alternate	Absent	1–4 banded	Uniseriate	100–200	>12	Proc short	Thick	–	–	A147
Sapotaceae	<i>Chrysophyllum viridifolium</i> J.M.Wood & Franks	Diffuse	>4 rm	100	>40	Minute, alternate	Absent	Diffuse in aggregate	1–4 seriate	200–300	±12	Procupr	Medium to thick, septate	In ray cells	–	A151; K74
Stilbaceae	<i>Halleria lucida</i> L	Semi-ring	1–4 rm	50	>40	Minute, alternate	Absent	Diffuse	2–5 seriate	100–400	4–12	Proc	Thin, septate	–	–	A158; K109

rm = radial multiples

A = Allott

K = Krom-hout

Table 2 Identification and distribution of charcoal woody species per area. Charcoal was retrieved from Ndongondwane cultural horizon 2 and the charcoal preparation area from cultural horizon 3

Taxon	Central communal zone				Peripheral zone			
	Dung east	Dung west	Transect 1	Mound	Midden 1	Midden 2	Midden 3	Charcoal prep
Anacardiaceae								
<i>Harpephyllum caffrum</i>	X							
<i>Sclerocarya birrea</i> ssp. <i>caffra</i>	X	X	X	X				
<i>Searsia rehmanniana</i>	X			X		X		
Apocynaceae								
<i>Rauvolfia caffra</i>	X							
Araliaceae								
<i>Cussonia spicata</i>	X							
Capparaceae								
<i>Boscia albitrunca</i>			X					
Combretaceae								
<i>Combretum apiculatum</i>	X					X		X
<i>C. erythrophyllum</i>	X							
<i>C. kraussii</i>	X							
<i>C. molle</i>					X			
Ebenaceae								
<i>Diospyros lycioides</i>			X					
Euphorbiaceae								
<i>Croton sylvaticus</i>					X			
<i>Spirostachys africana</i>			X		X		X	
Fabaceae								
<i>Schotia brachypetala</i>	X							
<i>Acacia</i> type 1 <i>Senegalia caffra</i>	X	X			X	X	X	
<i>Acacia</i> type 2 <i>Vachellia karroo</i>	X	X	X	X	X	X	X	X
<i>Acacia</i> type 3 <i>V. robusta</i>		X	X				X	X
<i>Acacia</i> type 4 <i>V. sieberiana</i>	X		X			X	X	X
<i>Acacia</i> type 5 <i>Vachellia</i> sp.	X	X	X	X	X			X
Lauraceae								
<i>Cryptocarya woodii</i>	X							
Oleaceae								
<i>Olea europaea</i> ssp. <i>africana</i>				X				
Phyllanthaceae								
<i>Bridelia micrantha</i>	X							
Rhamnaceae								
<i>Berchemia zeyheri</i>							X	
<i>Ziziphus mucronata</i>	X				X	X		
Rubiaceae								
<i>Breonadia salicina</i>						X		
Rutaceae								
<i>Calodendrum capense</i>	X							
<i>Ptaeroxylon obliquum</i>					X			
<i>Zanthoxylum capense</i>						X		
Sapotaceae								
<i>Chrysophyllum viridifolium</i>					X			

Table 2 (continued)

Taxon	Central communal zone				Peripheral zone			
	Dung east	Dung west	Transect 1	Mound	Midden 1	Midden 2	Midden 3	Charcoal prep
Stilbaceae								
<i>Halleria lucida</i>			X					
# of packets	24	2	15	4	4	4	49	1
Total # pieces	418+	75	217+	By L. van Schalkwyk (Maggs 1984)	131	67	500+	200+

67% of the CH2 assemblage (69 of 103 packets) (Table 2). The wood of this genus is characterised by diffuse-porous wood; simple perforation plates; inter-vessel pits alternate and vested; vessel-ray pits with distinct borders; paratracheal parenchyma varies from vasicentric to aliform to confluent (Robbertse et al. 1980). This genus was readily identifiable in the charcoal assemblage by the radial arrangement of the long, narrow, homocellular, procumbent ray cells (Fig. 3). Thereafter, separation of the species was determined by ray width, ray height, and vessel-parenchyma distribution. Four confirmed species of the “*Acacia* type” were identified as *Senegalia caffra*, *Vachellia karroo*, *V. robusta*, and *V. sieberiana* (Table 1; Fig. 3).

Five taxa, other than *Acacia*, were found in multiple areas (three or more), namely, *Sclerocarya birrea* sub-species *caffra* and *Searsia rehmanniana* of the family Anacardiaceae, *Combretum apiculatum* of the Combretaceae, *Spirostachys africana* of the Euphorbiaceae, and *Ziziphus mucronata*, a member of the Rhamnaceae (Table 1; Fig. 4).

Presently, these taxa grow in a variety of habitats, occurring in a range of geographical regions and have diverse wood characteristics and properties (Table 3). The species abundance (number of packets in which the species was identified, per area) within the site is presented in Table 3. All the identified taxa are still found in KZN today (Table 3).

The most abundant species was identified to be *Vachellia karroo*. It was found in all contexts and 53 of the total 103 packets contained this species, 51%. The exception was in T1, which was described as a hut floor of burned dhaka, where the other identified *Acacia* species were more dominant.

Central communal zone

A greater diversity of woody taxa were identified in the four separate areas of the central zone, compared to those of the peripheral zone. This included 23 species from 14 different families and 18 genera (Table 2). Most of the families, 11 out of the 14, were represented by a single taxon. A member of the Anacardiaceae, *Sclerocarya birrea* sub-species *caffra*, better known as the marula, was found throughout this zone, in all four areas, but was not identified in the peripheral zone (Table 2).

Dung East (DE)

A total of 24 packets of charcoal were examined. The charcoal was identified as belonging to nine families, 13 genera, and 17 species (Table 2). This was the most species-rich area. *Vachellia karroo* was the most abundant species and 15 of the 24 packets contained *V. karroo* (Table 3). A number of species, confined to this area, shared certain properties. *Harpephyllum caffrum*, *Rauvolfia caffra*, *Cussonia spicata*, *Cryptocarya woodii*, and *Bridelia micrantha* all prefer growing in wetter habitats and are all used in traditional medicine. With the exception of *C. spicata*, they all produce strong, good general-purpose wood (Table 3).

Dung West (DW)

This area contained two packets and the charcoal was identified as belonging to two families, three genera, and five species (Table 2). Both packets contained *Vachellia karroo* (Table 3). Most of the charcoal belonged to species from the genus *Acacia*. All the *Acacia* species identified in the assemblage, except *V. sieberiana*, were represented.

Transect 1 (T1)

A total of 15 packets of charcoal were examined. The charcoal was identified as belonging to five families, six genera, and nine species (Table 2). Two of the 15 packets contained *Vachellia karroo* (Table 3). The drought-resistant species *Boscia albitrunca* and the hut-building timber *Diospyros lycioides*, together with the culturally important traditional medicine tree, *Halleria lucida*, were restricted to this area (Tables 2 and 3).

Mound area (M)

The four packets of charcoal were examined by L. O. van Schalkwyk (Maggs 1984). The charcoal was identified as belonging to three families, four genera, and five species (Table 2). Three of the four packets contained *Vachellia karroo*. All the species identified in this area were found in the rest of the assemblage or also identified in this study, with the exception of *Olea europaea* sub-species *africana*.

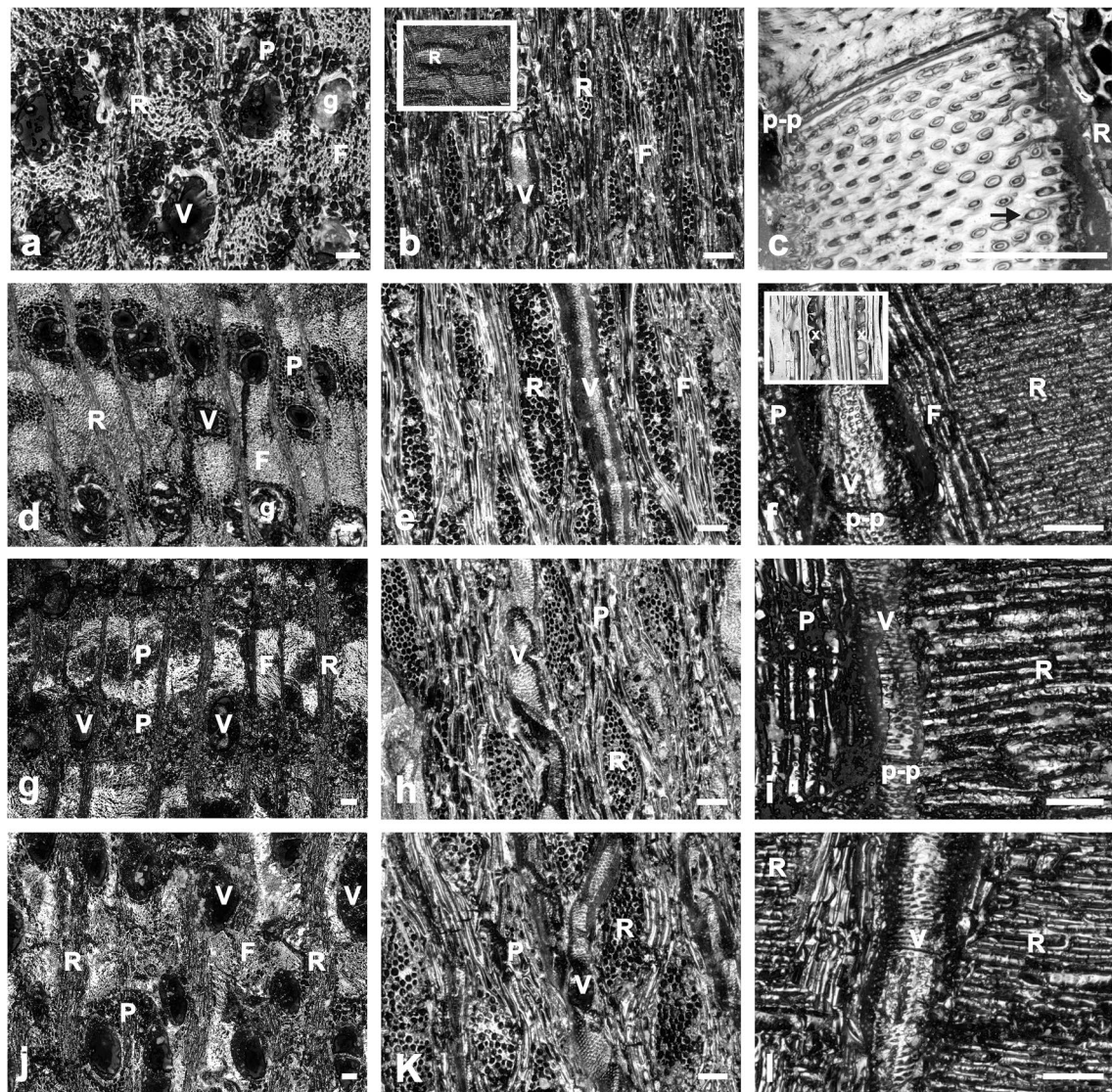


Fig. 3 Highlighting the distinctive anatomical features of some *Acacia* species from Ndongondwane Cultural Horizon2. *Senegalia caffra*: **a** TS vessels solitary, diameter~150 μm , gum present in vessels, parenchyma vasiscentric to aliform; **b** TLS rays 2–3 seriate, paratracheal parenchyma vasicentric to aliform, short (100–250 μm high). **Insert**: RLS rays homocellular with narrow procumbent cells. **c** TLS perforation plate simple, vessel pits alternate, minute with distinct borders and vested (arrow). *Vachellia karroo*: **d** TS vessels arranged in 1–2 radial multiples, often in groups of 2, vessel diameter~100 μm , gum recorded in some vessels, parenchyma vasicentric-aliform to confluent. **e** TLS rays 4–8, usually 4 seriate, 300–800 μm high. **f** RLS rays homocellular with narrow

procumbent cells, fibres with thick walls, adjacent to rays. **Insert**: TLS small prismatic crystals in parenchyma cells. *Vachellia robusta*: **g** TS vessels solitary, vessel diameter~125 μm , paratracheal parenchyma confluent, apotracheal parenchyma >4 banded. **h** TLS rays 4–6 seriate, <500 μm high. **i** RLS rays homocellular with narrow procumbent cells, paratracheal parenchyma storied. *Vachellia sieberiana*: **j** TS vessels solitary, vessel diameter 100–200 μm , parenchyma vasicentric to confluent. **k** TLS wide rays, 10–12 seriate, >500 μm high. **l** RLS ray cells all narrow procumbent. V, vessel; R, ray; P, parenchyma; F, fibres; x, crystals; g, gum; p-p, perforation plate. Scale bars=50 μm

Peripheral homestead zone

The three domestic middens in this zone yielded 16 species from eight different families and 12 genera (Table 2). Two families, Rubiaceae and Sapotaceae, were identified in this zone alone; however, they each were represented only by a single taxon (Table 2).

Midden 1 (M1)

Four packets of charcoal were examined. The charcoal was identified as belonging to six families, eight genera, and nine species (Table 2). Two of the four packets contained *Vachellia karroo* (Table 3). Four species were only identified in this area, namely, *Combretum molle*,

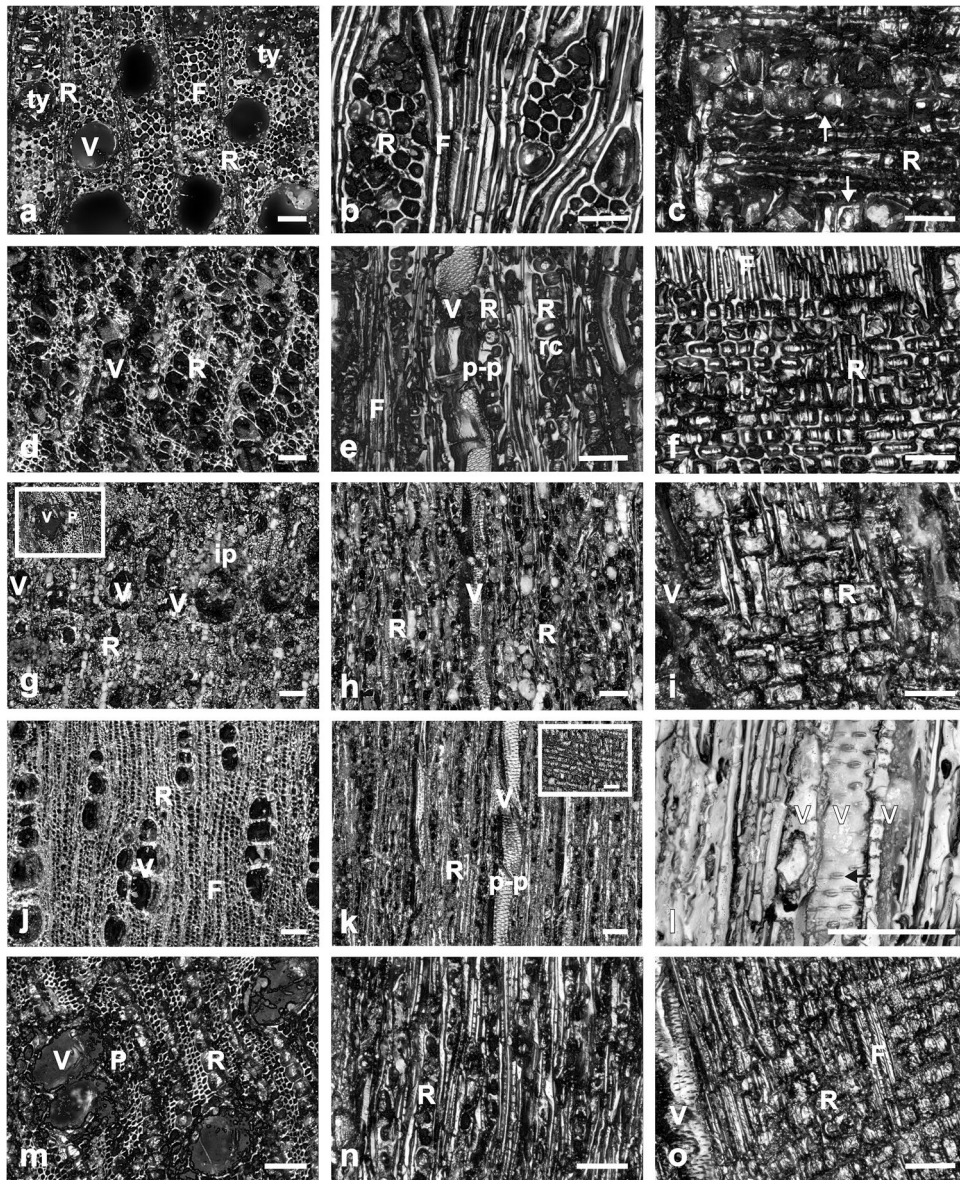


Fig. 4 Highlighting the distinctive anatomical features of some more abundant (not *Acacia*) woody species from Ndongdondwane Cultural Horizon 2. *Sclerocarya birrea* sub-species *caffra*: **a** TS vessels in 1–2 radial multiples, diameter ~150 μm , tyloses present, paratracheal parenchyma scanty or absent. **b** TLS rays 3–5 seriate, short (200–350 μm high). **c** RLS rays heterocellular with narrow procumbent body cells and square marginal cells, some with crystals (arrows). *Searsia rehmanniana*: **d** TS vessels arranged in ≤ 4 radial multiples, diameter ~50 μm , tyloses recorded in some vessels, parenchyma absent. **e** TLS rays 1(–2), usually uniseriate, 300–500 μm high, radial canals recorded. **f** RLS rays heterocellular with procumbent, square, and upright cells, fibre septate, with thin walls, adjacent to rays. *Combretum apiculatum*: **g** TS vessels solitary, diameter ~50 μm , included

phloem recorded. Insert: TS paratracheal parenchyma aliform. **h** TLS rays uniseriate, short, 150–200 μm high. **i** RLS rays heterocellular with procumbent and square cells. *Spirostachys africana*: **j** TS vessels in ≥ 4 radial multiples, diameter 50–75 μm . **k** TLS rays uniseriate, ~300 μm high. Insert: RLS ray body cells procumbent and square with 1 row marginal upright cells. **l** TLS vessels in radial multiples with bordered pits (arrow). *Ziziphus mucronata*: **m** TS vessels in 2–4 radial multiples, diameter <100 μm , parenchyma vascentric to aliform. **n** TLS rays uniseriate, 200–300 μm high. **o** RLS rays heterocellular with procumbent and square cells. V, vessel; R, ray; P, parenchyma; F, fibres; ty, tyloses; rc, radial canal; ip, included phloem; p-p, perforation plate. Scale bars = 50 μm

Croton sylvaticus, *Ptaeroxylon obliquum*, and *Chrysophyllum viridifolium* (Table 2). The latter has edible fruit, but the other three all have important medicinal value.

Midden 2 (M2)

A total of four packets of charcoal were examined. The charcoal was identified as belonging to six families, seven

Table 3 Modern wood taxa: form, geographical distribution, plant uses, and abundance in Ndongondwane cultural horizon 2 (Pooley 1997; CP&CP; Coates Palgrave and Coates Palgrave 2002; vW&vW, van Wyk and van Wyk 2013)

Taxon	Common names (English, isiZulu), Form (Pooley 1997; vW&vW 2013)	Geographical range in South Africa and neighbouring countries (CP&CP 2002; vW&vW 2013)	Uses (Pooley 1997; CP&CP 2002; vW&vW 2013)	Abundance (number of packets per activity area)
Anacardiaceae				
<i>Harpephyllum caffrum</i>	Wild-plum, umgwenya medium, evergreen tree	EC, KZN, LP, MP, Esw, Moz, Zim coastal forests	Edible fruit; general purpose timber; bark medicinal	DE112, DE227
<i>Sclerocarya birrea</i> ssp <i>caffra</i>	Marula medium to large, deciduous tree	KZN, LP, MP, Bts, Esw, Moz, Zim bushveld, woodland, drought resistant	Fruit edible and for brewing beer; wood used for implements; bark important medicinally	DE114, DE232; DW121; T1 241; M151, M153
<i>Searsia rehmanniana</i>	Blunt-leaved currant small tree	EC, KZN, MP, WC, Esw, Moz <i>Acacia</i> thornveld in KZN	unknown	DE120; M153; M2 220
Apocynaceae				
<i>Rauvolfia caffra</i>	Quinine tree, umHlambamanzi large, evergreen tree	EC, G, KZN, LP, MP, NW, WC, Esw coastal forests, wet areas, hydrophyte	Wood used for drums, general purpose; bark and latex used medicinally	DE116
Araliaceae				
<i>Cussonia spicata</i>	Kiepersol, cabbage tree, umsenge small to medium, evergreen tree	EC, G, KZN, LP, MP, NW, WC, Moz, Zim wide range, wetter areas	Leaves and roots used medicinally; wood soft, decays easily	DE114
Capparaceae				
<i>Boscia albitrunca</i>	Shepard's tree small to medium tree	FS, G, KZN, LP, MP, NW, NC, Bts, Esw, Moz, Zim drought resistant	Roots and fruit edible; roots and leaves used medicinally; wood for carving	T1 242; T1 251
Combretaceae				
<i>Combretum apiculatum</i>	Red bushwillow, umbondwe small to medium, deciduous tree	G, KZN, LP, MP, NW, Bts, Moz, Nam, Zim savanna species, drought resistant	Hard, termite resistant wood, firewood, charcoal, fencing posts; leaves and ash used medicinally	DE110; M2 220, CP221
<i>C. erythrophyllum</i>	River bushwillow, umhlalavane medium to large, deciduous tree	EC, FS, G, KZN, LP, MP, NW, NC; Zim riverine species, drought resistant	Wood used for fencing posts, grain mortars, carving; roots used medicinally and as a dye	DE110, DE236
<i>C. kraussii</i>	Forest bushwillow, uhwabhu medium to large, semi-deciduous tree	EC, KZN, LP, MP, Esw forests to dense woodland, drought resistant	Young stems for basket weaving, tough wood; medicinal plant	DE120
<i>C. molle</i>	Velvet bushwillow, umBondwe-omhlope small to medium, deciduous tree	FS, G, KZN, LP, MP, NW; Moz, Nam, Zim open woodland, bushveld, quartzite formations	Wood termite resistant, fence posts and implements; important traditional medicine tree; dyes from leaves and roots	M1 202

Table 3 (continued)

Taxon	Common names (English, isiZulu), Form (Pooley 1997; vW&vW 2013)	Geographical range in South Africa and neighbouring countries (CP&CP 2002; vW&vW 2013)	Uses (Pooley 1997; CP&CP 2002; vW&vW 2013)	Abundance (number of packets per activity area)
Ebenaceae				
<i>Diospyros lycioides</i>	Star-apple, Umbulwa shrub to small tree,	EC, FS, G, KZN, LP, MP, NW, NC rocky, well-drained soil, widely distributed in southern Africa	Wood used for hut building; edible fruit, beer making; dye from roots; medicinal plant	T1 247, T1 254
Euphorbiaceae				
<i>Croton sylvaticus</i>	Forest fever-berry, umHloshazane large tree	EC, KZN, LP, MP, Esw coastal and inland forests	Poisonous fruit; wood soft and easy to work, green wood burns hot; leaves and bark used medicinally; bark used as fish poison	M1 216
<i>Spirostachys africana</i>	Tambooti, umThombothi medium, semi-deciduous tree	G, KZN, LP, MP, NW, widespread in southern Africa except Lesotho, groups of trees along watercourse, drought resistant	Toxic latex used for fishing to anaesthetise fish; very strong wood, used in hut building, toxic smoke used as a fumigant; traditional medicine plant	T1 253; M1 201, M1 202; M3 158, M3 166, M3 175, M3 188, M3 190
Fabaceae				
<i>Schotia brachypetala</i>	Tree fuchsia, uvovovo medium to large tree	EC, G, KZN, LP, MP, Moz, Zim warm, dry areas, bushveld, woodland, scrub forest, river banks	Good quality strong wood; bark and roots medicinal; edible seeds	DE114
<i>Acacia</i> type 1 <i>Senegalia caffra</i>	Common hook-thorn, umTholo small to medium, deciduous tree	EC, FS, G, KZN, LP, MP, NW, WC wide range of habitats, tolerant of acidic soils	Hard dense wood; many traditional uses: fuel, fence posts, tanning, believed to be a lucky tree; medicinal uses	DE110, DE112, DE114, DE120, DE130, DE238; DW128; M1 203; M2 217, M2 219; M3 158, M3 160, M3 163, M3 175, M3 188, M3 194
<i>Acacia</i> type 2 <i>Vachellia karroo</i>	Sweet-thorn, umuNga small to medium tree	EC, G, KZN, MP, WC widespread and range of habitats, invasive in overgrazed areas, drought resistant	Firewood; gum edible; leaves and pods for fodder; bark, leaves and gum used medicinally	DE110, DE112, DE114, DE116, DE120, DE125, DE130, DE132, DE135, DE138, DE143, DE225, DE227, DE232, DE236; DW121, DW128; T1 249, T1 250; M141, M147, M153; M1 203, M1 216; M2 102, M2 217, M2 219, M2 220; M3 154, M3 156, M3 158, M3 159, M3 160, M3 164, M3 167, M3 168, M3 170, M3 171, M3 172, M3 173, M3 174, M3 175, M3 177, M3 185, M3 188, M3 189, M3 190, M3 192, M3 195, M3 197, M3 198; CP221
<i>Acacia</i> type 3 <i>V. robusta</i>	Broad pod, robust thorn, umngamanzi small to medium, deciduous tree	EC, FS, G, KZN, LP, MP, NC, NW, Esw, Moz, Nam dry savannas, drought resistant	Firewood; roots, bark and leaves used in traditional medicine	DE110, DE132; DW128; T1 246, T1 249; M1 203; M3 155; CP221

Table 3 (continued)

Taxon	Common names (English, isiZulu, Form (Pooley 1997; vW&vW 2013)	Geographical range in South Africa and neighbouring countries (CP&CP 2002; vW&vW 2013)	Uses (Pooley 1997; CP&CP 2002; vW&vW 2013)	Abundance (number of packets per activity area)
<i>Acacia</i> type 4 <i>V. sieberiana</i>	Paper bark-thorn, umKhamba large, deciduous tree	G, KZN, LP, MP; Esw, Bots, Nam, Zim wooded grassland and along riverbanks, drought resistant	Leaves, bark, roots used in traditional medicine; twine or string from inner bark; gum edible and adhesive	DE110, DE112, DE114, DE116, DE120, DE232; M2 220; M3 154, M3 157; T1 250, T1 251, T1 252; CP221
<i>Acacia</i> type 5 <i>Vachellia</i> sp.				DE110, DE125, DE135, DE138, DE140, DE148, DE223, DE225, DE227; DW128; T1 240, T1 244, T1 250; M151; M1 203; M2 102, M2 219; CP221
Lauraceae				
<i>Cryptocarya woodii</i>	Cape laurel, umNgcabe small to medium tree	EC, KZN, MP, Moz forests and wooded valleys, wetter areas	Very hard strong wood; traditional medicine tree; magical properties	DE239
Phyllanthaceae				
<i>Bridelia micrantha</i>	Mitzeeri (Afrikaans) medium to large, deciduous tree	EC, KZN, LP, MP, Zim coastal, riverine and swamp forest, wetter areas	Wood resistant to termites; bark, roots and leaf sap used medicinally	DE112
Rhamnaceae				
<i>Berchemia zeyheri</i>	Red ivorywood, umNcaka medium, semi-deciduous tree	EC, KZN, LP, MP, Moz, Zim bushveld, woodland, rocky areas, along rivers, drought resistant	Hard strong wood for fence posts, carving implements; edible fruit; cultural (royal tree) and medicinal uses	M3 158
<i>Ziziphus mucronata</i>	Buffalo thorn, umphafa small to medium tree	EC, FS, G, KZN, LP, MP, NW, NC southern Africa summer rainfall zone, indicates groundwater	Edible fruit; roots, bark and leaves medicinal properties; cultural and ritual uses	DE113; M1 201, M1 216; M2 220
Rubiaceae				
<i>Breonadia salicina</i>	African teak, umfula small to large evergreen tree	KZN, LP, MP, Moz, Esw, Zim riverine fringe forest	Hard, heavy, durable wood, termite resistant; bark medicinal	M2 220
Rutaceae				
<i>Calodendrum capense</i>	Wild chestnut, umbhaba large tree	EC, G, KZN, LP, MP, NW, WC, Esw forests and kloofs	Good general purpose wood; bark used in traditional medicine; seed oil for soap and magical properties	DE112
<i>Ptaeroxylon obliquum</i>	Sneezeewood large tree	EC, KZN, LP, MP, WC, Moz woodland, scrub forest and evergreen montane forest Protected tree	Very hard, durable wood; used for fuel (burns hot), fence posts, hut construction; used traditionally for medicine and ritual	M1 216

Table 3 (continued)

Taxon	Common names (English, isiZulu), Form (Pooley 1997; vW&vW 2013)	Geographical range in South Africa and neighbouring countries (CP&CP 2002; vW&vW 2013)	Uses (Pooley 1997; CP&CP 2002; vW&vW 2013)	Abundance (number of packets per activity area)
<i>Zanthoxylum capense</i>	Small knobwood, umnungamabele small tree	EC, FS, G, KZN, LP, MP, NW, WC, Zim dry woodland, rocky slopes, drought resistant Protected tree	Many traditional medicine uses, widely used	M2 220
Sapotaceae				
<i>Chrysophyllum viridifolium</i>	Fluted-milkwood large tree	EC, KZN, Esw, Moz evergreen lowland forest, coastal forest	Edible fruit	M1 202
Stilbaceae				
<i>Halleria lucida</i>	Tree fuchsia, white olive, indomela evergreen, large shrub to tree	EC, FS, G, KZN, LP, MP, NW, NC, WC, Esw, Lth, Zim wide range of habitat	Sticks for starting fire by friction; traditional medicine and ritual, cultural uses	T1 240

List of abbreviations: EC, Eastern Cape; FS, Free State; G, Gauteng; KZN, KwaZulu-Natal; LP, Limpopo; MP, Mpumalanga; NC, Northern Cape; NW, North West; WC, Western Cape; Bis, Botswana; Esw, Eswatini; Lth, Lesotho; Moz, Mozambique; Nam, Namibia; Zim, Zimbabwe;

DE, dung east; DW, dung west; TI, transect 1; M, mound; M1, midden 1; M2, midden 2; M3, midden 3; CP, charcoal preparation

genera, and eight species (Table 2). All four packets contained *Vachellia karroo* (Table 3). Two good general-purpose and medicinally useful trees, *Breonadia salicina* and *Zanthoxylum capense*, were only identified in this area.

Midden 3 (M3)

A total of 49 packets of charcoal were examined. The charcoal was identified as belonging to three families, four genera, and six species (Table 2). Twenty-three of the 49 packets contained *Vachellia karroo* (Table 3). *Berchemia zeyheri*, currently growing in the area, was only found in this midden.

CH3 peripheral activity area

Charcoal preparation area (CP)

Only one packet of charcoal, with over 100 pieces was retrieved. The charcoal was identified as belonging to two families, two genera, and five species (Table 2). A majority of the charcoal was identified as *Acacia* wood, and most pieces were identified as *Vachellia karroo*.

Woody species distribution by potential use

In this section, the use of woody taxa is considered to determine if there are spatial patterns of exploitation related to possible function.

Most trees have multiple uses (for example, for fuel, charcoal production, medicine, carving, building, or construction, as well as having edible parts). The same species may have served different purposes in the separate locations (Table 3).

Medicinal use. All species identified in the charcoal assemblage have parts (for example, bark, roots, leaves, or sap) that are used medicinally (Watt and Breyer-Brandwijk (1962) (Table 3).

Cooking and heating. It is assumed that all woody species identified from the charcoal assemblage were probably used as fuel or firewood for cooking and heating. *Halleria lucida*, found only in transect 1, is especially known for its use in starting fires by friction (Coates Palgrave and Coates Palgrave 2002; van Wyk and van Wyk 2013).

Iron working. Both *Croton sylvaticus* and *Ptaeroxylon obliquum* have wood that is known to burn hot (Coates Palgrave and Coates Palgrave 2002) and both were only found in midden 1, a domestic area where iron forging and smithing occurred. Species found in the charcoal preparation area are the *Acacia* species, especially *Vachellia karroo*, as well as *Combretum apiculatum*. These woods are known to produce good charcoal and not burn down quickly to ash (van Wyk and van Wyk 2013). They would be very suitable for iron working, including smelting.

Fencing. *Vachellia karroo* was the most common taxon identified in dung west, the livestock byre. Here it would

have been used for fencing, and the leaves, flower buds, and seed pods as fodder (Pooley 1997; van Wyk and van Wyk 2013).

Construction. Woods traditionally used in hut construction were found in the following areas. *Diospyros lycioides* (van Wyk and van Wyk 2013) found in transect 1, *Ptaeroxylon obliquum* (Coates Palgrave and Coates Palgrave 2002) found in Midden 1, and *Spirostachys africana* (Coates Palgrave and Coates Palgrave 2002) found in middens 1 and 3 and transect 1. It is unlikely that *Spirostachys africana* would have been used as firewood for cooking as toxic smoke is released during burning of this species (van Wyk et al. 2002). As well as construction purposes, it may have been used as a fumigant against parasites in households and other structures (Watt and Breyer-Brandwijk 1962).

Toxins. Two species of Euphorbiaceae, *Spirostachys africana* and *Croton sylvaticus*, have poisonous latex (Watt and Breyer-Brandwijk 1962) used for fishing to stun fish (Coates Palgrave and Coates Palgrave 2002). These species were mainly found in the domestic peripheral zone.

Edible parts. Numerous species with edible parts were found distributed throughout the site. *Diospyros lycioides* and *Sclerocarya birrea* which have edible fruit also used in beer brewing (van Wyk and van Wyk 2013) were both found in transect 1.

Discussion

Anthracology or charcoal identification is based on wood anatomy. Plant families share characteristic morphological features which come into play in the identification process. Many families were identified in the Ndongondwane charcoal assemblage, but most are represented by a single taxon, highlighting the need for species level identification. With knowledge of species specific habitat, distribution, ecology, uses, and wood properties, valuable ethnobotanical information can be gleaned. Although identification to species level is common in low diversity vegetation regions, in environments of high plant diversity, such as sub-tropical KZN, identification to species level relies on direct comparison with specimens in a modern charcoal reference collection. With our ever-improving modern reference collection and knowledge of the vegetation in the region, we are now able to make more accurate identifications and it was possible to identify most of the Ndongondwane charcoal assemblage to species level. Archaeological charcoal, together with other micro plant fossils (for example, pollen and phytoliths), provides data for reconstruction of past environments and climate in sites with occupation records spanning several hundreds or thousands of years. In short-term occupation archaeological sites with little stratification such as Ndongondwane, charcoal is the main archive of

the local vegetation, as it would have been collected in the vicinity of the settlement by the inhabitants. Identification of charcoal from separate spaces in these settlements provides archaeoethnobotanical information, such as domestic, ritual, medicinal, and cultural uses of wood, as well as providing evidence of the past landscape and foraging area (or distance from the settlement where wood was collected).

The archaeological charcoal recovered from the deepest horizon of Ndongondwane (CH1) identified by House and Bamford (2019) found that more than 80% of the charcoal belonged to the genus previously known as *Acacia*. The most abundant species were *Vachellia karroo*, *Senegalia caffra*, and *V. tortilis*, respectively. Only four taxa other than *Acacia* were identified and only in small numbers (for example, *Combretum* species). All identified species, however, are traditionally used for fencing (Liengme 1981; Pooley 1997; van Wyk and van Wyk 2013). This implies that wood was preferentially selected by the inhabitants for the purpose of constructing livestock enclosures and given the thick dung deposits surrounded by post holes in the dung area confirm that livestock were protected in specifically built enclosures at the site. The dominance of the thorny *Acacia* species in the dung area is indicative of their suitability for this application, as well as being readily available in the surroundings. CH1 was during the time of settlement establishment when the mound area and dung area most likely represented the full extent of the activities on the site. The dung area, comprised of livestock byre, dung west (DW), and an adjacent cultural activity area, dung east (DE), all enclosed within a post and thorn-bush fence. It was suggested that the dung area was burned at the end of CH1 for hygienic reasons when the dung became too deep, in the interest of animal health. It is presumed to have been rebuilt in CH2, and that the wooden fencing enclosing the byre and activity area may have accounted for most of the charcoal assemblage for CH1. Dung east was the main cultural activity area in CH1, assumed to be carried out by male members of the society because of evidence that ivory work (ivory chips, charred ivory), iron forging (slag deposits/concentrations, charcoal, and forge hearths), and possibly other ritual activities took place (Loubser 1993; Greenfield and van Schalkwyk 2003; Greenfield and Miller 2004).

The focus of the current study was identifying the charcoal from CH2. In contrast to CH1, 30 different species (including those identified by L. O. van Schalkwyk from the Mound Area) were identified in the charcoal assemblage of CH2. *Acacia* was still the most common taxon, making up 67%, with 51% identified as *Vachellia karroo*. Charcoal was recovered from all contexts in this middle horizon which represents the phase of maximum extent and occupancy.

As previously described, the site is arranged in a central communal zone surrounded by a peripheral household zone (Fig. 2). The central zone comprised three activity areas,

from north to south: (1) the dung area enclosing a livestock byre (DW) and the male activity area where iron forging and smithing took place (DE); (2) transect 1 (T1), with a burned dhaka hut floor which represents a meeting zone as well as a space for practising cultural activities (for example, iron forging); and (3) the mound area (M), the main area for cultural and ritual practises. At this stage of the settlement (CH 2), households were established in three different locations, represented by middens (M1, M2, M3) in the periphery zone. Households also stored grain and were involved in important cultural/settlement activities for example, iron smithing and forging and ceramic manufacture.

Central communal zone

Greenfield and Miller (2004) proposed that the main cultural practices (of dung east in CH1) moved to the mound area in CH2. This anthracological study found that in CH2, dung east, the human activity side of the larger dung area, was the most species-rich area. Apart from an abundance of *Acacia* species, a number of important medicinal species were found in this locality exclusively. In addition, these were species that grow in wetter, forested areas and would have been sourced from further afield in the small areas of coastal belt vegetation and scarp forest, within reasonable wood foraging limits (Fig. 1), for example, *Harpephyllum caffrum*, *Rauvolfia caffra*, *Cussonia spicata*, *Cryptocarya woodii*, *Bridelia micrantha*, and *Calodendrum capense*. Other drought-tolerant species, with various cultural, medicinal, and constructional uses identified in this area, were *Combretum erythrophyllum*, *C. kraussii*, and *Schotia brachypetala*. This indicates that dung east most likely remained an important focus area of cultural activity during the CH2 phase.

Dung west, the livestock enclosure part of the dung area, contained a majority of *V. karroo*, a tree used as fodder for stock, as well as fencing, representing continuity in this area's usage between CH1 and CH2.

Transect 1 (T1), described as a burned dhaka hut floor, was the largest structure built on the site (van Schalkwyk et al. 1997). This area yielded the least amount of *V. karroo*, but trees used for many different purposes were identified in this area alone, for example, *Diospyros lycioides* has edible fruit used in beer brewing; roots are used for dye, cleaning teeth, and in many medicinal remedies; and the wood is used for carving spoons and hut building (Coates Palgrave and Coates Palgrave 2002; van Wyk and van Wyk 2013). The drought-resistant species *Boscia albitrunca* was restricted to this area alone. There may be many reasons for burning a hut, for example, breaking of taboos or other cultural norms. In the terms of historic, southern African, traditional societies, a drought (dry for more than three consecutive seasons) may be caused by farmers breaking the cultural rules of the

community (Huffman 2009). There is LIA evidence from the Shashe-Limpopo River Basin (in the Mapungubwe region) in the southern African summer rainfall zone that inhabitants burned their grain bins and houses in a ritual to correct the breaking of rules that caused the drought (Huffman 2009). Thus, one possible explanation is that burned dhaka structures, such as the burned dhaka hut floor (T1) of Ndongondwane, and burned dhaka remains found at KwaGandaganda dated to the Ndongondwane phase of occupation (Whitelaw 1994) qualify as a cultural proxy for drought (Huffman 2009, 2010).

Peripheral homestead zone

During CH2, the main focus of iron work (ore preparation and forging) shifted to the peripheral domestic areas of midden 1 (M1), as well as a small amount that took place in midden 3 (M3) (Greenfield and Miller 2004). Midden 1 is believed to be a main site of iron working in CH2 because of the volume of raw ore and slag recovered as well as the concentration of forge bases or hearths in this location (Greenfield and Miller 2004). Although only a small amount of archaeological charcoal was found here, the woody species they represented were diverse. Many of these species are not particularly useful for charcoal production, but two species that have good fuel wood that burns hot, *Ptaeroxylon obliquum* and *Croton sylvaticus* (Coates Palgrave and Coates Palgrave 2002), were only found in this location, as one might expect in an iron-forging location. In addition, *Croton sylvaticus* is medicinally useful and is used while fishing to stun fish, and *Ptaeroxylon obliquum* is used for hut construction and has medicinal and ritual uses. Also identified were *Combretum molle*, an important traditional medicine tree, and *Chrysophyllum viridifolium*, which produces edible fruit (Coates Palgrave and Coates Palgrave 2002; van Wyk and van Wyk 2013). All of these species were only identified in this midden, suggesting that midden 1 was a “multi-purpose” household where various cultural activities took place.

Midden 2 was similarly diverse in species, also suggestive of a mixed activity area. *Breonadia salicina* and *Zanthoxylum capense*, both widely used traditional medicine trees (Coates Palgrave and Coates Palgrave 2002; van Wyk and van Wyk 2013), were identified in this midden exclusively.

Midden 3, previously referred to as the ivory midden due to evidence of ivory work recovered here, yielded the largest amount of charcoal. The strong, durable timber of *Berchemia zeyheri*, a culturally important tree, was identified in this midden, but not in any other location. The tree has various traditional uses such as crafting spear shafts and knob kerries (a stick with a rounded end) for chiefs, constructing fence poles, as well as medicinal uses (van Wyk and van Wyk 2013). The large amount of recovered charcoal,

especially *Acacia* wood (53%), suggests that iron manufacturing was conducted in M3. We know that *Acacia* is the preferred wood for charcoal production, and this provides the fuel for iron smelting, but it is very likely that the *Acacia* charcoal found in this midden was also used for firewood and construction purposes. The raw ore and small amount of slag recovered in this midden suggest that households played a role in collecting, grading, and/or storage of raw ore prior to its use in smelting or forging operations. The variety of woody species found in these domestic middens (M1, M2, and M3) alongside raw ore, as well as slag and forge bases in midden 1, suggests that secondary iron working for the repair of tools (smithing) and making (forging) of tools most likely took place in the domestic peripheral zone. This is possibly more indicative of the individual household or HHMP arrangement of Hall (1987), with shared gender responsibilities, than the CCP of Huffman (1990).

CH3 peripheral activity area

At the time of CH3 the site was for the most part abandoned and there was no evidence of domestic activities. Two areas of the site are chronologically linked to this upper horizon: the charcoal preparation area and mound area. Remains of an iron smelting furnace were found in situ in the mound area (Loubser 1993, 1998) and an area for preparing charcoal (CP) was identified at the south end of the site. Charcoal would have provided the fuel needed for iron smelting, believed to only occur following the abandonment of the site. The charcoal preparation area yielded a large amount of charcoal, although only one packet was collected. The charcoal was almost exclusively identified as *Vachellia karroo*, suggesting that this species was preferentially selected for charcoal production.

A number of drought-resistant species were identified in the Ndongondwane assemblage, for example, all the *Acacia* species, *Sclerocarya birrea* sub-species *caffra*, *Boscia albitrunca*, all the *Combretum* species, *Spirostachys africana* and *Berchemia zeyheri*. The end of the Ndongondwane phase corresponds to an El Nino event (Huffman 2010) causing two periods of drought, between 900 and 1000 AD, during this time.

One of the mysteries about Ndongondwane is why the site was abandoned after such a short time of occupation (50 to 100 years). However, none of the sites in the valley display continuous occupation through the EIA. When there is more than a single occupational phase, they are characterised by a series of short-term settlements, probably less than 50 years (Greenfield and van Schalkwyk 2003). It is likely that the whole valley was abandoned at the end of the ensuing Ntshekane phase, when people moved up to the escarpment highlands (Greenfield and van Schalkwyk 2008). There may be a number of reasons why settlements are abandoned

and one could be as a result of drought—the burned dhaka remains together with the numerous drought-tolerant species in the Ndongondwane charcoal assemblage and the El Nino climate data, resulting in a change in rainfall, suggest a drier climate or period of drought.

A decline in soil fertility could be another reason for settlement abandonment. During the EIA, there was a great expansion in the number of settlements, established anywhere arable soils were located, signalling a need to produce enough cereal or pulse crops for domestic consumption to satisfy the increase in population size (Greenfield and van Schalkwyk 2008). There is a proposal that land was intensively exploited close to each site and less intensively further away (Kay and Kaplan 2015). In the Lower Thukela River Valley, the sites were situated approximately 5 km apart (Greenfield and van Schalkwyk 2008) and the whole area was extensively inhabited and therefore would have been intensively exploited. In conjunction there is evidence that livestock was kept in the valley year round and not moved to higher grasslands for summer grazing (Arnold et al. 2013). This could have led to environmental degradation, overgrazing, and erosion. This is supported by the species composition in the Ndongondwane charcoal assemblage. *Vachellia karroo*, which is used as fodder for livestock, is invasive in overgrazed areas (van Wyk and van Wyk 2013). There was an abundance of this species in the charcoal assemblage; in fact, it is the dominant species and the only species identified in all contexts.

Conclusion

In this study, all selected charcoal specimens from the assemblage were identified to species level, except for one of the five *Acacia* species investigated. This confirms reflected light optical microscopy as a suitable methodology for anthracology as well as having a time-saving advantage over SEM. The importance of this level of anthracological identification is corroborated by these findings, which show the following by accomplishing species level identification:

- It was possible to corroborate existing evidence for drought conditions during the period of occupation, by identifying the presence of several drought-tolerant and -resistant species.
- The prevalence of *Vachellia karroo* was noted. This species, while drought resistant, is also indicative of overgrazed areas, where it becomes invasive. This and the prior point are of interest to questions as to the potential reasons for the abandonment of the site.
- It was determined that some species were foraged from further afield in forested areas, as they would not have

been available in the immediate vicinity of the site. This implies specific selection of these species, which importantly are those which are traditionally used as food sources and for medicinal treatments, not just for firewood and construction as the more locally abundant woody species.

- The variety of wood types with varying properties found in both the central communal and peripheral domestic zones confirmed the range of activities undertaken in all areas of the site.
- The cultural importance of the livestock enclosure and associated human activity area (dung east), where archaeological evidence of iron and ivory working were recovered, was reinforced by the presence of charcoal from tree species with strong timbers used for construction, carving implements, and grain mortars; species with edible parts; species used for brewing beer; species with bark typically used for basket weaving; and species with medicinal properties.
- It was suggested that fishing may also have been undertaken by the inhabitants, as two species, traditionally used for stunning and poisoning fish were identified.
- *Vachellia karroo* was the preferred choice for charcoal production used in iron smelting, which only occurred after the site was abandoned.

The variety of wood in this assemblage indicates that diverse woods were selected for particular purposes. Most of the species identified satisfy multiple requirements or needs (for example, construction, forage for livestock, carving small implements, fibre for rope, fuel wood and charcoal for metal work and ceramic firing, medicinal uses, and edible parts such as fruits, seeds, and roots) and the broad range of uses of these woody plants indicates their importance in EIA societies.

In conclusion, through this investigation of the temporal and spatial distribution of charcoal recovered from the settlement at Ndongondwane, the nature of wood exploitation within a single settlement during the EIA is revealed. The significance of the data from Ndongondwane is that this is the first EIA site from the region that yields not only the presence/absence of information of woody plants but also the nature and intensity of their use, and differential use across time and space within the settlement.

Acknowledgements We would like to express our gratitude to The Palaeontological Scientific Trust (PAST) for supporting the collection of modern samples for the comparative database. Alisoun would like to thank Tim Maggs for generously sharing his knowledge and expertise of Ndongondwane. We are also grateful for the support and knowledge contributed by the late Tom Huffman, Tina L. Jongsma-Greenfield, Jannie Loubser, Tim Maggs, and Gavin Whitelaw who shared their insights and experiences of and about the site, region, and cultures through the years.

Author contribution The charcoal assemblage was provided by Haskel J. Greenfield, as principal archaeologist on the Ndongondwane excavation (1995–1997). The study of the charcoal analysis was supervised by Marion K. Bamford; charcoal preparation and analysis was performed by Alisoun House. The first draft of the manuscript was written by Alisoun House and all co-authors (Marion K. Bamford, Haskel J. Greenfield, Len O. van Schalkwyk) reviewed and commented on the manuscript and checked for important intellectual content. All authors read and approved the final manuscript (Alisoun House, Marion K. Bamford, Haskel J. Greenfield, and Len O. van Schalkwyk).

Funding Open access funding provided by University of the Witwatersrand. This study, for charcoal analysis, was funded by the National Research Foundation—African Origins Platform (grant number 9823) awarded to M. K. Bamford. The Social Sciences and Humanities Research Council (SSHRC) (grant number 410–96–1153) of Canada and University of Manitoba/SSHRC Fund (grant number 329–1615–41) was awarded to H. J. Greenfield, for the excavation and analysis of the archaeological remains from Ndongondwane.

Declarations

Competing interests The authors declare no competing interests.

Conflict of interest The authors declare no competing interests.

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References

- Allott LF (2005) Palaeoenvironments of the Middle Stone Age at Sibudu Cave, KwaZulu-Natal, South Africa: an analysis of archaeological charcoal. PhD thesis, University of the Witwatersrand, Johannesburg
- Allott LF (2006) Archaeological charcoal as a window on palaeovegetation and wood-use during the Middle Stone Age at Sibudu Cave. *South Afr Humanit* 18(1):173–201
- Allue E, Picornell-Gelabert L, Daura J, Sanz M (2017) Reconstruction of the palaeoenvironment and anthropogenic activity from the upper Pleistocene/Holocene anthracological records of the NE Iberian Peninsula (Barcelona, Spain). *Quat Int* 457:172–189
- Arnold ER, Greenfield HJ, Creaser RA (2013) Domestic cattle mobility in early farming villages in southern Africa: harvest profiles and strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) isotope analyses from Early Iron Age sites in the lower Thukela River Valley of South Africa. *Archaeol Anthropol Sci* 5:129–144
- Asouti E, Austin P (2005) Reconstructing woodland vegetation and its exploitation by past societies, based on the analysis and interpretation of archaeological wood charcoal macro-remains. *Environ Archaeol* 10:1–18
- Badenhorst S (2009) The central cattle pattern during the Iron Age of southern Africa: a critique of its spatial features. *S A Archaeol Bull* 64(190):148–155
- Badenhorst S (2010) Descent of Iron Age farmers in Southern Africa during the last 2000 years. *Afr Archaeol Rev* 27:87–106. <https://doi.org/10.1007/s10437-010-9073-1>
- Barefoot AC, Hankins FW (1982) Identification of modern and tertiary woods. Clarendon Press, Oxford
- Braadbaart F, Poole I (2008) Morphological, chemical and physical changes during charcoalification of wood and its relevance to archaeological contexts. *J Archaeol Sci* 35:2434–2445
- Cartwright C, Parkington J (1997) The wood charcoal assemblage from Elands Bay Cave, southwestern Cape: principles, procedures and preliminary interpretation. *S A Archaeol Bull* 52:59–72
- Chikumbirike J, Bamford MK, Esterhuysen AB (2016) A study of archaeological charcoal from Great Zimbabwe. *S A Archaeol Bull* 71(204):107–118
- Chisholm M (1968) Rural settlement and land use: an essay in location, 2nd edn. Hutchinson and Co, London
- Coates Palgrave K, Coates Palgrave M (2002) Palgrave's trees of southern Africa, 3rd edn. Struik Publishers, Cape Town
- Corrigan BM, Van Wyk B-E, Geldenhuys CJ, Jardine JM (2011) Ethnobotanical plant uses in the KwaNobela Peninsula, St Lucia, South Africa. *S A J Bot* 77:346–359
- Coutu AN, Whitelaw G, le Roux P, Sealy J (2016) Earliest evidence for the ivory trade in Southern Africa: isotopic and ZooMS analysis of seventh–tenth century AD ivory from KwaZulu-Natal. *Afr Archaeol Rev*. <https://doi.org/10.1007/s10437-016-9232-0>
- Deacon HJ, Scholtz A, Daitz LD (1983) Fossil charcoals as a source of palaeoecological information in the Fynbos region. Fynbos palaeoecology: a preliminary synthesis. South African National Scientific Programmes Report 174–182
- Dotte-Sarout E, Carah X, Byrne C (2015) Not just carbon: assessment and prospects for the application of anthracology in Oceania. *Archaeol Ocean* 50:1–22
- Edwards D (1967) Plant ecology survey of the Tugela River Basin, Natal. Botanical Survey of South Africa: 36 (Natal Town and Regional Planning Commission report: 10)
- Esterhuysen AB, Mitchell PJ (1996) Palaeoenvironmental and archaeological implications of the charcoal assemblage from Holocene sites in western Lesotho, southern Africa. *Palaeoecol Afr* 24:203–232
- Fowler KD, Greenfield HJ (2009) Unravelling settlement history at Ndongondwane, South Africa: a micro-chronological analysis. *South Afr Humanit* 21:345–393
- Fowler KD, Greenfield HJ, van Schalkwyk LO (2000) The identification and significance of ceramic ecofacts from Early Iron Age Ndongondwane, South Africa. *South Afr Field Archaeol* 9:32–42
- Greenfield HJ, Miller D (2004) Spatial patterning of Early Iron Age metal production at Ndongondwane, South Africa: the question of cultural continuity between Early and Late Iron Ages. *J Archaeol Sci* 31:1511–1532
- Greenfield HJ, van Schalkwyk L (2003) Intra-settlement social and economic organization of Early Iron Age farming communities in southern Africa: a view from Ndongondwane. *Azania* 38:121–137
- Greenfield HJ, van Schalkwyk L, Jongsma TL (1997) Preliminary results of the 1995 research at the Early Iron Age site of Ndongondwane, KwaZulu-Natal, South Africa. *Nyame Akuma* 47:42–52
- Greenfield HJ, van Schalkwyk L, Jongsma TL (2000) Surface and sub-surface reconnaissance at Ndongondwane: preliminary results of the 1995–97 field seasons. *South Afr Field Archaeol* 9:5–16
- Greenfield HJ, Fowler KD, van Schalkwyk LO (2005) Where are the gardens? Early Iron Age horticulture in the Thukela River Basin of South Africa. *World Archaeol* 37(2):307–328. <https://doi.org/10.1080/00438240500095496>

- Greenfield HJ, van Schalkwyk LO (2008) Early Iron Age regional settlement and demographic patterns along the eastern seaboard of South Africa: a view from the Lower Thukela River Valley. In *Animals and people archaeozoological papers in honour of Ina Plug* (Badenhorst S, Mitchell P, Driver JC eds) BAR International Series 1849, Archaeopress, Oxford, UK pp. 131–151
- Hall M (1987) Archaeology and modes of production in precolonial southern Africa. *J South Afr Stud* 16:1–17
- House A, Bamford MK (2019) Investigating the utilisation of woody plant species at an Early Iron Age site by means of identifying archaeological charcoal. *Archaeol Anthropol Sci* 11:6737–6750. <https://doi.org/10.1007/s12520-019-00939-9>
- Huffman TN (1982) Archaeology and ethnohistory of the African Iron Age. *Ann Rev Anthropol* 11:133–150
- Huffman TN (1986) Archaeological evidence and conventional explanations of southern Bantu settlement patterns. *Africa: J Int Afr Inst* 56(3):280–298
- Huffman TN (1990) Broederstroom and the origins of cattle-keeping in southern Africa. *Afr Stud* 49(2):1–12
- Huffman TN (1993) Broederstroom and the Central Cattle Pattern. *S A J Sci* 89:220–226
- Huffman TN (1994) Archaeological evidence for climatic change during the last 2000 years in southern Africa. *Quat Int* 33:55–60
- Huffman TN (2009) A cultural proxy for drought: ritual burning in the Iron age of Southern Africa. *J Archaeol Sci* 36:991–1005
- Huffman TN (2010) Intensive El Niño and the Iron Age of South-eastern Africa. *J Archaeol Sci* 37:2572–2586
- IAWA Committee (1989) IAWA list of microscopic features for hardwood identification. *IAWA Bulletin*, n.s.10, 219–332. <http://insidewood.lib.ncsu.edu/search> [2019]
- Kay AU, Kaplan JO (2015) Human subsistence and land use in sub-Saharan Africa, 1000 BC to AD 1500: a review, quantification, and classification. *Anthropocene* 9:14–32. <https://doi.org/10.1016/j.ancene.2015.05.001>
- Klehm CE, Ernenwein EG (2016) Iron Age transformations at Mmadipudi Hill, Botswana: Identifying spatial organization through Electromagnetic Induction Survey. *Afr Archaeol Rev* 33:45–59
- Kromhout CP (1975) 'n Sleutel vir die mikroskopiese uitkenning van die vernaamste inheemse houtsoorte van Suid-Afrika. South African Department of Forestry, Pretoria
- Lennox S, Wadley L, Bamford M (2015) Charcoal analysis from 49 000-year-old hearths at Sibudu: implications for wood uses and the KwaZulu-Natal environment. *S A Archaeol Bull* 70(201):36–52
- Liengme CA (1981) Plants used by the Tsonga people of Gazankulu. *Bothalia* 13(3, 4):501–518
- Loubser JHN (1993) Ndongondwane: the significance of features and finds from a ninth-century site on the lower Thukela River, Natal. *Natal Museum J Humanit* 5:109–151
- Loubser J (1998) Ndongondwane and the archaeology of deeply buried deposits conducted under unusual conditions: a response to van Schalkwyk et al. *South Afr Field Archaeol* 7:111–114
- Ludemann T, Nelle O (2017) Anthracology: local to global significance of charcoal science. *Quat Int* 457:1–5
- Maggs T (1980) Msuluzi confluence: a seventh century Early Iron Age site on the Tugela River. *Ann Natal J Humanit* 26(1):111–145
- Maggs T (1984) Ndongondwane: a preliminary report on an Early Iron Age site on the lower Tugela River. *Ann Natal Museum* 26(1):71–93
- Maggs T, Michael M (1976) Ntshekane: an Early Iron Age site in the Tugela Basin, Natal. *Ann Natal Museum* 22(3):705–740
- Maggs T, Ward V (1984) Early Iron Age sites in the Muden area of Natal. *Ann Natal Museum* 26(1):105–140
- Marston JM (2009) Modeling wood acquisition strategies from archaeological charcoal remains. *J Archaeol Sci* 36:2192–2200
- Miller DE, Whitelaw G (1994) Early Iron Age metal working from the site of KwaGandaganda, Natal, South Africa. *S A Archaeol Bull* 49:79–89
- Mucina L, Rutherford MC (2006) The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia*: 19. South African Biodiversity Institute, Pretoria pp. 518–521
- Parkington J, Cartwright C, Cowling RM, Baxter A, Meadows M (2000) Palaeovegetation at the last glacial maximum in the western Cape, South Africa: wood charcoal and pollen evidence from Elands Bay Cave. *S A J Sci* 96:543–546
- Pooley E (1997) The complete field guide to trees of Natal. Natal Flora Publications Trust, Durban, Zululand and Transkei
- Prins F, Hall S (2013) Cultural Heritage Impact Assessment of the proposed Ngcebo water treatment works, located within the Maphumulo local municipality
- Puech E, Bamford M, Porraz G, Val A, Théry-Pariset I (2021) Evaluating sampling methods in charcoal-rich layers and high diversity environment: a case study from the Later Stone Age of Bushman Rock Shelter, South Africa. *Quat Int* 593–594:36–49. <https://doi.org/10.1016/j.quaint.2020.11.018>
- Robbertse PJ, Venter G, Janse van Rensburg H (1980) The wood anatomy of the South African Acacias. *IAWA Bull* 1:93–103
- Shackleton CM, Prins F (1992) Charcoal analysis and the “principle of least effort” - a conceptual model. *J Archaeol Sci* 19:631–637
- Théry-Pariset I, Chabal L, Chravzez J (2010) Anthracology and taphonomy, from wood gathering to charcoal analysis. A review of the taphonomic processes modifying charcoal assemblages, in archaeological contexts. *Palaeogeogr Palaeoclimatol Palaeoecol* 291:142–153
- van Schalkwyk LO (1991) Society in transformation. Early Iron Age mixed farming communities in the lower Thukela Basin, Zululand. MA dissertation, University of Cape Town
- van Wyk B, van Wyk P (2013) Field guide to trees of southern Africa, 2nd edn. Struik Publishers, Cape Town
- van Schalkwyk LO, Greenfield HJ, Jongsma TL (1997) The Early Iron Age site of Ndongondwane, KwaZulu-Natal, South Africa: preliminary report on the 1995 excavations. *South Afr Field Archaeol* 6:65–117
- Van Wyk B-E, Van Heerden F, Van Oudtshoorn B (2002) Poisonous plants of South Africa. Briza Publications, Pretoria
- Vita-Finzi C, Higgs ES (1970) Prehistoric economy in the Mount Carmel area of Palestine: site catchment analysis. *Proc Prehist Soc* 36:1–37
- Voigt EA, Von den Driesch A (1984) Preliminary report on the faunal assemblage from Ndongondwane. *Natal Ann Natal Museum* 26(1):95–104
- Wadley L, Esterhuysen AB, Jeannerat C (1992) Vegetation changes in the eastern Orange Free State: the Holocene and later Pleistocene evidence from charcoal studies at Rose Cottage Cave. *S A J Sci* 88:558–563
- Watt JM, Breyer-Brandwijk MG (1962) The medicinal and poisonous plants of Southern and Eastern Africa. 2nd edn. E and S Livingstone Ltd, Edinburgh
- Wheeler EA, Baas P, Gasson PE (1989) IAWA list of microscopic features for hardwood identification. *IAWA Bull* 10:219–332
- Whitelaw GDA (1994) KwaGandaganda: settlement patterns in the Natal Early Iron Age. *Natal Museum J Humanit* 6:1–64
- Whitelaw G (1995) Towards an Early Iron Age worldview: some ideas from KwaZulu-Natal. *Azania* 29–30:37–50. <https://doi.org/10.1080/00672709409511660>
- Whitelaw GDA (2015) Economy and cosmology in the iron age of KwaZulu-Natal. PhD Thesis, University of the Witwatersrand
- Zipf GK (1949) Human behavior and the principle of least resistance. Harvard University Press, Cambridge, MA, USA

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