

# Archaeobotanical evidence for the emergence of pastoralism and farming in southern Africa

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**ABSTRACT.** Several models which remain equivocal and controversial cite migration and/or diffusion for the emergence and spread of pastoralism and farming in southern Africa during the first millennium AD. A synthesis of archaeobotanical proxies (e.g., palynology, phytoliths, anthracology) consistent with existing archaeobotanical and archaeological data leads to new insights into anthropogenic impacts in palaeorecords. Harnessing such archaeobotanical evidence is viable for tracing the spread of pastoralism and farming in the first millennium AD because the impact of anthropogenic practices is likely to result in distinct patterns of vegetation change.

We assess this impact through the synthesis of published archaeobotanical evidence of pastoralism and farming, as well as vegetation changes in southern Africa during the first millennium AD. It has been argued that the decline of forests during the first millennium AD in southern Africa predominantly relates to climate change. This argument often precludes anthropogenic effects on vegetation. Our reassessment of the relationship between vegetation, climate, and human activities in southern Africa reveals evidence of human impact during the same period. We also highlight gaps in the current knowledge of early pastoralism and farming and potential future research directions. We hypothesize that the pattern exhibited by the decline of forest tree pollen, coupled with the increase of open-land indicators, the occurrence of pioneer trees, as well as the spores of coprophilous fungi, and possible changes in the fire regime are reflective of, and consistent with, anthropogenic activities of pre-European pastoralists and farmers.

**KEYWORDS:** pastoralism, farming, southern Africa, anthropogenic impact, archaeobotany, *Tribulus* spp.

## INTRODUCTION

What impact did the introduction and spread of pastoralism and farming have on vegetation in southern Africa? Is it possible to distinguish such impact from the effect of climate change, through palynological research, complementary evidence and proxies such as archaeological,

anthracological and/or phytolith data? Farming encompasses crop cultivation and the associated practices (e.g., slash-and-burn) while pastoralism comprises livestock herding/grazing.

In southern Africa, there are both contrasting and complementary models for the beginning and expansion of pastoralism (e.g., Elphick, 1977, 1985; Smith, 2008, 2017; Sadr, 2008, 2015,

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2019; Jerardino et al., 2014; Orton, 2015) and for the emergence and spread of farming (e.g., Huffman, 1982, 2007; Maggs, 1994; Phillipson, 2005; Lander and Russell, 2018). Proponents of the migration model argue that the Khoi pastoralists moved from northern Botswana/western coast of Namibia/eastern Africa into southern Africa with sheep and pottery ~2000 years ago based on archaeological (Elphick, 1985; Smith, 2008; Muigai and Hanotte, 2013; Orton et al., 2013; Pluerdeau et al., 2012), linguistic (Guldemann, 2008; Ehret, 2020) and genetic data (Henn et al., 2008; Ranciaro et al., 2014). The diffusion model proposes that pottery was independently invented by hunter-gatherers (Sadr and Sampson, 2006), and that livestock diffused among indigenous populations (Badenhorst, 2006; Prendergast, 2011; Sadr, 2014), although recent studies supporting this model suggest the interplay of a rapid cultural diffusion and population movements (Orton, 2013, 2015; Sadr, 2015, 2019).

In comparison with other parts of Africa, the relatively late emergence of farming in southern Africa during the second and third centuries AD has previously been attributed to migrations from western and eastern Africa penetrating a landscape that was previously populated by hunter-gatherers (Huffman, 1970, 1979, 1982; Phillipson, 1976; Maggs, 1980a). Recent spatial distribution studies (e.g., Sadr and Sampson, 2006; Sadr, 2008, 2015, 2019; Russell et al., 2014; Lander and Russell, 2018, 2020) have shown that pottery, cattle and sheep were present in southern Africa independent of the arrival of the so-called 'Iron Age package' and the population movements from western and eastern Africa. Furthermore, geneticists, while supporting some form of population movement (e.g., Li et al., 2014), have suggested that the demic diffusion was sex-biased (see Wood et al., 2005; Marks et al., 2015) and that the local pattern of population movement, interaction and replacement varied (Wang et al., 2020).

Direct evidence for the spread of pastoralism and farming is scarce, and proxy evidence has been used extensively. Pottery was used as a proxy for pastoralism (i.e., livestock herding) (Smith, 2008; Sadr and Sampson, 2006; Sadr, 2008), while pottery, pits, grain bins, grindstones, iron slag and iron objects were proxies for farming (i.e., crop cultivation) (Huffman, 1998). Using these proxies as evidence of pastoralism and farming remains controversial.

Archaeologists such as Andah (1979, 1995), Garlake (1982) and Hall (1983, 1984) have expressed concerns about the methodological and theoretical approaches underpinning the migration model for the emergence and spread of farming in southern Africa. The linking of ceramic style to linguistic and cultural identities (Hall, 1983; Lane, 2004) and the conflation of physical attributes ('race') and culture have been of particular concern (Hall and Morris, 1983).

While the spread of people, livestock and pottery has been revisited and disentangled from the 'Iron Age package', the emergence and expansion of pastoralism and crop farming in southern Africa remain under-theorised and under-investigated. We suggest a synergy between archaeological and archaeobotanical research that integrates both types of data to provide new insights regarding pastoralism and farming practices in southern Africa.

To reassess the relationship between vegetation, climate and human activities in southern Africa, we revisit published archaeological records that give clear evidence of human occupation within the first millennium AD (e.g., Maggs, 1984; Maggs and Whitelaw, 1991; Smith, 1992; Mitchell, 1996; Mitchell and Whitelaw, 2005) and published archaeobotanical evidence (e.g., Denbow and Wilmsen, 1986; Barham and Jarman, 2005; Neumann et al., 2008, 2010; Hahn et al., 2021).

Harnessing archaeobotanical evidence is potentially viable for tracing the spread of farming and livestock herding in the first millennium AD because of the nature of first millennium AD settlements and associated practices. More often, farmers used slash-and-burn techniques to prepare fields for farming, e.g., in the coastal belt on dunes along the Indian Ocean, ~950 cal BP (~1000 AD) (Hall, 1980, 1984; MacDevette et al., 1989). Wood was also harvested and used for building, metalworking (charcoal production) (Maggs and Ward, 1984; Whitelaw, 1991) and other domestic purposes. The combination of these factors and actions is likely to have resulted in distinct patterns of vegetation change, such as forest decline and dominance of open-land indicators (e.g., Carrión et al., 2000; Breman et al., 2011; Hahn et al., 2021).

Herein, we review the archaeobotanical evidence of pastoralism and farming, as well as changes in vegetation from sites in southern Africa dating to the first millennium AD to highlight patterns, possible anthropogenic

indicators, gaps in knowledge and potential areas for further research. We hypothesize that the decline of forests (tree pollen) coupled with the increase of open-land indicators (e.g., Amaranthaceae, Asteraceae; Baxter and Davies, 1994) or pioneer trees (e.g., *Trema*; Goodale et al., 2012), within an archaeological context, can be attributed to anthropogenic activities rather than climate drivers. In addition, an increase in the spores of coprophilous fungi (e.g., *Sporormiella*, *Sordaria*; Cordova et al., 2017) during the first millennium AD could be indicative of domestic animal herds (Carrion et al., 2000).

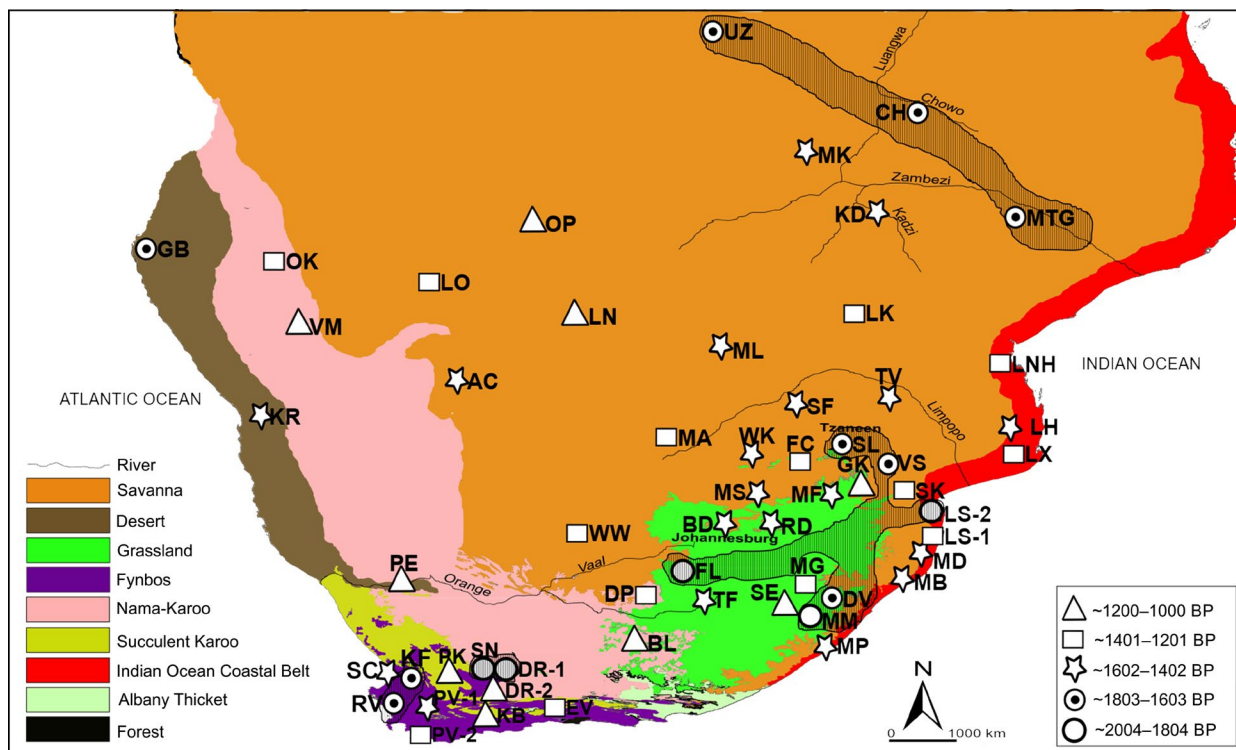
## MATERIALS AND METHODS

### SITE SELECTION AND DATING

We consider archaeobotanical and palynological data from previously published sites (Fig. 1, Table 1) indicating the direct presence of farming and/or possible anthropogenic impacts on the vegetation in southern Africa due to pastoralism and/or farming within

the first millennium AD. The second millennium AD is excluded because it is not relevant to the beginnings of pastoralism and farming in the region.

Evidence from individual sites is chronologically examined and grouped according to the classification of biomes of southern Africa (Rutherford and Westfall, 1994; Mucina and Rutherford, 2006). Although the phytogeographical map provided by Mucina and Rutherford (2006) does not include Mozambique, coastal sites from southern Mozambique (e.g., Ekblom, 2008; Ekblom et al., 2014a) are grouped under the Indian Ocean Coastal Belt Biome since the vegetation in the region is similar to the vegetation in adjacent eastern South Africa. Marine sediment cores (e.g., Shi et al., 1998; Hahn et al., 2021) are excluded from the biome classifications and grouped separately due to the possibility of mixing of pollen assemblages from diverse biome sources via the input of extensive river systems like the Limpopo or Orange River and sea currents (Agulhas current, Benguela current) (Scott et al., 2012). This grouping helps to present a refined view of the proxies and direct evidence in each biome and prevents the conflation of patterns in the data considering the great ecological diversity of the region. Radiocarbon dates for key records (see Table 1) are based on the calibrated date range using the OxCal 4.4 web interface and the SHCal 20 calibration curve with a probability of 95.4 % (Hogg et al., 2013; Bronk Ramsey, 2017).



**Figure 1.** Map of southern Africa showing sites discussed in text and current biomes (adapted after Mucina and Rutherford 2006). The earliest evidence of human impact in the Western Cape and summer rainfall region north and south of Limpopo are marked with hatching lines. AC – Arnhem Cave, BD – Broederstroom, BL – Blydefontein, CH – Chovo River, DP – Deelpan, DR-1 – De Rif, DR-2 – De Rif, DV – Dartmoor Vlei, EV – Eilandvlei, FC – Ficus Cave, FL – Florisbad, GB – GeoB 1023, GK – Graskop, KB – Katbakkies, KD – Kadzi, KF – Klaarfontein, KR – Kuiseb River, LH – Lake Nhaucati, LK – Leopard’s Kopje, LN – Lake Ngami, LNH – Lake Nhauhache, LO – Lake Otjikoto, LS-1 – Lake Sibaya composite core, LS-2 – Lake Sibaya, LX – Lake Xiroche, MA – Magagarape, MB – Mfabeni peatland, MD – Mdlanzi swamp, MF – Mashishing Fen (Thaba Chweu Fen), MG – Magogo, MK – Mondake, ML – Maunatlala, MM – Mahwaqa Mountain, MP – Mpondoland, MS – Moreleta Stream, MTG – Mount Gorongosa, OK – Okandjomblo, OP – Okavango Panhandle, PE – Pella, PK – Pakhuis Pass, PV-1 – Princessvlei (vZB), PV-2 – Princessvlei (PV11.3), RD – Rietvlei Dam, RV – Rietvlei Still Bay, SC – Spring Cave, SE – Sekhokong, SF – Scot’s Farm, SK – SK 17, SL – Silver Leaves, SN – Sneeberg, TF – Tiffindell, TV – Tate Vondo, UZ – Upper Zambezi valley, VM – Vrede hyrax midden, VS – Versailles, WK – Wonderkrater, WW – Wonderwerk Cave

**Table 1.** Evidence of micro-botanical (A) and macro-botanical (B) remains for pastoralism and farming in southern Africa during the first millennium AD

A. Micro-botanical remains						
	Biozone	Site	Abbr.	Pollen, spores and charcoal evidence	Date (cal.)	References
South Africa	Savanna	Versailles	VS	Decline of <i>Podocarpus</i> , increased charred fragments	~1800 BP	Breman et al., 2011
		Wonderkrater	WK	Decline of <i>Podocarpus</i> , increased open vegetation (e.g., <i>Amaranthaceae</i> ), increased charred fragments, <i>Poaceae</i> , <i>Cyperaceae</i>	~1500 BP	Scott, 1982a, 2002; Scott and Thackeray, 1987; Scott et al., 2003
		Tate Vondo	TV	Decline of <i>Podocarpus</i> , increased open vegetation (e.g., <i>Asteraceae</i> )	~1500 BP	Scott, 1987
		Scot's Farm (Soutpansberg)	SF	Decline of <i>Podocarpus</i> , increased open vegetation (e.g., <i>Amaranthaceae</i> )	~1500 BP	Scott, 1982c
		Morelleta Stream	MS	Decline of <i>Podocarpus</i> , increased open vegetation (e.g., <i>Amaranthaceae</i> )	~1500 BP	Scott, 1984
		Broederstroom	BD	Decline of trees (e.g., <i>Olea</i> ), increased open-land indicators (e.g., <i>Caryophyllaceae</i> , and <i>Amaranthaceae</i> ), increased coprophilous fungal spores (e.g., <i>Sordariaceae</i> )	~1500 BP	Carrión et al., 2000
		Wonderwerk Cave	WW	Decline of <i>Podocarpus</i> , <i>Olea</i> , increased <i>Asteraceae</i> , <i>Poaceae</i> , <i>Cyperaceae</i>	~1250 BP	Brook et al., 2010
	Grassland	Mahwaqa Mountain	MM	Increased coprophilous fungal spores (e.g., <i>Sordariaceae</i> , <i>Coniochaeta lignaria</i> , <i>Gelasinospora</i> ) and charred fragments	~2000 BP	Neumann et al., 2014
		Florisbad	FL	Decline of trees, increased <i>Amaranthaceae</i> , <i>Asteraceae</i> and <i>Poaceae</i>	~1950 BP	Nyakale, 1999; Scott and Nyakale, 2002
		Dartmoor Vlei	DV	Decline of <i>Podocarpus</i> , <i>Olea</i> , <i>Celtis</i> , dominance of <i>Poaceae</i> >40 µm, increased charred fragments	~1600 BP	Geer, 2013
		Rietvlei Dam	RD	Decline of <i>Podocarpus</i> , increased open vegetation (e.g., <i>Amaranthaceae</i> )	~1500 BP	Scott and Vogel, 1983
		Tiffindell	TF	Decline of trees, increased <i>Poaceae</i> , <i>Asteraceae</i> , <i>Cyperaceae</i>	~1500 BP	Rosen et al., 1999
		Graskop	GK	Decline of <i>Podocarpus</i> , increased charred fragments	~1000 BP	Breman et al., 2011
		Mashishing (Thaba Chweu) Fen	MF	Shift from the dominance of C <sub>4</sub> to C <sub>3</sub> vegetation	~1600 BP-pres. (AD 400-pres.)	Sjöström et al., 2017
	Indian Ocean Coastal Belt (IOCB)	Lake Sibaya	LS-2	Decline of <i>Podocarpus</i> , increased charred fragments, <i>Poaceae</i> and <i>Cyperaceae</i>	~1895 BP	Walther and Neumann, 2011
		Mdlanzi swamp	MD	Few trees, increased <i>Asteraceae</i> , larger <i>Poaceae</i> >40 µm, <i>Anthoceros</i> -type, <i>Typha</i> and charred fragments	~1450 BP	Turner and Plater, 2004
		Mfabeni peatland	MB	Decline of <i>Podocarpus</i> , increased <i>Morella serrata</i> and <i>Senegalia/Vachellia</i>	~1425 BP	Finch and Hill, 2008
		Lake Sibaya composite core	LS-1	Decline of <i>Podocarpus</i> , appearance of <i>Cerealia</i> -type pollen	~1400 BP	Neumann et al., 2008
	Nama Karoo	Deelpan	DP	Decline of trees, increased <i>Amaranthaceae</i> , <i>Poaceae</i> and <i>Cyperaceae</i>	~1250 BP	Scott, 1988; Scott and Nyakale, 2002
		Blydefontein	BL	Decline of trees, increased <i>Asteraceae</i> , <i>Poaceae</i>	~1200 BP	Scott et al., 2005
	Marine Sites	Mpondoland	MP	Increased <i>Asteraceae</i> , <i>Amaranthaceae</i> , appearance of <i>Poaceae</i> >40 µm, increased coprophilous fungal spores (e.g., <i>Sordariaceae</i> , <i>Gelasinospora</i> )	~1500 BP	Hahn et al., 2021
	Fynbos	Sneeuberg (Cederberg)	SN	Decline of trees, increased disturbance indicators ( <i>Oxalidaceae</i> , <i>Montiniaceae</i> , <i>Plantaginaceae</i> ), increased <i>Poaceae</i> , <i>Asteraceae</i> and <i>Cyperaceae</i>	~1800 BP	Meadows and Sugden, 1991
		Klaarfontein (KFN-B2)	KF	Decline of trees, increased charred fragments, increased <i>Amaranthaceae</i> , <i>Poaceae</i> >40 µm, and <i>Asteraceae</i> , sharp increase in <i>Juncus</i>	~1600 BP	Baxter, 1996; Meadows and Baxter, 2001
		Rietvlei Still Bay	RV	Decline of trees, increased charred fragments, increased <i>Amaranthaceae</i> , <i>Asteraceae</i> and <i>Poaceae</i>	~1650 BP*	Quick et al. 2015
		Spring Cave	SC	Decline of trees, increased <i>Amaranthaceae</i> , <i>Poaceae</i> >40 µm, <i>Asteraceae</i> , <i>Juncus</i> and <i>Typha</i>	~1500 BP	Baxter, 1996
		Princessvlei (vZB)	PV-1	Increased charred fragments, decline of <i>Restionaceae</i> and <i>Crassula</i> , increased <i>Cyperaceae</i> , <i>Carpacoce</i> , <i>Botryococcus</i> and <i>Nymphaea</i>	~1450	Neumann et al., 2011
		Princessvlei (PV11.3)	PV-2	Increased <i>Asteraceae</i> , increased charred fragments, decline of <i>Restionaceae</i>	~1300 BP	Cordova et al., 2019
Eilandvlei		EV	Decline of trees (e.g., <i>Podocarpus</i> ), increased charred fragments, increased <i>Amaranthaceae</i> , <i>Poaceae</i> and <i>Cyperaceae</i>	~1300 BP	Du Plessis, 2015	
Pakhuis Pass		PK	Decline of trees, increased <i>Asteraceae</i> , <i>Amaranthaceae</i> , <i>Poaceae</i>	~1200 BP	Scott and Woodborne, 2007	
Katbakkies		KB	Decline of trees, increased <i>Cyperaceae</i>	~1100 BP	Meadows et al., 2010	
De Rif (Cederberg)		DR-1	Decline of trees, increased charred fragments, <i>Asteraceae</i> , <i>Poaceae</i> and <i>Cyperaceae</i>	~1900 BP	Valsecchi et al., 2013	
De Rif (Cederberg)		DR-2	Decline of trees, increased <i>Asteraceae</i> , <i>Poaceae</i> and <i>Cyperaceae</i>	~1000 BP	Quick, 2009; Quick et al. 2011	

Table 1. Continued

Micro-botanical Remains						
	Biome	Site	Abbr.	Pollen, spores and charcoal evidence	Date (cal.)	References
S Afr.	Desert	Pella	PE	Decline of trees, increased <i>Forsskaolea</i> , Poaceae	~1150 BP	Lim et al., 2016
Lesotho	Grass-land	Sekhokong	SE	Decline of <i>Podocarpus</i> , increased <i>Crassula</i> , and Asteraceae	~1100 BP	Fitchett et al., 2016
Botswana	Savanna	Lake Ngami	LN	Decline of trees, increased charred fragments, increased Amaranthaceae, increased coprophilous fungal spores (e.g., <i>Sporormiella</i> )	~1100 BP	Cordova et al., 2017
		Okavango Panhandle	OP	Increased Asteraceae and Cyperaceae	~1000 BP	Nash et al., 2006
Namibia	Savanna	Arnhem Cave	AC	Decline of trees, increased Amaranthaceae	~1540 BP	Marais et al., 2015
		Lake Otjikoto	LO	Decline of trees, increased <i>Tribulus</i>	~1300 BP	Scott et al., 1991
	Nama Karoo	Okandjombo	OK	Decline of trees, increased <i>Tribulus</i> and Poaceae	~1300 BP	Gil-Romera et al., 2007
		Vrede hyrax midden	VM	Increased Amaranthaceae, Asteraceae and <i>Tribulus</i>	~1200 BP	Gil-Romera et al., 2006
	Marine Site	GeoB 1023	GB	Decline of <i>Podocarpus</i> forests and woodlands, increased <i>Tribulus</i> , fern spores and charred fragments	~1800 BP	Shi et al., 1998
Desert	Kuiseb River	KR	Decline of trees, increased Amaranthaceae, Asteraceae and Poaceae	~1450 BP	Scott, 1996	
Zambia	Savanna	Upper Zambezi valley	UZ	Decline of trees (e.g., <i>Podocarpus</i> ), increased charred fragments	~1800 BP	Burrough and Willis, 2015
Mozambique	Savanna	Mount Gorongosa	MTG	Decline of Afromontane <i>Podocarpus</i> forests and Ericaceae, expansion of pioneer trees (e.g., <i>Macaranga</i> , <i>Trema</i> ), and grasses, pronounced increase of charred fragments and <i>Pediastrum</i>	~1700 BP	McWethy et al., 2016
		Lake Nhaucati	LH	Increased Asteraceae, <i>Trema</i> , <i>Alchornea</i> , and Poaceae	~1500 BP	Eklblom, 2008
	Indian Ocean Coastal Belt (IOCB)	Lake Nhauhache	LNH	Decline of trees, increased Poaceae, increased charred fragments, presence of coprophilous fungal spores (e.g., <i>Coniochaeta lignaria</i> )	~1300 BP	Eklblom et al., 2014a
		Lake Xiroche	LX	Few trees, increased Amaranthaceae, Asteraceae, <i>Alchornea</i> , <i>Trema</i> , and Poaceae	~1300 BP	Eklblom, 2008

\* Single radiocarbon date in the Late Holocene (upper section)

B. Macrobotanical Remains						
	Biome	Site	Abbr.	Fruits and seeds	Date (cal.)	References
South Africa	Savanna	Silver Leaves	SL	<i>Cenchrus americanus</i> (pearl millet) seed impressions on pottery	1760 ± 40 BP (AD 242–415)	Klapwijk, 1974; Klapwijk and Huffman, 1996
		Ficus Cave	FC	Carbonized seeds (unidentified)	1400 ± 40 BP (AD 605–774)	Partridge, 1966; Moore, 1981
		SK 17	SK	Carbonized <i>Sorghum</i> seeds	1335 ± 25 BP (AD 666–775)	Meyer, 1986; Jordaan, 2017
	Grassland	Magogo	MG	<i>Cenchrus americanus</i> , <i>Eleusine coracana</i> (finger millet) and <i>Citrullus</i> (melon) seeds	1360 ± 50 BP (AD 640–860)	Maggs and Ward, 1984; Voigt, 1984
Botswana	Savanna	Maunatlala	ML	Carbonized <i>Cucurbita</i> seeds	1570 ± 140 BP (AD 168–834)	Denbow, 1986; Denbow and Wilmsen, 1986
		Magagarape	MA	Carbonized <i>Sorghum</i> seeds	1350 ± 80 BP (AD 594–953)	Campbell et al., 1996
Zimbabwe	Savanna	Kadzi	KD	<i>Eleusine coracana</i> (finger millet)	1475 ± 70 BP (AD 435–772)	Pwiti, 1996; Katsamudanga and Pwiti, 2017
		Leopard's Kopje	LK	<i>Vigna unguiculata</i> (cowpea)	1280 ± 90 BP (AD 654–988)	Robinson, 1966; Huffman, 1971; Voigt, 1980
Zambia/Malawi Border	Savanna	Chowo River	CH	<i>Sorghum bicolor</i> (sorghum) seeds	1670 ± 40 BP (AD 339–541)	Barham and Jarman, 2005
Zambia	Savanna	Mondake	MK	<i>Sorghum</i> , <i>Vigna unguiculata</i> (cowpea) seeds	1510 ± 60 BP (AD 435–668)	Robertson, 2000

**Table 2.** List of examined archaeobotanical sources

Classification	Evidence	References
Charred seeds	<i>Cenchrus americanus</i> (pearl millet), <i>Sorghum bicolor</i> (sorghum), <i>Vigna unguiculata</i> (cowpea), <i>Eleusine coracana</i> (finger millet) and <i>Citrullus lanatus</i> (melon)	E.g., Antonites and Antonites, 2014; Lander and Russell, 2018; Crowther et al., 2018
Pollen of forest trees	<i>Podocarpus</i> , <i>Olea</i> , <i>Celtis</i>	E.g., Neumann et al., 2008; Breman et al., 2011
Pollen of disturbance/open-land indicators	Asteraceae, Amaranthaceae, <i>Macaranga</i> , <i>Trema</i> , Oxalidaceae, Montiniaceae, Plantaginaceae	E.g., Meadows and Sugden, 1991; Baxter and Davies, 1994; Hahn et al., 2021
Pollen of likely cultivated cereals	Larger Poaceae >40–50 µm	E.g., Turner and Plater, 2004; Hahn et al., 2021
Pollen of ruderal species	<i>Tribulus</i>	E.g., Gil-Romera et al., 2007
Spores of coprophilous fungi	<i>Sporormiella</i> , <i>Gelasinospora</i> , <i>Coniochaeta</i> , <i>Sordaria</i>	E.g., Carrion et al., 2000; Neumann et al., 2014
Charred particles	Macro- and micro-charcoal particles	E.g., Scott, 2002; Li et al., 2008; Lebamba et al., 2016
Phytoliths	Shift from C <sub>4</sub> to C <sub>3</sub> vegetation	E.g., Sjöström et al., 2017

## ARCHAEOBOTANICAL SOURCES

Here, we examine macro- and micro-botanical remains from southern Africa (Table 2). A significant factor explaining the relative scarcity of plant remains in comparison to temperate regions in the Northern Hemisphere is non-preservation in subtropical environments, mechanical disintegration from repeated wet and dry cycles, infrequent charring, and limited studies focused on botanical remains from botanically diverse regions (see Young and Thompson, 1999; Mitchell, 2005; Fuller and Hildebrand, 2013). Also, there is a difficulty in differentiating the pollen of African domesticates such as *Cenchrus americanus* from wild grasses, because of overlaps in sizes and an overall similar pollen morphology (Tomlinson, 1973; Andersen, 1979; Bonnefile and Riollot, 1980).

We also note that research investigating plant diversity in transformed versus untransformed areas in current grass-dominated ecosystems in southern Africa cannot be regarded as an analogue for the first millennium AD context because current transformed grassy landscapes are affected by the more recent invasion of neophytes such as *Campuloclinium macrocephalum* (Pompom Weed) and *Opuntia engelmannii* (Small Round-leaved Prickly Pear) (O'Connor and van Wilgen, 2020) and by different land-use patterns and fire management regimes (compare Muller et al., 2021). The differentiation of anthropogenic pollen indicators is complicated by the fact that taxa such as Asteraceae and Amaranthaceae, which might indicate human disturbances, are commonly interpreted also as signals for dry periods (see discussion in Hahn et al., 2021, compare Fitchett and Bamford, 2017).

In addition to the general challenge to differentiate vegetation changes resulting from climate change from fluctuations caused by anthropogenic impact, low sampling resolution and dating problems provide an obstacle to a detailed comparison between environmental records and archaeological sites (see Scott et al., 2012).

## RESULTS AND DISCUSSION

Our evaluation of the data is presented according to the biomes of southern Africa (Mucina and Rutherford, 2006) and in chronological order from earlier to more recent evidence (Table 1).

### SAVANNA

Pollen records indicate a possible anthropogenic impact since ~1800–1700 BP, representing important changes in the vegetation cover and composition of southern Africa in the savanna (Breman et al., 2011; Burrough and Willis, 2015; McWethy et al., 2016). The Versailles (Fig. 1: VS) pollen sequence suggests an open savanna extension, possibly due to intensive grazing coupled with vegetation clearance for farming and iron smelting (Mitchell, 2002; Breman et al., 2011). Also, weak representation of pollen of forest elements (e.g., *Podocarpus*) continues into the second millennium AD despite cool, moist 'Little Ice Age' conditions around ~650–150 cal. BP, suggesting the prevalence of anthropogenic influences, e.g., wood cutting (Staver et al., 2009; Breman et al., 2011). Archaeological research in the region attests to the interpretation of a steady expansion of human occupation into a wider area with sites such as the Eiland Salt Works (Evers, 1974) and Riverside near Nelspruit in northeastern South Africa (Huffman, 1998) dated 1680 ± 30 BP (cal. AD 343–525) and 1540 ± 50 BP (cal. AD 435–645) respectively.

Around the same time, the pollen sequence from Mount Gorongosa (Fig. 1: MTG) in central

Mozambique suggests the impact of pastoralism (e.g., *Gelasinospora*) ~1700 cal. BP. In addition, the evidence of an increase of charred particles and the algae *Pediastrum*, which often signals eutrophication (which itself primarily indicates increased runoff, see Dubois et al., 2018), synchronous with the pollen records suggests possible human disturbances likely linked to the presence of early farmers in the region (McWethy et al., 2016). This vegetation change coincided with evidence of the spread of pastoralism and farming comprising ceramics and faunal remains recovered in central and southern Mozambique ~2000–1400 BP (Sinclair et al., 1987; Morais, 1988; Madiquida, 2006; Badenhorst et al., 2011; Mercader and Sillé, 2013).

Furthermore, macro-remains of domesticated *Sorghum bicolor* dated 1670 ± 40 BP (cal. AD 339–541) at Chowo River (Fig. 1: CH) on the Zambia/Malawi border (Barham and Jarman, 2005), carbonized *Cucurbita* seeds dated 1570 ± 140 BP (cal. AD 168–834) at Maunatlala (Fig. 1: ML) in eastern Botswana (Denbow, 1986; Denbow and Wilmsen, 1986) and *Pennisetum glaucum* (syn. *Cenchrus americanus*) seed impressions on pottery dated 1760 ± 40 BP (cal. AD 242–415) at Silver Leaves (Fig. 1: SL) in South Africa (Klapwijk, 1974; Klapwijk and Huffman, 1996) attest to the beginnings of farming and other human activities around this period.

The pollen analysis of dung from the cattle enclosure at Silver Leaves in northeastern South Africa and Broederstroom (Fig. 1: BD), shows treeless vegetation (Carrión et al. 2000:248) and dominance of open-land indicators (e.g., Caryophyllaceae and Amaranthaceae) respectively, indicating an opening of the landscape by pastoralists and farmers ~1500 BP (Carrión et al., 2000). Archaeological excavations at Broederstroom provide indirect evidence of livestock keeping in the form of storage pits lined with cattle dung (Mason, 1981, 1986; Huffman, 1993). Also, open vegetation taxa (e.g., Asteraceae) from a mountainous area near Tate Vondo (Fig. 1: TV) in northern South Africa coincided with the sharp decline of *Podocarpus* forests ~1500 BP, probably due to wood-burning and forest clearance by farmers (Scott, 1987). This is supported by the archaeological record (e.g., ceramics, *Cenchrus americanus* seed impressions on pottery) indicating the presence of farmers as early as ~1700 BP within the region (Klapwijk and Huffman, 1996; Mitchell and Whitelaw, 2005).

The surge of charcoal particles and the concurrent increase of Amaranthaceae in Wonderkrater Spring deposits (Fig. 1: WK) near Mookgophong, northeastern South Africa suggests local burning was likely driven by farmers within the area (see Scott, 1982a, 2002; Scott et al., 2003; Scott and Thackeray, 1987). More recent evidence of *Zea mays* (maize) pollen dated ~440 cal. BP further supports human habitation and possible cultivation in the area (Scott 1982a, b, 2016; Scott et al., 2003). Also, contemporaneous pollen records from sites such as Scot's Farm (Fig. 1: SF) at the foot of the Soutpansberg (Scott, 1982c) and Morelletta stream (Fig. 1: MS) near Johannesburg (Scott, 1984) conform with the Wonderkrater vegetation record ~1500 BP, except that the forest retreats did not correspond with peaks of charred fragments until ~500 cal. BP at Morelletta. A similar phenomenon has been documented in the region where there was no general correlation of increased charcoal particles with the arrival and settlement of farming communities (Scott, 2002), despite the conventional knowledge that burning was likely a common occurrence during the late Holocene in South African savannas (e.g., Turner and Plater, 2004; Govender et al., 2006).

By contrast, drier conditions were inferred from similar evidence at Arnhem Cave (Fig. 1: AC) in central Namibia ~1540 cal. BP, primarily due to the accompanying increase of Amaranthaceae and decrease of Poaceae in the pollen record (Marais et al., 2015). Poaceae are often regarded as humidity indicators, especially in comparison to more drought-adapted plants such as Amaranthaceae and Asteraceae (Fitchett and Bamford, 2017).

Meanwhile, Poaceae and Asteraceae, due to the diversity of species, are considered not useful for quantitative climatic reconstructions (Chevalier et al., 2021). However, if the increase in Amaranthaceae pollen is considered a potential indicator of anthropogenic vegetation disturbance (Baxter and Davies, 1994; Hahn et al., 2021) and is seen in conjunction with evidence of human presence indicated by the nearby archaeological sites in the area (Lander and Russell, 2018), the anthropogenic influence on the vegetation may not be completely ruled out.

Additional micro-botanical evidence of *Sorghum* sp. grains and *Vigna unguiculata* recovered at Mondake (Fig. 1: MK), in the Mulungushi drainage basin, Central Zambia dated

1510 ± 60 BP (cal. AD 435–668) (Robertson, 2000) and carbonized grains of *Eleusine coracana* from different stratified contexts at Kadzi (Fig. 1: KD) dated 1475 ± 70 BP (cal. AD 435–772) in the middle Zambezi Valley in northern Zimbabwe (Pwiti, 1996; Katsamudanga and Pwiti, 2017) further suggests the presence of humans on the landscape ~1500 BP in the savanna. By ~1300 cal. BP, minor vegetation change in the Wonderwerk Cave (Fig. 1: WW) record from northwestern South Africa might signal anthropogenic impact despite the low sample resolution for this period (Brook et al., 2010). However, the major driver(s) of the vegetation change cannot be determined without higher resolution records.

In northern Namibia, pollen records from Lake Otjikoto (Fig. 1: LO) in the Tsumeb District (Scott et al., 1991), can be used as indicators of the extension of anthropogenic activities in the region although the authors attributed the vegetation change predominantly to climate since *Tribulus* is regarded as an aridity indicator (compare Chevalier et al., 2021). However, anthropogenic impact is plausible with the increased presence of *Tribulus*, a plant typically associated with human disturbances and specifically animal husbandry (Scott and Morrison, 1996) coinciding with the decline of the forest. While further work and higher resolution records are needed at Lake Otjikoto, these changes coincide with human occupation in this region at this time, which is documented in the archaeological records from the faunal and pottery remains recovered at Jakkalsberg towards the mouth of the Orange River in northwestern South Africa (Brink and Webley, 1996).

Macro-botanical remains from various sites, for example, *Sorghum* spp., *Vigna unguiculata*, *Citrullus vulgaris*, dating to ~1300–1400 BP (see Fig. 1: LK, MA, FC, SK) further suggest the established presence of humans in the region (Campbell et al., 1996; Partridge, 1966; Moore, 1981; Meyer, 1986; Huffman, 1971).

By ~1100 cal. BP, the pollen sequence at Lake Ngami (Fig. 1: LN) in northern Botswana reflects the emergence of pastoralism in the region with significantly increased spores of coprophilous fungi (e.g., *Sporormiella*, *Sordaria*) and charred fragments (Cordova et al., 2017). This sequence correlates with archaeological evidence comprising ceramics, iron, and faunal remains (e.g., cattle, sheep/goat) from sites such as Panga Hill, Bisoli, Chobe,

Qugana, and Serondola, and further confirms the widespread presence of pastoralists and farmers in northern Botswana between 1100 and 1300 BP (see Denbow, 1986; Denbow and Wilmsen, 1986; Robbins et al., 2008; Coulson et al., 2016). Similarly, the presence of humans earlier documented by the remains of ceramics and cattle bones dated as early as ~1200–1300 BP at Divuyu and Nqoma, about 70 km west of Okavango (Denbow and Wilmsen, 1986) could have been mirrored by the significant shift from grass- to sedge (Cyperaceae)-dominated vegetation and increased Asteraceae ~1000 BP at Okavango Panhandle (Fig. 1: OP), in northwest Botswana. Other factors such as climate and hydrology are also plausible (Nash et al., 2006).

### *Tribulus*

*Tribulus terrestris* is a protein-rich fodder for livestock in parts of Zimbabwe and South Africa, especially in the Karoo (Sebata et al., 2005; Bromilow, 2018). Recent evidence from cattle dung from Shashe-Limpopo Confluence Area (SLCA), dating between AD 1000 and 1200, points to >20% *Tribulus* pollen in samples (Mvelase, 2021). A *Tribulus* mericarp (fruit) has been identified in a dung layer, although dating to a later date, at Sibudu Cave on the east coast of South Africa (Scott, 2005). Analysis of modern pollen samples from different landscape types in northcentral Namibia also indicated the dominance of pollen taxa such as *Tribulus* at grazed sites, suggesting local grazing pressure (Tabares et al., 2018). The common occurrence of *Tribulus* was recorded in distant northern China too and attributed to heavy trampling by livestock, known to increase with grazing pressure; therefore, *Tribulus* is a potential indicator of grazing pressure on local vegetation (Li et al., 2008; Wei and Zhao, 2016). Similarly, palynological analysis of coprolites in the Central Sahara points to the significant presence of *Tribulus*, suggested to spread due to selective response to animal grazing (Rotunno et al., 2020). These records suggest that *Tribulus* might reflect human disturbances since it is most abundant in overgrazed veld or along roads (Scott and Morrison, 1996; Johannsmeier, 2016)

However, *Tribulus* is spread through fruits with thorns, clinging to the hair and hooves of livestock and leaves and flowers are often not incorporated into the diet (see Kinahan, 2005; Sarwat et al., 2008). Also, *Tribulus* dates



further back in the fossil records. For example, *Tribulus* was recorded at Tswaing Crater at ~200 ky (Scott, 1999) and at least at ~50 ky in Namibia (Scott et al., 2018). *Tribulus* should be considered, however, as likely evidence for herding when significant increases in the fossil record are associated with supporting evidence such as livestock remains.

#### GRASSLAND

The increase of spores of coprophilous fungi and charred fragments at the Drakensberg outlier Mahwaqa Mountain (Fig. 1: MM) after ~2000 cal. BP indicates a possible anthropogenic impact (Neumann et al., 2014) and is tentatively linked to livestock keeping by pastoralists and/or farmers who entered the region ~1500 BP (e.g., Mazel, 1989, 1992, 2022). *Glomus*, a mycorrhizal fungus often linked to an increase in erosion, which might be a consequence of human disturbance, also increased (Neumann et al., 2014). Significantly, recent investigations at Cherangani Hills in eastern Kenya correlated the increase of dung fungal spores with notable grazing activity during the late Holocene (Cheruiyot et al., 2020). Also, studies at historical sites in the western United States showed a positive correlation between *Sporormiella* and grazed areas (Davis and Shafer, 2006).

Notable vegetation changes coupled with the dominance of large Poaceae pollen grains (>40 µm) at Dartmoor Vlei (Fig. 1: DV) around Mount Gilboa situated on the headwaters of the Myamvubu River, to the east of the Drakensberg escarpment, might also indicate a possible anthropogenic impact ~1600 cal. BP (Geer, 2013). While Geer (2013) suggested the cultivation of *Zea mays* due to the large Poaceae pollen, this is unlikely because *Zea mays* only reached southern Africa through the Indian Ocean exchange in the AD 1600s (Miracle, 1965; McCann, 2001). Consequently, the large Poaceae pollen may rather be interpreted as possible early cultivated cereals such as sorghum or millet, although pollen of wild grasses cannot be excluded.

Palynological data from Tiffindell (Fig. 1: TF) in the southern Drakensberg Mountains (Rosen et al., 1999), and Rietvlei Dam (Fig. 1: RD) further north (Scott and Vogel, 1983) might also indicate anthropogenic impact in the South African Grassland Biome ~1500 BP. However, accurate palynological interpretation of

Rietvlei Dam is hampered by the possible contamination of top layers by ploughing (Scott and Vogel, 1983).

Phytolith analysis at Thaba Chweu Fen (formerly Lydenburg) (Fig. 1: MF) in northeastern South Africa records a shift from the dominance of C<sub>4</sub> to C<sub>3</sub> vegetation (Sjöström et al., 2017). However, the local vegetation change reconstructed at Thaba Chweu Fen was limited to the increase in grasses only. Further to the southeast, archaeobotanical evidence recovered in the Muden area at Magogo (Fig. 1: MG), indicate the likely cultivation of *Cenchrus americanus* and *Eleusine coracana* dated 1360 ± 50 BP (AD 640–860) (Maggs and Ward, 1984).

After ~1200 cal. BP, further anthropogenic impact was present in eastern Lesotho (Fig. 1: SE) (Fitchett et al., 2016). Although the pollen and diatom records from Sekhokong suggested contrasting climate and environmental conditions which are probably due to the limited samples represented by this period, the vegetation change might provide likely evidence of anthropogenic influence in eastern Lesotho.

Further north of Sekhokong, the non-recovery of *Podocarpus* pollen even during climatically favourable conditions at Graskop (Fig. 1: GK) indicates that the continuous activities of humans within the area possibly hindered the regrowth of forests, thus supporting the earlier suggestion of anthropogenic disturbances recovered at Versailles (~14 km from Graskop) (Breman et al., 2011).

#### INDIAN OCEAN COASTAL BELT (IOCB)

The Lake Sibaya (Fig. 1: LS-2) pollen sequence suggests that anthropogenic disturbances after ~1900 cal. BP are more likely to be responsible for the *Podocarpus* forest decline (Walther and Neumann, 2011), thereby correlating with possible human impact along and nearby the east coast of South Africa documented by remains of houses, granaries, pits, cattle byres, and pottery mostly dated ~1600–1300 BP in the archaeological records (Whitelaw, 1994; Whitelaw and Moon, 1996; Mitchell and Whitelaw, 2005).

In southern Mozambique, the Lake Nhaucati (Fig. 1: LH) pollen assemblage comprising Asteraceae, *Trema*, *Alchornea* and Poaceae (Ekblom, 2008) likely indicates anthropogenic impact ~1500 cal. BP, although Ekblom (2008) attributed the vegetation shift observed in the record to climate despite the known arrival of

farmers in the region ~1600 years ago. This argument was based on the record showing that the charcoal peaks did not correlate with the forests' decline despite the archaeological evidence of the presence and continuous occupation of farming communities and possibly higher population densities since 1600 years ago (Sinclair, 1987; Ekblom, 2004, 2008). However, the dominance of pollen of *Trema* and *Alchornea*, which are usually regarded as pioneer trees, is frequently associated with human disturbances when accompanied by increased Poaceae (cf. Van Valkenburg and Ketner, 1994; Kjellmark, 1996; Dull, 2004).

In addition, Ekblom (2008) tentatively linked the non-recovery of forests despite the prevalence of favourable climatic conditions, to soil erosion. Soil erosion is often connected to human disturbances close to farming community settlements in eastern South Africa (Marker and Evers, 1976; Breman et al., 2011). Human impact cannot be ruled out for this period considering the non-recovery of forests, the possible association of soil erosion with human disturbances, and the associated regional archaeological evidence of settled human occupation during the first millennium AD (see Sinclair, 1982, 1987; Ekblom, 2004).

By ~1400 cal. BP, the Mdlanzi (Fig. 1: MD) pollen sequence indicates the evidence of early anthropogenic impact along the northeastern coast of South Africa (Turner and Plater, 2004; Finch and Hill, 2008). While the change in vegetation was likely a result of tree felling and burning, the accompanying increase of large Poaceae pollen grains (>40 µm) suggests the possible cultivation of cereals (e.g., sorghum, millet) (Turner and Plater, 2004). These human disturbances mirror the archaeological records (Maggs, 1984) of farming occupations since the mid-third century AD. Further north of Mdlanzi, palynological information from the Lake Sibaya core (Fig. 1: LS-1) further supports anthropogenic disturbances in the region 1400 BP (Neumann et al., 2008). The interpretation is supported by archaeological data (e.g., cattle and sheep bones, pearl millet and sorghum grains, and ceramics) that indicate the settlement of farming communities (Maggs, 1980b; Maggs and Ward, 1984; Miller and Whitelaw, 1994). Also, the Mfabeni Peatland record (Fig. 1: MB) to the east of Lake St. Lucia supports the evidence of forest clearance and wood burning by farmers in the IOCB, showing similar forest

decline and a shift to more open grassland/savanna, although due to the weak chronology, those disturbances cannot be accurately dated (see Finch and Hill, 2008).

Around 1300 BP, the pollen record in the coastal lowlands of Mozambique at Lake Nhauhache (Fig. 1: LNH) shows possible anthropogenic disturbances. While Ekblom (2008) argued that the vegetation change observed in the pollen records from the nearby sites e.g., Lake Nhaucati are not in harmony with the arrival of farmers and settlement changes, the pollen assemblages at Lake Nhauhache coupled with the presence of the coprophilous fungal spore (*Coniochaeta lignaria*) might suggest the opening of the landscape by human occupation around this time (Ekblom et al., 2014a).

Likewise, the possible human impact in the pollen record is contemporaneous with the archaeological evidence (e.g., cattle, sheep/goat remains and ceramics) of the expansion of humans within the area (Badenhorst et al., 2011; Ekblom et al., 2014b). Moreover, the pollen sequence from Lake Xiroche (Fig. 1: LX) in the Chibuene coastal plain of southern Mozambique provides evidence of sparse tree pollen accompanied by high representations of open-land indicators (e.g., Asteraceae, Amaranthaceae) and pioneer trees (e.g., *Trema*) ~1300 BP (Ekblom, 2008). While Ekblom (2008) argued for the prevalence of climate change, the reassessment of the pollen record, particularly the presence of pioneer trees and open-land indicators, as discussed earlier, suggests otherwise. A similar vegetation change pattern recorded from nearby coastal pollen sites suggests possible anthropogenic impacts around this time (Ekblom et al., 2014b). Meanwhile, the slight differences in the overall pollen sequences between Lake Xiroche and Lake Nhaucati where certain variations exist in the forest decline are likely a result of localized signals. Sparse forest tree pollen was recorded at the former site, whereas the pollen record at the latter showed no significant forest decline (Ekblom, 2008). This further attests to the likely impact of the intensification of local cultivation and higher population densities already extending to other areas in the region.

#### NAMA-KAROO

In northwestern Namibia, the pollen record from Okandjombo (Fig. 1: OK) in the Nama-Karoo Biome documents the retreat of forests and increased *Tribulus* ~1300 cal. BP (see

Gil-Romera et al., 2007). Also, similar pollen assemblages coupled with the increase in open-land indicators were recorded from the pollen analysis of fossil hyrax dung near Vrede (Fig. 1: VM) in the same region ~1200 cal. BP (Gil-Romera et al., 2006). The authors argued that human activities might not be the likely explanation for major vegetation change due to archaeological records showing ephemeral human presence. However, possible anthropogenic impacts cannot be excluded as the pattern of vegetation change is consistent with other records showing likely human impact. This change also correlates with the evidence of human occupation (e.g., sheep bones, ceramics, iron tools) within the different localities of northwestern Namibia around this time (see Albrecht et al., 2001; Vogelsang et al., 2002; Lenssen-Erz and Vogelsang, 2005).

After ~1300 BP, similar trends in vegetation fluctuations were recorded at different localities in the Nama-Karoo of South Africa (e.g., Scott et al., 2005). Notable vegetation changes were recorded at Deelpan (Fig. 1: DP) ~1250 BP (Scott, 1988; Scott and Nyakale, 2002) and Blydefontein Rockshelter (Fig. 1: BL) ~1200 BP (Rosen et al., 1999; Scott et al., 2005). These vegetation shifts have been attributed to climate change due to the increase in Asteraceae which might also point to anthropogenic disturbances as earlier suggested (see Baxter and Davies, 1994). While early archaeological investigations at Blydefontein suggest the presence of humans at ~1255 BP (Bousman, 1991), more recent faunal studies, albeit tentative, pushed the early presence of pastoralists in this area to  $2791 \pm 25$  BP (cal. 967–817BC) (Bousman et al., 2016; Scott and Plug, 2016). Consequently, the pollen evidence may mirror the evidence of anthropogenic impact through herding. However, Bousman and Scott (1994) argued that similar vegetation changes noticed during the historical time in the Blydefontein area are likely due to both climate and overgrazing.

#### DESERT

The Kuiseb River (Fig. 1: KR) sequence provides a possible anthropogenic impact during the first millennium AD. While Scott (1996) argued that climate was likely the major driver of these vegetation changes, the principal components taxa used for the interpretation (e.g., *Salvadora*, *Faidherbia albida*,

*Tribulus*, *Amaranthaceae*, *Asteraceae*) failed to show a sound distinction for moisture and temperature conditions, which signals that the interpretation warrants a reassessment. Meanwhile, favourable conditions reported within the region supported the presence of livestock farming as early as ~1500 BP (Sandelowsky, 1977). These, coupled with the increase of archaeological sites in western Namibia during the first millennium AD (see Lander and Russell, 2018) suggest that pastoralism activities could have been responsible for the vegetation changes. Around 1500–800 cal. BP, an increase in *Forsskaolea* and *Poaceae* pollen at Pella, South Africa (Fig. 1: PE) associated with increased humidity in the region for this period indicating an open landscape (see Castilla-Beltrán et al., 2021) is likely due to anthropogenic influences (Lim et al., 2016).

#### FYNBOS AND SUCCULENT KAROO

Intensive grazing, occasional burning, and settlement would have had a significant impact on the vegetation in the Fynbos Biome (Parkington, 1977). Notable vegetation changes from De Rif at 1900 cal. BP, (Fig. 1: DR-1) in the central Cederberg mountains might attest to anthropogenic impact (Valsecchi et al., 2013). While there is no reference to anthropogenic impact by the palynologists, the archaeological evidence of the introduction of livestock ~1800 BP into the area (Parkington, 1977) coincides with these vegetation changes and with increased charred fragments at De Rif, likely indicating the impact of human activities in the area. Also, the Sneeuberg (Fig. 1: SN) pollen sequence showing trends synchronous with increased vegetation disturbances taxa (e.g., *Oxalidaceae*, *Plantaginaceae*, *Montiniaceae*) which are often associated with fire suggests evidence of human disturbances after ~1800 cal. BP (Meadows and Sugden, 1991).

Sheep bones and pottery along the southern Cape coast at Byneskranskop, Die Kelders, Blombos, and Pearly Beach strongly indicate the presence of pastoralists in the southwestern parts of South Africa during the first millennium AD (Avery, 1974; Schweitzer, 1974; Schweitzer and Wilson, 1982; Henshilwood, 1996). In the southern Cape, the presence of pastoralism has been documented archaeologically with the help of ceramics and faunal remains (e.g., sheep) at Nelson Bay Cave, with the additional evidence of domesticated sheep

dung at Boomplas Cave in the interior mountains ~2000–1700 BP (Beaumont and Vogel, 1972; Deacon et al., 1978).

By ~1600 cal. BP, evidence of likely anthropogenic impact in the western part of the Cape was recorded at Klaarfontein (Fig. 1: KF; Meadows and Baxter, 2001), reflecting the impact of pastoralists, who were present on the Vredenburg Peninsula on the west coast by ~1860 BP (Smith, 1987). Additional evidence of a pronounced increase in charred fragments attests to the increase in fire possibly used to burn reedbeds and promote new growth, a practice that is still applied in the region today (see Skead, 1980). Rietvlei Still Bay (Fig. 1: RV), further south, also documents likely human presence ~1650 BP (Quick et al., 2015). While the possibility of anthropogenic impact was not considered, the pollen record follows similar trends of vegetation changes likely caused by the activities of pastoralists.

At ~1500 BP, patterns of vegetation change similar to those recorded from earlier sites in the Fynbos were documented in a pollen sequence at Spring Cave (Fig. 1: SC), collected from a dated archaeological exposure on the west coast of South Africa (Baxter, 1996). This phenomenon suggests further anthropogenic impact by pastoralists and is supported by the archaeological record indicating their presence along the west coast since ~1600 BP (Klein, 1986).

Further south, the Princessvlei (Fig. 1: PV-1) record on the Cape Flats close to Cape Town shows minor changes after 1800 BP which have been tentatively linked to the impact of early pastoralists. (Neumann et al., 2011). More pollen records from Eilandvlei (Fig. 1: EV, Du Plessis, 2015) and Princessvlei (Fig. 1: PV-2, Cordova et al., 2019) documented a similar trend of anthropogenic disturbance in the eastern and western parts of the Cape. At Princessvlei, the coincidence of vegetation changes and increased charred fragments with moist periods was likely due to greater biomass fuel loads (Cordova et al., 2019).

The likelihood of continued exploration of the landscapes by pastoralists towards the end of the first millennium AD was recorded farther north from pollen records like Pakhuis Pass (Fig. 1: PK), Katbakkies (Fig. 1: KB) and De Rif (Cederberg Mountains) (Fig. 1: DR-2) in the Western Cape (Scott and Woodborne, 2007; Meadows et al., 2010; Quick, 2009). These records agree with archaeological sites such as

Diepkloof, Elands Bay Cave and Tortoise Cave along the Atlantic coast that have livestock remains and pottery dated around the mid-first millennium AD (Klein, 1986; Parkington and Poggenpoel, 1987; Sadr and Sampson, 2006).

#### MARINE RECORDS

A marine pollen record (GeoB 1023) (Fig. 1: GB) obtained from a core off the southwest African coast, with main pollen source areas from the northern Namibian desert, Angolan highlands and northwestern Kalahari seems to suggest vegetation clearance for cultivation and increased burning ~1800 cal. BP, (Shi et al., 1998). The likely activities of pastoralism and farming during this period coincided with the archaeological evidence (e.g., ceramics, faunal, and iron tools) in the region between 1800 and 1500 cal. BP (Phillipson, 1977).

The possible cultivation of cereals and the practice of livestock keeping is also reflected on the east coast of southern Africa in a more recent record from offshore the Umzimvubu River (GeoB20623), Mpondoland (Fig. 1: MP), at ~1500 BP. This provided evidence of an increase in open-land indicators coupled with the dominance of large Poaceae pollen grains (>40 µm) and the increase in spores of coprophilous fungi (Hahn et al., 2021). The pollen record, evidence of increased erosion, and the presence of pastoralists and farmers in the archaeological record dated ~1400 BP (Feely and Bell-Cross, 2011), provides evidence of possible human impact in the area. However, there is a need for caution in the pollen interpretation considering the possibility of the conflation of pollen from differing source areas which are often incorporated into the marine records (see Scott et al., 2012).

#### SYNTHESIS

Our review of pollen data from sites across the nine biomes of southern Africa explored the potential of using micro- and macro-botanical remains to identify the introduction and spread of pastoralism and farming in southern Africa. In general, the palynological records for southern Africa show similar patterns of vegetation change across the biomes from 2000 to 1000 years ago. Previous studies often argue that these patterns could be linked to the prevalence of generally drier conditions due

**Table 3.** Summary of possible anthropogenic indicators

Human activity	Likely evidence	Associated taxa/remains
Felling of trees for wood, clearing of forest for cultivation	Decline in tree pollen	<i>Podocarpus</i> , <i>Olea</i> , <i>Celtis</i>
Clearing of forest for cultivation	Increase in open-land/disturbance indicators/pioneer trees	Asteraceae, Amaranthaceae, <i>Macaranga</i> , <i>Trema</i> , Oxalidaceae, Montiniaceae, Plantaginaceae
Crop cultivation	Increase in large Poaceae pollen (>40 µm)	Likely <i>Pennisetum</i> (syn. for <i>Cenchrus americanus</i> ), <i>Sorghum</i>
Crop cultivation	Presence of charred grains and seeds	<i>Cenchrus americanus</i> , <i>Sorghum bicolor</i> , <i>Vigna unguiculata</i> , <i>Eleusine coracana</i> , <i>Citrullus lanatus</i> , <i>Zea mays</i>
Clearance of vegetation by fire	Increase in charred fragments	Micro- and macro-charcoal
Livestock herding	Increase in spores of coprophilous fungi	<i>Sordaria</i> , <i>Sporormiella</i> , <i>Gelasinospora</i> , <i>Coniochaeta</i>
Livestock herding	Increase in ruderal species	<i>Tribulus</i>

to climate change during the first millennium AD for this region (Scott et al., 2012; Chevalier and Chase, 2016). However, the impact of pastoralism and farming can also lead to a decline in tree pollen and consequently an increase in open-land indicators/pioneer trees, coprophilous fungal spores, and large Poaceae pollen (>40 µm) (see Li et al., 2008). To evaluate the evidence for the different scenarios we examined the patterns in the pollen data from the various sites recorded in southern Africa (see Table 1). Here we evaluate the indicators of anthropogenic impacts on vegetation (see Table 3), suggest patterns observed in the data, and identify research gaps.

#### POSSIBLE ANTHROPOGENIC INDICATORS

##### Tree pollen (see Table 3)

A decline in tree (forest) pollen can be driven by anthropogenic impact (e.g., Shi et al., 1998; Li et al., 2008; Neumann et al., 2008), climate (e.g., Scott et al., 2003; Chevalier and Chase, 2016), or a combination of both (Finch and Hill, 2008). A decline of *Podocarpus* (but sometimes *Olea*) was generally documented at different sites in the Savanna, Grassland, IOCB, and Fynbos of South Africa, Zambia, and Mozambique (See Table 1), suggesting possible selective exploitation of trees for wood or a combination of the impact of people and climate. It is, however, more reliable to associate the decline of trees with anthropogenic impact when accompanied by the increase of other possible anthropogenic indicators such as charred fragments, spores of coprophilous fungi, large Poaceae (Cerealia-type) pollen (>40 µm) and open-land indicators (e.g., Neumann et al., 2008; Breman et al., 2011; Hahn et al., 2021).

##### Increase in open-land/disturbance indicators/pioneer trees

The high representation and diverse occurrence of open-land indicators (e.g., Amaranthaceae, Asteraceae) in the different biomes (see Table 1) are commonly interpreted as effects of anthropogenic disturbances particularly farming (Baxter and Davies, 1994; Neumann et al., 2011; Hahn et al., 2021) but often argued to be indicators of regional aridity (Scott et al., 2003; Chevalier and Chase, 2015, 2016). Following the associations of these open-land indicators with large Poaceae pollen (>40 µm), which are tentatively interpreted as cultivated cereals and known to have coincided with the arrival of farmers in southern Africa from sites such as Mdlanzi and Mpondoland (Turner and Plater, 2004; Hahn et al., 2021), they more likely indicate anthropogenic impact during the first millennium AD.

The increase of light-adapted pioneer trees such as *Trema* and *Macaranga*, which are widespread from the pollen records in Mozambique from ~1700 BP (see Table 1), often indicates anthropogenic disturbances and growth of secondary forests (Goodale et al., 2012). Their increase which coincides with high frequencies of charred fragments particularly at Mount Gorongosa in central Mozambique (McWethy et al., 2016) further points to the likely removal of canopy forests for farming which in turn favoured the expansion of trees adapted to light-demanding conditions. These changes in the vegetation have also been related to anthropogenic activities in other areas such as Europe, Asia and America (Dubois et al., 2018). Ekblom (2008) has, however, argued for climate changes suggesting that the increase of these pioneer species did not have a close relationship with anthropogenic impact owing

to the lack of increased charred fragments in the local records from southern Mozambique.

#### Increase in charred fragments

Charred fragments are one of the most important indicators of anthropogenic presence and activities (e.g., Dubois et al., 2018). The clearance of vegetation by fire was commonly practised by pastoralists and farmers to prepare land for fields and settlements (e.g., Nkala et al., 2011). Burning is a common practise to stimulate grass growth (Neary and Leonard, 2020). Human-induced fires are often differentiated from natural fires when accompanied by the occurrence of other anthropogenic indicators such as weeds, large Poaceae pollen (>40 µm) and open-land indicators (Li et al., 2008), but coincidences cannot be excluded.

This phenomenon is widespread in southern Africa across the Fynbos, Savanna, Grassland, and IOCB with the co-occurrence of open-land indicators and decline of trees, and more likely indicates the impact of anthropogenic burning particularly when archaeological data provide evidence of human occupation (Scott, 1982c; Roos et al., 2016; Scott et al., 2022). Meanwhile, a few sites showing evidence of likely anthropogenic impact (e.g., Broederstroom, Mdlanzi, Mpondoland) did not show the co-occurrence of charred fragments peak with other anthropogenic indicators. The absence of evidence may not necessarily mean evidence of absence of anthropogenic impact as the lack of peaks of charred fragments might be due to effective management of fires (see Scott, 2002) or a small number of farmers moving into a landscape already managed by hunter-gatherers (Wadley, 1978, 1996).

#### Large Poaceae pollen (>40 µm)

The appearance of large Poaceae pollen (>40 µm) in the Grassland Biome, marine and IOCB sites might indicate the cultivation of crops. At many sites in southern Africa, these pollen grains co-occurred with increased charred fragments and open-land indicators, as well as the decline of trees (see Table 1), indicating possible farming practices in the region. While it is possible to link the large Poaceae pollen grains with early cultivated cereals (e.g., *Pennisetum* – syn. for *Cenchrus americanus*, *Sorghum*), as has been done in other contexts (see Hahn et al., 2021), the

above-mentioned size overlaps with wild grass taxa (see Bonnefille and Riollet, 1980) in the summer rainfall areas of South Africa where the early farmers settled. Also, large Poaceae pollen (>40 µm) grains may not reflect cultivated grasses in the Fynbos, as they are commonly found in pollen records before the first millennium AD when farming was known to have started in southern Africa (e.g., Baxter, 1996). So, caution must be taken in interpreting them as cultivated cereals in the Fynbos.

#### Increase in spores of coprophilous fungi

Abundant fungal spores (e.g., *Sordaria*, *Sporormiella*, *Gelasinospora*) commonly associated with dung were recovered in sediment pollen archives in the Savanna, Grasslands and IOCB Biomes, possibly indicating the presence of pastoralism across South Africa, Botswana, and Mozambique beginning as early as 2000–1500 BP (Neumann et al., 2014; Ekblom et al., 2014b; Cordova et al., 2017; Hahn et al., 2021). Palaeoecological studies focused on dung fungal spores have shown that their presence is often associated with the dung of herbivores (Cugny et al., 2010; Baker et al., 2013; Cheruiyot et al., 2020; van Asperen et al., 2020), though some fungal taxa (e.g., *Gelasinospora*) grow rapidly on other substrates (Cheruiyot et al., 2020; van Asperen et al., 2020). Thus, a significant increase in dung fungal spores is a potential indicator of grazing particularly during known periods of pastoralism in the archaeological record especially if spores of coprophilous fungi co-occur with e.g., pollen of crops and weeds. It is worth noting that the absence of dung fungal spores in records from other biomes of southern Africa (e.g., Fynbos) does not preclude pastoralism, as their presence is more remarkable than their absence (see Cheruiyot et al., 2020).

#### Increase in ruderal species

Ruderal species (e.g., *Tribulus*) are known to spread rapidly in highly disturbed areas, which may be due to climate change and/or anthropogenic impact from pastoralism and farming (Grime, 1979; Cilliers and Bredenkamp, 1999; Verdú and Mas, 2006). The increase of *Tribulus*, which is often associated with increased grazing pressure (Li et al., 2008), coincided with the decline of trees across the Savanna, Nama-Karoo and marine sites in offshore Namibia

(Scott et al., 1991; Gil-Romera et al., 2007; Shi et al., 1998) possibly suggesting widespread anthropogenic activities, particularly pastoralism, in the region. The role of *Tribulus* as an anthropogenic indicator is underlined by the palynological results of our preliminary study on early second millennium AD cattle dung from the SLCA region (Mvelase, 2021).

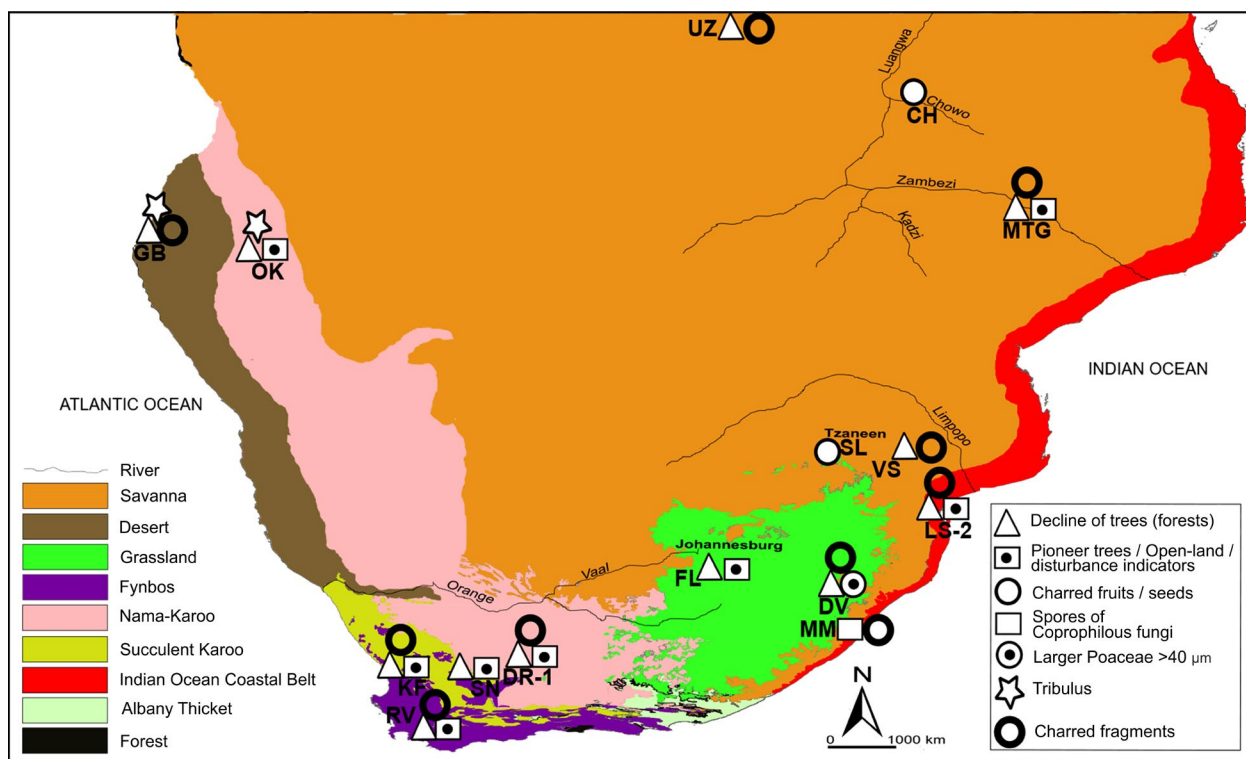
#### PATTERNS OF VEGETATION CHANGE

The archaeobotanical data across the biomes of southern Africa showed similar changes in vegetation during the first millennium AD (see Table 1). This was marked by the decline of forest elements (e.g., *Podocarpus*), the spread of open-land/disturbance indicators (e.g., Amaranthaceae, Asteraceae, Oxalidaceae, Plantaginaceae, Montiniaceae), as well as an extension of savanna and/or pioneer trees and coprophilous fungi (e.g., *Sordaria*, *Sporormiella*). Considering that southern African climates are diverse with a high degree of temporal and spatial variability across the region, it is unlikely that the climate in different biomes fluctuated in the same way during the first millennium AD (see Tyson and Preston-Whyte, 2000; Chevalier and Chase, 2016). More likely, anthropogenic

impact is responsible for similar palynological fluctuations for this period.

Increased charred fragments were observed at several sites across all the biomes (e.g., Versailles, Mahwaqa Mountain, Mdlanzi Swamp, PrincessVlei, GeoB 1023) except in the Nama-Karoo and Desert Biomes. This is likely due to the lack of combustible mass in the two biomes (see Bond, 1997; Allen et al., 2011; Muller et al., 2016).

Also, essential resources probably played a role in site selection by pastoralists and early farmers, with fertile soils, grazing fields, an adequate supply of water and wood, and a favourable climate being likely factors. In South Africa, the early sites clustered around the northeastern region (see Fig. 1), attesting to the fact that early pastoralists and farmers likely favoured relatively lower altitudes with nutrient-rich colluvial soils and sweetveld which allowed grazing (e.g., Maggs and Ward, 1984; Parkington and Hall, 2010). This is also supported by preserved charred seed remains, which are limited to the savanna and grasslands (see Table 1). While the soils in the grasslands are especially suitable for growing cultivated grasses, pastoralists and early farmers initially avoided higher altitude regions due to highly variable rainfall, severe



**Figure 2.** Map of southern Africa showing sites with the first occurrence of potential anthropogenic impacts in each region (adapted after Mucina and Rutherford 2006). Site abbreviations are listed in Table 1 according to biome and country

frost occurrence and low winter temperatures unfavourable for crops and livestock (see Huffman, 1996; Eeley et al., 1999; Sadr, 2020).

Furthermore, the likely anthropogenic impact observed from the archaeobotanical data suggests the continuing presence of pastoralism and farming in southern Africa beginning from ~1900–1600 BP across the Savanna, Grassland, Fynbos, and IOCB Biomes (see Figs 1 and 2). Later sites within these biomes indicated a concentration of evidence of anthropogenic impact within much of the interior, suggesting a likely spread. At ~1500 BP, a wide expansion of pastoralists/farmers into other areas of southern Africa is suggested, as revealed by a general and wide increase of archaeobotanical data showing vegetation changes likely due to anthropogenic impact (see Fig. 1). However, the records showed that the drier regions e.g., Nama-Karoo and desert were likely explored much later ~1450–1300 BP (Fig. 1). Hence, the anthropogenic disturbances might be blurred by vegetation changes due to climatic fluctuations, and vice versa.

Currently, there is a strong bias towards the understanding of climate fluctuations, rather than anthropogenic drivers, during the late Holocene in palynological studies in southern Africa (see Dubois et al., 2018). On the other hand, many indicators for intense droughts are also regarded as signals for human disturbances. We suggest that the vegetation shifts cannot be fully explained solely by climate variations particularly the gradual replacement of forest tree pollen with open-land indicators at individual sites. More often, regional pollen composition is an indicator of climate (Scott et al., 2012), while the pollen composition from local sites typically reflects the impact of anthropogenic activities and/or climate as well as other landform processes shaping the landscapes (Li et al., 2008). Thus, anthropogenic disturbances (e.g., cultivation, fire, grazing) can transform the landscapes independently of, or in conjunction with climate change, and might result in changes in the vegetation composition (Li et al., 2008; Gillson and Ekblom, 2020).

Furthermore, larger Poaceae (>40µm) pollen grains, as well as macro-charcoal, often reflect local signals due to short dispersal distances (see Edwards and McIntosh, 1988; Whittington et al. 1991), thus it is important to identify likely anthropogenic impact within a localized

area. Similarly, differentiating between local and regional pollen taxa through the analysis of modern pollen-vegetation relationships fosters a more accurate interpretation of the major driver(s) of vegetation changes (see Ekblom et al., 2017; Chen et al., 2017; Geng et al., 2019). These coupled with supporting archaeological evidence of human habitation in the area facilitate the identification of likely anthropogenic disturbances as local signals.

Also, palaeoclimate studies have shown that climate in the different biomes did not fluctuate in the same way throughout the region during the late Holocene (Chevalier and Chase, 2015, 2016). For instance, although much of the observed climate variability along the eastern African margin has been attributed to changes in global conditions, the observed variations within the central and eastern South African sites, particularly during the Late Holocene, remain patchy. This lack of consistent patterning between these sites may be due to varying degrees of anthropogenic disturbances. However, the pollen data we reviewed showed similar patterns of vegetation disturbance, particularly with the decline in forests and increased open-land indicators across all the biomes for the first millennium AD.

While much of our focus in the paper has been on the decline of trees, recovery patterns are also important. For example, forest trees, which are less capable of recovery in a fire-dominated environment, mostly do not recover once they have declined, while savanna trees, which are in contrast better adapted to regenerate in such environments, prevail (Gillson and Ekblom, 2020).

## SUMMARY

A synthesis of archaeobotanical proxies within the context of existing macro-botanical and archaeological data shows the potential of exploring the beginnings and spread of pastoralism and farming in southern Africa during the first millennium AD. The pollen records indicate a distinct pattern of vegetation change evident in the decline of trees (forest), an increase of open-land indicators/pioneer trees, spores of coprophilous fungi, *Tribulus*, large Poaceae pollen (>40 µm) and charred fragments. While the data show a continuing presence of pastoralism and farming from



~2000–1000 BP in southern Africa, convincing evidence for the beginnings of likely anthropogenic impact are documented between ~1900 and 1600 BP across the Savanna, Grassland, Fynbos and IOCB Biomes, and ~1450–1300 BP in the Nama-Karoo and Desert. Also, a widespread increase of archaeobotanical data showing similar vegetation changes possibly from anthropogenic impact suggests an expansion of pastoralists and/or farmers into other areas of southern Africa at ~1500 BP.

However, our conclusions are tentative considering the bias in the archaeobotanical data towards areas where research has been focused. We hope that additional research in these countries and other under-represented areas will help to improve the overall picture and patterns of the emergence and spread of pastoralism and farming in southern Africa.

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#### REFERENCES

- Albrecht, M., Berke, H., Eichhorn, B., Frank, T., Kuper, R., Prill, S., Vogelsang, R., Wenzel, S., 2001. Oruwanje 95/1: a late Holocene stratigraphy in northwestern Namibia. *Cimbebasia* 17, 1–22.
- Allen, E.B., Steers, R.J., Dickens, S.J., 2011. Impacts of fire and invasive species on desert soil ecology. *Rangeland Ecology & Management* 64, 450–462. <https://doi.org/10.2111/REM-D-09-00159.1>
- Andah, B.W., 1979. Iron Age Beginnings in West Africa: Reflections and Suggestions in Perspectives on West Africa's Past. *West African Journal of Archaeology* 9, 135–150.
- Andah, B.W., 1995. The earliest human occupation and settlement in West Africa. *The Epistemology of west African Settlements*. Andah. *African Peoples and Their Cultural Resources Series* 25, 8–33.
- Andersen, S.T., 1979. Identification of wild grass and cereal pollen [fossil pollen, Annulus diameter, surface sculpturing]. *Danmarks Geologiske Undersøgelse Aarbog*, 69–92.
- Antonites, A., Antonites, A.R., 2014. The Archaeobotany of Farming Communities in South Africa. In: Stevens, C.J., Nixon, S., Murray, M.A., Fuller, D.Q. (eds), *The Archaeology of African Plant Use*. Left Coast Press, Walnut Creek, pp. 225–232.
- Avery, G., 1974. Open station shell midden sites and associated features from the Pearly Beach area, southwestern Cape. *South African Archaeological Bulletin* 29, 104–114. <https://doi.org/10.2307/3888336>
- Badenhorst, S., 2006. Goats (*Capra hircus*), the Khoekhoen and pastoralism: current evidence from southern Africa. *African Archaeological Review* 23, 45–53. <https://doi.org/10.1007/s10437-006-9007-0>
- Badenhorst, S., Sinclair, P., Ekblom, A., Plug, I., 2011. Faunal remains from Chibuene, an Iron Age coastal trading station in central Mozambique. *Southern African Humanities* 23, 1–15.
- Baker, A.G., Bhagwat, S.A., Willis, K.J., 2013. Do dung fungal spores make a good proxy for past distribution of large herbivores?. *Quaternary Science Reviews* 62, 21–31. <https://doi.org/10.1016/j.quascirev.2012.11.018>
- Barham, L., Jarman, C.L., 2005. New radiocarbon dates for the Early Iron Age in the Luangwa Valley, eastern Zambia. *Azania: Journal of the British Institute in Eastern Africa* 40, 114–121. <https://doi.org/10.1080/00672700509480417>
- Baxter, A.J., 1996. Late Quaternary palaeoenvironments of the Sandveld, Western Cape Province, South Africa. PhD thesis, University of Cape Town, Cape Town.
- Baxter, A.J., Davies, B.R., 1994. Palaeoecological insights for the conservation of aquatic ecosystems in dryland environments: a case study of the Verlor-envlei system, South Africa. *Aquatic Conservation. Marine and Freshwater Ecosystems* 4, 255–271. <https://doi.org/10.1002/aqc.3270040306>
- Beaumont, P.B., Vogel, J.C., 1972. On a new radiocarbon chronology for Africa south of the Equator: part 2. *African Studies* 31, 155–182. <https://doi.org/10.1080/00020187208707381>
- Bond, W.J., 1997. Fire. In: Cowling, R.M., Richardson, D.M., Pierce, S.M. (eds), *Vegetation of Southern Africa*. Cambridge University Press, Cambridge.
- Bonnefile, R., Riollet, G., 1980. *Pollens des savanes O'Afrique Orientale*. Editions du Centre National de la Recherche Scientifique, Paris.
- Bousman, C.B., 1991. Holocene paleoecology and Later Stone Age hunter-gatherer adaptations in the South African interior plateau. PhD thesis, Southern Methodist University, Dallas.
- Bousman, B., Scott, L., 1994. Climate or overgrazing?: the palynological evidence for vegetation change in the eastern Karoo. *South African Journal of Science* 90, 575–578.
- Bousman, B.C., Mauldin, R., Zoppi, U., Higham, T., Scott, L., Brink, J., 2016. The quest for evidence of domestic stock at Blydefontein Rock Shelter. *Southern African Humanities* 28, 39–60.

- Breman, E., Gillson, L., Willis, K., 2011. How fire and climate shaped grass-dominated vegetation and forest mosaics in northern South Africa during past millennia. *The Holocene* 22, 1427–1439. <https://doi.org/10.1177/0959683611400196>
- Brink, J., Webley, L., 1996. Faunal evidence for pastoralist settlement at Jakkalsberg, Richtersveld, northern Cape Province. *Southern African Field Archaeology* 5, 70–78.
- Bromilow, C., 2018. Problem Plants and Alien Weeds of Southern Africa. Briza, Pretoria, South Africa, 464 pp.
- Bronk Ramsey, C., 2017. OxCal 4.3 Manual. OxCal Program 4.3. Oxford Radiocarbon Accelerator Unit, University of Oxford.
- Brook, G.A., Scott, L., Railsback, L.B., Goddard, E.A., 2010. A 35 ka pollen and isotope record of environmental change along the southern margin of the Kalahari from a stalagmite and animal dung deposits in Wonderwerk Cave, South Africa. *Journal of Arid Environments* 74, 870–884. <https://doi.org/10.1016/j.jaridenv.2009.11.006>
- Burrough, S.L., Willis, K.J., 2015. Ecosystem resilience to late-Holocene climate change in the Upper Zambezi Valley. *The Holocene* 25, 1811–1828. <https://doi.org/10.1177/0959683615591355>
- Campbell, A.C., Van Waarden, C., Holmberg, G., 1996. Variation in the early iron age of southeastern Botswana Botswana Notes and Records, 1–22.
- Carrión, J.S., Scott, L., Huffman, T., Dreyer, C., 2000. Pollen analysis of Iron Age cow dung in southern Africa. *Vegetation History and Archaeobotany* 9, 239–249. <https://doi.org/10.1007/BF01294638>
- Castilla-Beltrán, A., de Nascimento, L., Fernández-Palacios, J.M., Whittaker, R.J., Romeiras, M.M., Cundy, A.B., Edwards, M., Nogué, S., 2021. Effects of Holocene climate change, volcanism and mass migration on the ecosystem of a small, dry island (Brava, Cabo Verde). *Journal of Biogeography* 48, 1392–1405. <https://doi.org/10.1111/jbi.14084>
- Chen, X., Huang, X., Wu, D., Zhang, X., Dodson, J., Zhou, A., Chen, F., 2017. Modern pollen assemblages in topsoil and surface sediments of the Xingyun Lake catchment, central Yunnan Plateau, China, and their implications for interpretation of the fossil pollen record. *Review of Palaeobotany and Palynology* 241, 1–12. <https://doi.org/10.1016/j.revpalbo.2017.01.003>
- Cheruiyot, V.C., Gebregiorgis, D., Opiyo, B., Kiage, L.M., 2020. Revisiting the palaeoenvironmental and climatic history of the Cherangani Hills using fungal spores. *Journal of Quaternary Science* 35, 737–742. <https://doi.org/10.1002/jqs.3223>
- Chevalier, M., Chase, B.M., 2015. Southeast African records reveal a coherent shift from high-to low-latitude forcing mechanisms along the east African margin across last glacial–interglacial transition. *Quaternary Science Reviews* 125, 117–130. <https://doi.org/10.1016/j.quascirev.2015.07.009>
- Chevalier, M., Chase, B.M., 2016. Determining the drivers of long-term aridity variability: a southern African case study. *Journal of Quaternary Science* 31, 143–151. <https://doi.org/10.1002/jqs.2850>
- Chevalier, M., Chase, B.M., Quick, L.J., Scott, L., 2021. An Atlas of Southern African pollen taxa and their climatic affinities. In: Runge, J., Gosling, W.D., Lézine A-M., Scott, L. (eds), *Quaternary Vegetation Dynamics: The African Pollen Database*. CRC Press/Balkema, The Netherlands, pp. 239–257.
- Cilliers, S.S., Bredenkamp, G.J., 1999. Ruderal and degraded natural vegetation on vacant lots in the Potchefstroom Municipal Area, North West Province, South Africa. *South African Journal of Botany* 65(2), 163–173. [https://doi.org/10.1016/S0254-6299\(15\)30956-X](https://doi.org/10.1016/S0254-6299(15)30956-X)
- Cordova, C.E., Scott, L., Chase, B.M., Chevalier, M., 2017. Late pleistocene-holocene vegetation and climate change in the middle kalahari, lake Ngami, Botswana. *Quaternary Science Reviews* 171, 199–215. <https://doi.org/10.1016/j.quascirev.2017.06.036>
- Cordova, C.E., Kirsten, K.L., Scott, L., Meadows, M., Luecke, A., 2019. Multi-proxy evidence of late-Holocene paleoenvironmental change at Princessvlei, South Africa: The effects of fire, herbivores, and humans. *Quaternary Science Reviews* 221, 105896. <https://doi.org/10.1016/j.quascirev.2019.105896>
- Coulson, S., Segadika, P., Walker, N., 2016. Ritual in the Hunter-Gatherer/Early Pastoralist Period: Evidence from Tsodilo Hills, Botswana. *African Archaeological Review* 33, 205–222. <https://doi.org/10.1007/s10437-016-9218-y>
- Crowther, A., Prendergast, M.E., Fuller, D.Q., Boivin, N., 2018. Subsistence mosaics, forager-farmer interactions, and the transition to food production in eastern Africa. *Quaternary International* 489, 101–120. <https://doi.org/10.1016/j.quaint.2017.01.014>
- Cugny, C., Mazier, F., Galop, D., 2010. Modern and fossil non-pollen palynomorphs from the Basque mountains (western Pyrenees, France): the use of coprophilous fungi to reconstruct pastoral activity. *Vegetation History and Archaeobotany* 19, 391–408. <https://doi.org/10.1007/s00334-010-0242-6>
- Davis, O.K., Shafer, D.S., 2006. *Sporormiella* fungal spores, a palynological means of detecting herbivore density. *Palaeogeography, Palaeoclimatology, Palaeoecology* 237, 40–50. <https://doi.org/10.1016/j.palaeo.2005.11.028>
- Deacon, H.J., Deacon, J., Brooker, M., Wilson, M.L., 1978. The evidence for herding at Boomplaas Cave in the southern Cape, South Africa. *South African Archaeological Bulletin* 33, 39–65. <https://doi.org/10.2307/3888251>
- Denbow, J., 1986. A New Look at the Later Prehistory of the Kalahari. *The Journal of African History* 27, 3–28. <https://doi.org/10.1017/S0021853700029170>
- Denbow, J.R., Wilmsen, E.N., 1986. Advent and course of pastoralism in the Kalahari. *Science* 234, 1509–1515. <https://doi.org/10.1126/science.234.4783.1509>

- Dubois, N., Saulnier-Talbot, É., Mills, K., Gell, P., Batarbee, R., Bennion, H., Chawchai, S., Dong, X., Francus, P., Flower, R., 2018. First human impacts and responses of aquatic systems: A review of palaeolimnological records from around the world. *The Anthropocene Review* 5, 28–68. <https://doi.org/10.1177/2053019617740365>
- Du Plessis, N., 2015. 4000 years of environmental and climate change at Eilandvlei: a palynological investigation into the late Holocene palaeoenvironment of the Wilderness Embayment. Masters thesis, University of Capetown, Capetown.
- Dull, R.A., 2004. An 8000-year record of vegetation, climate, and human disturbance from the Sierra de Apaneca, El Salvador. *Quaternary Research* 61, 159–167. <https://doi.org/10.1016/j.yqres.2004.01.002>
- Edwards, K.J., McIntosh, C.J., 1988. Improving the detection rate of cereal-type pollen grains from *Ulmus* decline and earlier deposits from Scotland. *Pollen et spores* 30,179–188
- Eeley, H.A.C., Lawes, M.J., Piper, S.E., 1999. The influence of climate change on the distribution of indigenous forest in KwaZulu-Natal, South Africa. *Journal of Biogeography* 26, 595–617. <https://doi.org/10.1046/j.1365-2699.1999.00307.x>
- Ehret, C., 2020. The First Spread of Food Production to Southern Africa. In: Ehret, C., Posnansky, M. (eds), *The Archaeological and Linguistic Reconstruction of African History*. University of California Press, California, pp. 158–181. <https://doi.org/10.1525/9780520314757-010>
- Ekblom, A., 2004. Changing landscapes: An environmental history of Chibuenne, southern Mozambique, *Global Studies in Archaeology* 5. Uppsala: Department of Archaeology and Ancient History.
- Ekblom, A., 2008. Forest–savanna dynamics in the coastal lowland of southern Mozambique since c. AD 1400. *The Holocene* 18, 1247–1257. <https://doi.org/10.1177/0959683608096599>
- Ekblom, A., Risberg, J., Holmgren, K., 2014a. Coastal forest and Miombo woodland history of the Vilankulo region, Mozambique. *The Holocene* 24, 284–294. <https://doi.org/10.1177/0959683613518592>
- Ekblom, A., Eichhorn, B., Sinclair, P., Badenhorst, S., Berger, A., 2014b. Land use history and resource utilisation from AD 400 to the present, at Chibuenne, southern Mozambique. *Vegetation History and Archaeobotany* 23(1), 15–32. <https://doi.org/10.1007/s00334-013-0392-4>
- Ekblom, A., Gillson, L., Notelid, M., 2017. Water flow, ecological dynamics, and management in the lower Limpopo Valley: a long-term view. *Wiley Interdisciplinary Reviews: Water* 4, e1228. <https://doi.org/10.1002/wat2.1228>
- Elphick, R., 1977. *Kraal and Castle: Khoikhoi and the Founding of White South Africa*. New Heaven, Connecticut. Yale University Press.
- Elphick, R., 1985. *Khoikhoi and the founding of white South Africa*. Johannesburg. Ravan Press.
- Evers, T.M., 1974. Three Iron Age industrial sites in the eastern Transvaal Lowveld. PhD thesis, University of the Witwatersrand, Johannesburg.
- Feely, J.M., Bell-Cross, S.M., 2011. The distribution of early iron age settlement in the Eastern Cape: some historical and ecological implications. *South African Archaeological Bulletin* 66, 105–112.
- Finch, J.M., Hill, T.R., 2008. A late Quaternary pollen sequence from Mfabeni Peatland, South Africa: Reconstructing forest history in Maputaland. *Quaternary Research* 70, 442–450. <https://doi.org/10.1016/j.yqres.2008.07.003>
- Fitchett, J.M., Bamford, M.K., 2017. The validity of the Asteraceae: Poaceae fossil pollen ratio in discrimination of the southern African summer- and winter-rainfall zones. *Quaternary Science Reviews* 160, 85–95. <https://doi.org/10.1016/j.quascirev.2017.02.008>
- Fitchett, J.M., Grab, S.W., Bamford, M.K., Mackay, A.W., 2016. A multi-proxy analysis of late Quaternary palaeoenvironments, Sekhokong Range, eastern Lesotho. *Journal of Quaternary Science* 31, 788–798. <https://doi.org/10.1002/jqs.2902>
- Fuller, D.Q., Hildebrand, E., 2013. Domesticating plants in Africa. In: Mitchell, P., Lane, P. (eds), *The Oxford handbook of African Archaeology*. Oxford University Press, Oxford, pp. 507–525.
- Garlake, P.S., 1982. Prehistory and ideology in Zimbabwe. *Africa*, 1–19.
- Geer, A., 2013. Holocene environmental changes derived from a montane pollen sequence in the KwaZulu-Natal midlands, South Africa. Masters thesis, University of KwaZulu-Natal, Pietermaritzburg.
- Geng, R., Zhao, Y., Cui, Q., Qin, F., 2019. Representation of modern pollen assemblages with respect to vegetation and climate in Northeast China. *Quaternary International* 532, 126–137. <https://doi.org/10.1016/j.quaint.2019.11.003>
- Gillson, L., Ekblom, A., 2020. Using palaeoecology to explore the resilience of southern African savannas. *Koedoe: African Protected Area. Conservation and Science* 62, 1–12. <https://doi.org/10.4102/koe-doe.v62i1.1576>
- Gil-Romera, G., Scott, L., Marais, E., Brook, G.A., 2006. Middle-to late-Holocene moisture changes in the desert of northwest Namibia derived from fossil hyrax dung pollen. *The Holocene* 16, 1073–1084. <https://doi.org/10.1177/0959683606069397>
- Gil-Romera, G., Scott, L., Marais, E., Brook, G.A., 2007. Late Holocene environmental change in the northwestern Namib Desert margin: new fossil pollen evidence from hyrax middens. *Palaeogeography, Palaeoclimatology, Palaeoecology* 249, 1–17. <https://doi.org/10.1016/j.palaeo.2007.01.002>
- Goodale, U.M., Ashton, M.S., Berlyn, G.P., Gregoire, T.G., Singhakumara, B.M.P., Tennakoon, K.U., 2012. Disturbance and tropical pioneer species: Patterns of association across life history stages. *Forest Ecology and Management* 277, 54–66. <https://doi.org/10.1016/j.foreco.2012.04.020>

- Govender, N., Trollope, W.S.W., Van Wilgen, B.W., 2006. The effect of fire season, fire frequency, rainfall and management on fire intensity in savanna vegetation in South Africa. *Journal of Applied Ecology* 43, 748–758. <https://doi.org/10.1111/j.1365-2664.2006.01184.x>
- Grime, J.P., 1979. *Plant strategies and vegetation processes*. New York. John Wiley and Sons.
- Guldemann, T., 2008. A linguist's view: Khoe-Kwadi speakers as the earliest food-producers of southern Africa. *Southern African Humanities* 20, 93–132.
- Hahn, A., Neumann, F.H., Miller, C., Finch, J., Frankland, T., Cawthra, H.C., Schefuß, E., Zabel, M., 2021. Mid-to Late Holocene climatic and anthropogenic influences in Mpondoland, South Africa. *Quaternary Science Reviews* 261, 106938. <https://doi.org/10.1016/j.quascirev.2021.106938>
- Hall, M., 1980. Man's role in the development of threatened habitats HABCON. Working Document, vol. 5, CSIR, Pretoria.
- Hall, M., 1983. Tribes, traditions and numbers: The American model in southern African Iron Age ceramic studies. *South African Archaeological Bulletin* 38, 51–57. <https://doi.org/10.2307/3888636>
- Hall, M., 1984. Man's historical and traditional use of fire in southern Africa. In: Booysen, P. de V., Tainton, N.M. (eds), *Ecological effects of fire in South African ecosystems*. Springer-Verlag, Berlin, pp. 39–52. [https://doi.org/10.1007/978-3-642-69805-7\\_3](https://doi.org/10.1007/978-3-642-69805-7_3)
- Hall, M., Morris, A., 1983. Race and Iron Age human skeletal remains from southern Africa: an assessment. *Social Dynamics* 9, 29–36. <https://doi.org/10.1080/02533958308458344>
- Henn, B.M., Gignoux, C., Lin, A.A., Oefner, P.J., Shen, P., Scozzari, R., Cruciani, F., Tishkoff, S.A., Mountain, J.L., Underhill, P.A., 2008. Y-chromosomal evidence of a pastoralist migration through Tanzania to southern Africa. *Proceedings of the National Academy of Sciences* 105, 10693–10698. <https://doi.org/10.1073/pnas.0801184105>
- Henshilwood, C., 1996. A revised chronology for pastoralism in southernmost Africa: new evidence of sheep at c. 2000 bp from Blombos Cave, South Africa. *Antiquity* 70, 945–949. <https://doi.org/10.1017/S0003598X00084210>
- Hogg, A.G., Hua, Q., Blackwell, P.G., Niu, M., Buck, C.E., Guilderson, T.P., Heaton, T.J., Palmer, J.G., Reimer, P.J., Reimer, R.W., 2013. SHCal13 Southern Hemisphere calibration, 0–50,000 years cal BP. *Radiocarbon* 55, 1889–1903. [https://doi.org/10.2458/azu\\_js\\_rc.55.16783](https://doi.org/10.2458/azu_js_rc.55.16783)
- Huffman, T.N., 1970. The Early Iron Age and the spread of the Bantu. *South African Archaeological Bulletin* 25, 3–21. <https://doi.org/10.2307/3888762>
- Huffman, T.N., 1971. Excavations at Leopard's Kopje Main Kraal: a preliminary report. *The South African Archaeological Bulletin*, 85–89.
- Huffman, T.N., 1979. African origins. *South African Journal of Science* 75, 233–237.
- Huffman, T.N., 1982. Archaeology and ethnohistory of the African Iron Age. *Annual Review of Anthropology* 11, 133–150. <https://doi.org/10.1146/annurev.an.11.100182.001025>
- Huffman, T.N., 1993. Broederstroom and the central cattle pattern. *South African Journal of Science* 89, 220–226.
- Huffman, T.N., 1996. Archaeological evidence for climatic change during the last 2000 years in southern Africa. *Quaternary International* 33, 55–60. [https://doi.org/10.1016/1040-6182\(95\)00095-X](https://doi.org/10.1016/1040-6182(95)00095-X)
- Huffman, T.N., 1998. Presidential address: the antiquity of lobola. *South African Archaeological Bulletin* 53, 57–62. <https://doi.org/10.2307/3889180>
- Huffman, T.N., 2007. *Handbook to the Iron Age*. Pietermaritzburg. University of KwaZulu-Natal Press.
- Jerardino, A., Fort, J., Isern, N., Rondelli, B., 2014. Cultural diffusion was the main driving mechanism of the Neolithic transition in southern Africa. *PloS one* 9, e113672. <https://doi.org/10.1371/journal.pone.0113672>
- Johannsmeier, M.F., 2016. *Bee plants of South Africa. Sources of nectar, pollen, honeydew and propolis for honeybees*. South African National Biodiversity Institute.
- Jordaan, G., 2017. *An archaeological study of two Early Farming sites in the southern Kruger National Park, South Africa: Masters thesis*. University of Pretoria, Pretoria.
- Katsamudanga, S., Pwiti, G., 2017. Chronology of Early Farming Communities of northern Zimbabwe: a Reappraisal. In: Manyanga, M., Chirikure, S. (eds), *Archives, Objects, Places and Landscapes: Multidisciplinary approaches to Decolonized Zimbabwean pasts*. Langaa Research and Publishing CIG, Bamenda, Cameroon, pp. 119–136.
- Kinahan, J., 2005. The late Holocene human ecology of the Namib Desert. M. Smith & P. Hesse (eds.) 23, 120–131.
- Kjellmark, E., 1996. Late Holocene climate change and human disturbance on Andros Island, Bahamas. *Journal of Paleolimnology* 15, 133–145. <https://doi.org/10.1007/BF00196777>
- Klapwijk, M., 1974. A preliminary report on pottery from the north-eastern Transvaal, South Africa. *South African Archaeological Bulletin* 29, 19–23. <https://doi.org/10.2307/3887933>
- Klapwijk, M., Huffman, T., 1996. Excavations at Silver Leaves: A preliminary report. *South African Archaeological Bulletin* 51, 84–93.
- Klein, R.G., 1986. The prehistory of Stone Age herders in the Cape Province of South Africa. *South African Archaeological Bulletin Goodwin Series* 5, 5–12. <https://doi.org/10.2307/3858140>
- Lander, F., Russell, T., 2018. The Archaeological evidence for the appearance of Pastoralism and Farming in southern Africa. *PloS ONE* 13(6), e0198941. <https://doi.org/10.1371/journal.pone.0198941>

- Lander, F., Russell, T., 2020. A southern African archaeological database of organic containers and materials, 800 cal BC to cal AD 1500: Possible implications for the transition from foraging to livestock-keeping. *PLoS ONE* 15, e0235226. <https://doi.org/10.1371/journal.pone.0235226>
- Lane, P., 2004. The ‘moving frontier’ and the transition to food production in Kenya. *Azania: Journal of the British Institute in Eastern Africa* 39, 243–264. <https://doi.org/10.1080/00672700409480402>
- Lebamba, J., Vincens, A., Lézine, A.-M., Marchant, R., Buchet, G., 2016. Forest-savannah dynamics on the Adamawa plateau (Central Cameroon) during the “African humid period” termination: A new high-resolution pollen record from Lake Tizong. *Review of Palaeobotany and Palynology* 235, 129–139. <https://doi.org/10.1016/j.revpalbo.2016.10.001>
- Lenssen-Erz, T., Vogelsang, R., 2005. Populating No-Man’s-Land: Rock art in northern Namibia. *South African Archaeological Bulletin Goodwin Series* 9, 54–62.
- Li, S., Schlebusch, C., Jakobsson, M., 2014. Genetic variation reveals large-scale population expansion and migration during the expansion of Bantu-speaking peoples. *Proceedings of the Royal Society B: Biological Sciences* 281, 20141448. <https://doi.org/10.1098/rspb.2014.1448>
- Li, Y., Zhou, L., Cui, H., 2008. Pollen indicators of human activity. *Chinese Science Bulletin* 53, 1281–1293. <https://doi.org/10.1007/s11434-008-0181-0>
- Lim, S., Chase, B.M., Chevalier, M., Reimer, P.J., 2016. 50,000 years of vegetation and climate change in the southern Namib Desert, Pella, South Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* 451, 197–209. <https://doi.org/10.1016/j.palaeo.2016.03.001>
- MacDevette, D.R., MacDevette, D.K., Gordon, I.G., Bartholomew, R.L.C., 1989. Floristics of the Natal indigenous forests. In: Geldenhuys, C.J. (ed.), *Biogeography of the Mixed Evergreen Forests of southern Africa*. Foundation of Research Development, Pretoria, pp. 124–145.
- Madiquida, H., 2006. The Iron Age communities in the Zambezi river basin: excavations in Mozambique. SAFA 23–26 June, 2006, University of Calgary, Alberta, Canada.
- Maggs, T., 1980a. The Iron Age Sequence South of the Vaal and Pongola Rivers: some Historical Implications. *The Journal of African History* 21, 1–15. <https://doi.org/10.1017/S0021853700017825>
- Maggs, T., 1980b. Mzonjani and the beginning of the Iron Age in Natal. *Annals of the Natal Museum* 24, 71–96.
- Maggs, T., 1984. The Iron Age south of the Zambezi. In: Klein, R.G. (ed.), *Southern African Prehistory and Palaeoenvironments*. Balkema, Rotterdam, pp. 329–361.
- Maggs, T., 1994. The Early Iron Age in the extreme south: some patterns and problems. *Azania: Archaeological Research in Africa* 29, 168–178. <https://doi.org/10.1080/00672709409511669>
- Maggs, T., Ward, V., 1984. Early Iron Age sites in the Muden area of Natal. *Annals of the Natal Museum* 26, 105–140.
- Maggs, T., Whitelaw, G., 1991. A review of recent archaeological research on food-producing communities in southern Africa. *The Journal of African History* 32, 3–24. <https://doi.org/10.1017/S0021853700025317>
- Marais, E., Scott, L., Gil-Romera, G., Carrión, J.S., 2015. The potential of palynology in fossil bat-dung from Arnhem Cave, Namibia. *Transactions of the Royal Society of South Africa* 70, 109–115. <https://doi.org/10.1080/0035919X.2014.999734>
- Marker, M.E., Evers, T.M., 1976. Iron Age Settlement and Soil Erosion in the Eastern Transvaal, South Africa. *South African Archaeological Bulletin* 31, 153–165. <https://doi.org/10.2307/3887737>
- Marks, S.J., Montinaro, F., Levy, H., Brisighelli, F., Ferri, G., Bertocini, S., Batini, C., Busby, G.B.J., Arthur, C., Mitchell, P., 2015. Static and moving frontiers: the genetic landscape of Southern African Bantu-speaking populations. *Molecular Biology and Evolution* 32, 29–43. <https://doi.org/10.1093/molbev/msu263>
- Mason, R., 1981. Early Iron Age settlement at Broederstroom 24/73, Transvaal, South Africa. *South African Journal of Science* 77, 401–416.
- Mason, R.J., 1986. Origins of Black People of Johannesburg and the Southern Western Central Transvaal, AD 350–1880 (Occasional Paper 16). University of the Witwatersrand Archaeological Research Unit, Johannesburg.
- Mazel, A.D., 1989. People making history: the last ten thousand years of hunter-gatherer communities in the Thukela Basin. *Southern African Humanities* 1, 1–168.
- Mazel, A.D., 1992. Collingham Shelter: the excavation of late Holocene deposits, Natal, South Africa. *Southern African Humanities* 4, 1–51.
- Mazel, A.D., 2022. Mountain living: The Holocene people of the uKhahlamba-Drakensberg, South Africa. *Quaternary International* 611–612, 190–210. <https://doi.org/10.1016/j.quaint.2021.04.039>
- McCann, J., 2001. Maize and Grace: History, corn, and Africa’s new landscapes, 1500–1999. *Comparative Studies in Society and History* 43, 246–272. <https://doi.org/10.1017/S0010417501003486>
- McWethy, D.B., Neumann, F.H., Steinbruch, F., Ryan, C.M., Valsecchi, V., 2016. Late Quaternary vegetation development and disturbance dynamics from a peatland on Mount Gorongosa, central Mozambique. *Quaternary Science Reviews* 137, 221–233. <https://doi.org/10.1016/j.quascirev.2016.02.004>
- Meadows, M.E., Baxter, A.J., 2001. Holocene vegetation history and palaeoenvironments at Klaarfontein Springs, Western Cape, South Africa. *The Holocene* 11, 699–706. <https://doi.org/10.1191/09596830195726>

- Meadows, M.E., Sugden, J.M., 1991. A vegetation history of the last 14 000 years on the Cederberg, south-western Cape Province. *South African Journal of Science* 87, 34–43.
- Meadows, M.E., Chase, B.M., Seliane, M., 2010. Holocene palaeoenvironments of the Cederberg and Swartruggens mountains, Western Cape, South Africa: pollen and stable isotope evidence from hyrax dung middens. *Journal of Arid Environments* 74, 786–793. <https://doi.org/10.1016/j.jaridenv.2009.04.020>
- Mercader, J., Sillé, P., 2013. Middle and later stoneage sites from Sofala, Gorongosa (Central Mozambique). *Nyame akuma* 80, 1–13.
- Meyer, A., 1986. 'N Kultuurhistoriese interpretasie van die ystertydperk in die Nasionale Krugerwildtuin. PhD thesis, University of Pretoria, Pretoria.
- Miller, D., Whitelaw, G., 1994. Early Iron Age metal working from the site of KwaGandaganda, Natal, South Africa. *South African Archaeological Bulletin* 49, 79–89. <https://doi.org/10.2307/3889226>
- Miracle, M.P., 1965. The introduction and spread of maize in Africa. *Journal of African History* 6(1), 39–55.
- Mitchell, P., 2002. *The Archaeology of southern Africa*. Cambridge. Cambridge University Press.
- Mitchell, P., 2005. *African connections: Archaeological perspectives on Africa and the wider world*. Lanham, Maryland. Rowman Altamira press.
- Mitchell, P., Whitelaw, G., 2005. The Archaeology of Southernmost Africa from c. 2000 BP to the Early 1800s: A Review of Recent Research. *Journal of African History* 46, 209–241. <https://doi.org/10.1017/S0021853705000770>
- Mitchell, P.J., 1996. Sehonghong: the late Holocene assemblages with pottery. *South African Archaeological Bulletin* 51, 17–25. <https://doi.org/10.2307/3888928>
- Moore, M.P.J., 1981. The Iron age of the Makapan valley area, Central Transvaal. Masters Thesis, University of the Witwatersrand, Johannesburg.
- Morais, J.M., 1988. *The Early Farming Communities of Southern Mozambique*. Studies in African Archaeology 3, Uppsala University, Uppsala.
- Mucina, L., Rutherford, M., 2006. *The vegetation of South Africa, Lesotho and Swaziland*. Strelitzia 19, South African National Biodiversity Institute, Pretoria, South Africa.
- Muigai, A.W.T., Hanotte, O., 2013. The Origin of African sheep: Archaeological and Genetic perspectives. *African Archaeological Review* 30, 39–50. <https://doi.org/10.1007/s10437-013-9129-0>
- Muller, K., O'Connor, T.G., Henschel, J.R., 2016. Impact of a severe frost event in 2014 on woody vegetation within the Nama-Karoo and semi-arid savanna biomes of South Africa. *Journal of Arid Environments* 133, 112–121. <https://doi.org/10.1016/j.jaridenv.2016.06.010>
- Muller, M., Siebert, S.J., Ntloko, B.R., Siebert, F., 2021. 'A floristic assessment of grassland diversity loss in South Africa', *Bothalia-African Biodiversity and Conservation* 51(1), 1–9. <http://dx.doi.org/10.38201/btha.abc.v51.i1.11>
- Mvelase, S., 2021. *Palaeoenvironments at the Shashe-Limpopo Confluence Area from 1000 to 1220 AD: Palynological Analysis of Cattle Dung Samples*. BSc Honours Thesis, University of the Witwatersrand, Johannesburg.
- Nash, D.J., Meadows, M.E., Gulliver, V.L., 2006. Holocene environmental change in the Okavango Panhandle, northwest Botswana. *Quaternary Science Reviews* 25, 1302–1322. <https://doi.org/10.1016/j.quascirev.2005.11.004>
- Neary, D.G., Leonard, J.M., 2020. Effects of Fire on Grassland Soils and Water: A Review. In: Kin-domihou, V.M., editor. *Grasses and Grassland Aspects* [Internet]. London: IntechOpen; [cited 2022 Apr 28]. Available from: <https://www.intechopen.com/chapters/70724> doi: 10.5772/intechopen.90747
- Neumann, F.H., Botha, G.A., Scott, L., 2014. 18,000 years of grassland evolution in the summer rainfall region of South Africa: evidence from Mahwaqa Mountain, KwaZulu-Natal. *Vegetation History and Archaeobotany* 23, 665–681. <https://doi.org/10.1007/s00334-014-0445-3>
- Neumann, F.H., Scott, L., Bamford, M., 2011. Climate change and human disturbance of fynbos vegetation during the late Holocene at Princess Vlei, Western Cape, South Africa. *The Holocene* 21, 1137–1149. <https://doi.org/10.1177/0959683611400461>
- Neumann, F.H., Scott, L., Bousman, C., Van As, L., 2010. A Holocene sequence of vegetation change at Lake Eteza, coastal KwaZulu-Natal, South Africa. *Review of Palaeobotany and Palynology* 162, 39–53. <https://doi.org/10.1016/j.revpalbo.2010.05.001>
- Neumann, F.H., Stager, J.C., Scott, L., Venter, H.J., Weyhenmeyer, C., 2008. Holocene vegetation and climate records from lake Sibaya, KwaZulu-Natal (South Africa). *Review of Palaeobotany and Palynology* 152, 113–128. <https://doi.org/10.1016/j.revpalbo.2008.04.006>
- Nkala, P., Mango, N.A.R., Corbeels, M., Veldwisch, G.J.A., Huising, E.J., 2011. The conundrum of conservation agriculture and livelihoods in Southern Africa. *African Journal of Agricultural Research* 6(24), 5520–5528.
- Nyakale, M., 1999. *Palynology of Late Quaternary deposits from the central plateau, South Africa: Masters thesis*. University of the Orange Free State, Bloemfontein.
- O'Connor, T.G., van Wilgen, B.W., 2020. The Impact of Invasive Alien Plants on Rangelands in South Africa. In van Wilgen, B.W., Measey, J., Richardson, D.M., Wilson, J.R., Zengeya, T.A. (eds), *Biological Invasions in South Africa*. Springer, Switzerland, pp. 459–487. [https://doi.org/10.1007/978-3-030-32394-3\\_16](https://doi.org/10.1007/978-3-030-32394-3_16)
- Orton, J.D.J., 2013. *Late Holocene archaeology in Namaqualand, South Africa: hunter-gatherers and herders in a semi-arid environment*. PhD thesis, University of Oxford, Oxford.

- Orton J.D.J., Mitchell, P., Klein, R., Steele, T., Horsburgh, K.A., 2013. An early date for cattle from Namaqualand, South Africa: implications for the origins of herding in southern Africa. *Antiquity* 87, 108–120. <https://doi.org/10.1017/S0003598X00048651>
- Orton, J.D.J., 2015. The Introduction of Pastoralism to southernmost Africa: thoughts on new contributions to an ongoing debate. *Azania: Archaeological Research in Africa* 50, 250–258. <https://doi.org/10.1080/0067270X.2015.1019262>
- Parkington, J., 1977. Soaqua: hunter-fisher-gatherers of the Olifants river valley western Cape. *South African Archaeological Bulletin* 32, 150–157. <https://doi.org/10.2307/3888661>
- Parkington, J., Hall, S., 2010. The appearance of food production in southern Africa 1,000 to 2,000 years ago. *The Cambridge History of South Africa* 1, 63–111. <https://doi.org/10.1017/CHOL9780521517942.003>
- Parkington, J., Poggenpoel, C., 1987. Diepkloof Rock Shelter. In: Parkington, J., Hall, M. (eds) *Papers in the Prehistory of the Western Cape, South Africa*. British Archaeological Reports International Series 332(ii), pp. 269–293.
- Partridge, T., 1966. Ficus Cave: an Iron Age living site in the central Transvaal. *South African Archaeological Bulletin* 21, 125–132. <https://doi.org/10.2307/3888431>
- Phillipson, D.W., 1976. Archaeology and Bantu linguistics. *World Archaeology* 8, 65–82. <https://doi.org/10.1080/00438243.1976.9979653>
- Phillipson, D.W., 1977. *The later prehistory of eastern and southern Africa*. New York. Africana Pub. Co.
- Phillipson, D.W., 2005. *African archaeology*. Cambridge. Cambridge University Press.
- Pleurdeau, D., Imalwa, E., Détroit, F., Lesur, J., Veldman, A., Bahain, J.-J., Marais, E., 2012. “Of sheep and men”: earliest direct evidence of caprine domestication in southern Africa at Leopard Cave (Erongo, Namibia). *PloS One* 7: e40340. <https://doi.org/10.1371/journal.pone.0040340>
- Pleurdeau, D., Imalwa, E., Détroit, F., Lesur, J., Veldman, A., Bahain, J.-J., Marais, E., 2012. “Of sheep and men”: earliest direct evidence of caprine domestication in southern Africa at Leopard Cave (Erongo, Namibia). *PLoS ONE* 7: e40340.
- Prendergast, M.E., 2011. Hunters and herders at the periphery: The spread of herding in eastern Africa. In: Jousse, H., Lesur, J. (eds), *People and Animals in Holocene Africa: Recent Advances in Archaeozoology*. Africa Magna Verlag, Frankfurt, pp. 43–58.
- Pwiti, G., 1996. Settlement and subsistence of prehistoric farming communities in the mid-Zambezi valley, Northern Zimbabwe. *The South African Archaeological Bulletin* 51, 3–6. <https://doi.org/10.2307/3888926>
- Quick, L., 2009. Late quaternary vegetation history and palaeoenvironments of the Cederberg Mountains, South Africa: evidence from hyrax (*Procavia capensis*) middens. Masters Thesis, University of Capetown, Capetown.
- Quick, L.J., Carr, A.S., Meadows, M.E., Boom, A., Bateman, M.D., Roberts, D.L., Reimer, P.J., Chase, B.M., 2015. A late Pleistocene–Holocene multiproxy record of palaeoenvironmental change from Still Bay, southern Cape Coast, South Africa. *Journal of Quaternary Science* 30, 870–885. <https://doi.org/10.1002/jqs.2825>
- Quick, L.J., Chase, B.M., Meadows, M.E., Scott, L., Reimer, P.J., 2011. A 19.5 kyr vegetation history from the central Cederberg Mountains, South Africa: palynological evidence from rock hyrax middens. *Palaeogeography, Palaeoclimatology, Palaeoecology* 309, 253–270. <https://doi.org/10.1016/j.palaeo.2011.06.008>
- Ranciaro, A., Campbell, M.C., Hirbo, J.B., Ko, W.Y., Froment, A., Anagnostou, P., Kotze, M.J., Ibrahim, M., Nyambo, T., Omar, S.A., 2014. Genetic origins of lactase persistence and the spread of pastoralism in Africa. *The American Journal of Human Genetics* 94, 496–510. <https://doi.org/10.1016/j.ajhg.2014.02.009>
- Robbins, L.H., Campbell, A.C., Murphy, M.L., Brook, G.A., Liang, F., Skaggs, S.A., Srivastava, P., Mabuse, A.A., Badenhorst, S., 2008. Recent archaeological research at Toteng, Botswana: early domesticated livestock in the Kalahari. *Journal of African Archaeology* 6, 131–149. <https://doi.org/10.3213/1612-1651-10106>
- Robertson, J.H., 2000. Early Iron Age archaeology in central Zambia. *Azania: Journal of the British Institute in Eastern Africa* 35, 147–182. <https://doi.org/10.1080/00672700009511600>
- Robinson, K.R., 1966. The Leopard’s Kopje culture, its position in the Iron Age of Southern Rhodesia. *The South African Archaeological Bulletin* 21, 5–51.
- Roos, C.I., Field, J.S., Dudgeon, J.V., 2016. Anthropogenic burning, agricultural intensification, and landscape transformation in Post-Lapita Fiji. *Journal of Ethnobiology* 36, 535–553. <https://doi.org/10.2993/0278-0771-36.3.535>
- Rosen, D.Z., Lewis, C.A., Illgner, P.M., 1999. Palaeoclimatic and archaeological implications of organic-rich sediments at Tiffidell Ski Resort, near Rhodes, eastern Cape province, south Africa. *Transactions of the Royal Society of South Africa* 54, 311–321. <https://doi.org/10.1080/00359199909520630>
- Rotunno, R., Mercuri, A.M., Florenzano, A., Zerbini, A., di Lernia, S., 2020. The Visibility of Mobility: Coprolites, Dung and Neolithic Herders in Central Saharan Rock Shelters. *Environmental Archaeology*, 1–16. <https://doi.org/10.1080/14614103.2020.1777057>
- Russell, T., Silva, F., Steele, J., 2014. Modelling the spread of farming in the Bantu-speaking regions of Africa: an archaeology-based phylogeography. *PLoS ONE* 9(1), e87854. <https://doi.org/10.1371/journal.pone.0087854>
- Rutherford, M.C., Westfall, R.H., 1994. Biomes of southern Africa: an objective categorization. *Memoirs of the Botanical Survey of South Africa* 63, 1–94.

- Sadr, K., 2008. Invisible herders? The archaeology of Khoekhoe pastoralists. *Southern African Humanities* 20, 179–203.
- Sadr, K., 2014. Radiocarbon dates, stone tools and the origin of herding on the West Coast of South Africa. Frankfurt. Africa Magna Verlag.
- Sadr, K., 2015. Livestock first reached southern Africa in two separate events. *PLoS ONE* 10, e0134215. <https://doi.org/10.1371/journal.pone.0134215>
- Sadr, K., 2019. The ‘Neolithic’ Concept in South Africa. *South African Archaeological Bulletin Goodwin Series* 12, 69–71.
- Sadr, K., 2020. The Archaeology of Highveld Farming Communities. In: *Oxford Research Encyclopedia of African History*. <https://doi.org/10.1093/acrefore/9780190277734.013.731>
- Sadr, K., Sampson, C.G., 2006. Through thick and thin: early pottery in southern Africa. *Journal of African Archaeology* 4, 235–252. <https://doi.org/10.3213/1612-1651-10074>
- Sandelowsky, B.H., 1977. Mirabib-an archaeological study in the Namib. *Madoqua*, 221–253.
- Sarwat, M., Das, S., Srivastava, P.S., 2008. Analysis of genetic diversity through AFLP, SAMPL, ISSR and RAPD markers in *Tribulus terrestris*, a medicinal herb. *Plant Cell Reports* 27, 519–528. <https://doi.org/10.1007/s00299-007-0478-5>
- Schweitzer, F.R., 1974. Archaeological evidence for sheep at the Cape. *South African Archaeological Bulletin* 29, 75–82. <https://doi.org/10.2307/3888331>
- Schweitzer, F.R., Wilson, M.L., 1982. Byneskranskop 1: a late Quaternary living site in the southern Cape Province, South Africa. *Annals of the South African Museum* 88, 1–203.
- Scott, C., 2005. Analysis and interpretation of botanical remains from Sibudu Cave, Kwazulu Natal. Masters Thesis, University of the Witwatersrand, Johannesburg
- Scott, J.K., Morrison, S.M., 1996. Variation in populations of *Tribulus terrestris* (Zygophyllaceae). 1. Burr morphology. *Australian Journal of Botany* 44, 175–190. <https://doi.org/10.1071/BT9960175>
- Scott, K., Plug, I., 2016. Osteomorphology and osteometry versus aDNA in taxonomic identification of fragmentary sheep and sheep/goat bones from archaeological deposits: Blydefontein Shelter, Karoo, South Africa. *Southern African Humanities* 28, 61–79
- Scott, L., 1982a. A Late Quaternary pollen record from the Transvaal bushveld, South Africa. *Quaternary Research* 17, 339–370. [https://doi.org/10.1016/0033-5894\(82\)90028-X](https://doi.org/10.1016/0033-5894(82)90028-X)
- Scott, L., 1982b. Late Quaternary fossil pollen grains from the Transvaal, South Africa. *Review of Palaeobotany and Palynology* 36, 241–278. [https://doi.org/10.1016/0034-6667\(82\)90022-7](https://doi.org/10.1016/0034-6667(82)90022-7)
- Scott, L., 1982c. A 5000-year old pollen record from spring deposits in the bushveld at the north of the Soutpansberg, South Africa. *Palaeoecology of Africa* 14, 45–55.
- Scott, L., 1984. Reconstruction of Late Quaternary palaeoenvironments in the Transvaal on the basis of palynological evidence. In: Vogel, J.C. (ed.), *Late Cainozoic Palaeoclimates of the Southern Hemisphere*. Balkema, Rotterdam, pp. 317–327.
- Scott, L., 1987. Late Quaternary forest history in Venda, southern Africa. *Review of Palaeobotany and Palynology* 53, 1–10. [https://doi.org/10.1016/0034-6667\(87\)90008-X](https://doi.org/10.1016/0034-6667(87)90008-X)
- Scott, L., 1988. Holocene environmental change at western Orange Free State pans, South Africa, inferred from pollen analysis. *Palaeoecology of Africa* 19, 109–118.
- Scott, L., 1996. Palynology of hyrax middens: 2000 years of palaeoenvironmental history in Namibia. *Quaternary International* 33, 73–79. [https://doi.org/10.1016/1040-6182\(95\)00093-3](https://doi.org/10.1016/1040-6182(95)00093-3)
- Scott, L., 1999. Palynological analysis of the Pretoria Saltpan (Tswaing Crater) sediments and vegetation history in the bushveld savanna biome, South Africa. In: Partridge, T.C. (ed.) *Tswaing- investigations into the Origin, Age and Palaeoenvironments of the Pretoria Saltpan*. Council for Geosciences, Pretoria, pp. 143–166.
- Scott, L., 2002. Microscopic charcoal in sediments: Quaternary fire history of the grassland and savanna regions in South Africa. *Journal of Quaternary Science* 17, 77–86. <https://doi.org/10.1002/jqs.641>
- Scott, L., 2016. Fluctuations of vegetation and climate over the last 75 000 years in the Savanna Biome, South Africa: Tswaing Crater and Wonderkrater pollen sequences reviewed. *Quaternary Science Reviews* 145, 117–133. <https://doi.org/10.1016/j.quascirev.2016.05.035>
- Scott, L., Nyakale, M., 2002. Pollen indications of Holocene palaeoenvironments at Florisbad spring in the central Free State, South Africa. *The Holocene* 12, 497–503. <https://doi.org/10.1191/0959683602hl563rr>
- Scott, L., Thackeray, J.F., 1987. Multivariate analysis of late Pleistocene and Holocene pollen spectra from Wonderkrater, Transvaal, South Africa. *South African Journal of Science* 83, 93–98.
- Scott, L., Vogel, J.C., 1983. Late Quaternary pollen profile from the Transvaal highveld South Africa. *South African Journal of Science* 79, 266–272.
- Scott, L., Woodborne, S., 2007. Vegetation history inferred from pollen in Late Quaternary faecal deposits (hyraceum) in the Cape winter-rain region and its bearing on past climates in South Africa. *Quaternary Science Reviews* 26, 941–953. <https://doi.org/10.1016/j.quascirev.2006.12.012>
- Scott, L., Bousman, C.B., Nyakale, M., 2005. Holocene pollen from swamp, cave and hyrax dung deposits at Blydefontein (Kikvorsberge), Karoo, South Africa. *Quaternary International* 129, 49–59. <https://doi.org/10.1016/j.quaint.2004.04.006>
- Scott, L., Cooremans, B., De Wet, J.S., Vogel, J.C., 1991. Holocene environmental changes in Namibia inferred from pollen analysis of swamp and



- lake deposits. *The Holocene* 1, 8–13. <https://doi.org/10.1177/095968369100100103>
- Scott, L., Holmgren, K., Talma, A.S., Woodborne, S., Vogel, J.C., 2003. Age interpretation of the Wonderkrater spring sediments and vegetation change in the Savanna Biome, Limpopo province, South Africa. *South African Journal of Science* 99, 484–488.
- Scott, L., Neumann, F.H., Brook, G.A., Bousman, C.B., Norström, E., Metwally, A., 2012. Terrestrial fossil-pollen evidence of climate change during the last 26 thousand years in Southern Africa. *Quaternary Science Reviews* 32, 100–118. <https://doi.org/10.1016/j.quascirev.2011.11.010>
- Scott, L., Romera, G.G., Marais, E., Brook, G.A., 2018. Pollen in fossil hyrax dung from Marine Isotope Stages 2 and 3 reveals past environments in Namibia. *Quaternary International* 464, 260–272. <https://doi.org/10.1016/j.quaint.2017.06.054>
- Scott, L., Sobol, M., Neumann, F.H., Gil Romera, G., Fernandez-Jalvo, Y., Bousman, C.B., Horwitz, L.K., van Aardt, A.C., 2022. Late Quaternary palaeoenvironments in the central semi-arid region of South Africa from pollen in cave, pan, spring, stream and dung deposits. *Quaternary International* 614, 84–97. <https://doi.org/10.1016/j.quaint.2020.10.065>
- Sebata, A., Ngongoni, N.T., Mupangwa, J.F., Nyakudya, I.W., Dube, J.S., 2005. Chemical composition and degradation characteristics of puncture vine (*Tribulus terrestris*). *Tropical and Subtropical Agroecosystems* 5, 85–89.
- Shi, N., Dupont, L.M., Beug, H.-J., Schneider, R., 1998. Vegetation and climate changes during the last 21 000 years in SW Africa based on a marine pollen record. *Vegetation History and Archaeobotany* 7, 127–140. <https://doi.org/10.1007/BF01374001>
- Sinclair, P.J., 1982. Chibuene – an early trading site in southern Mozambique. *Paideuma* 28, 159–164.
- Sinclair, P.J., 1987. Space, time and social formation: a territorial approach to the archaeology and anthropology of Zimbabwe and Mozambique c 0–1700 AD. *Societas Archaeologica Upsaliensis*, Uppsala.
- Sinclair, P.J., Nydolf, N.-G., Wickman-Nydolf, G., 1987. Excavations at the University Campus, Maputo, Mozambique, 1984–85. *Studies in African Archaeology* 1. Maputo and Stockholm: Eduardo Mondlane University and the Central Board of National Antiquities.
- Sjöström, J., Norström, E., Risberg, J., Schoeman, M.H., 2017. Late Holocene palaeoenvironmental reconstruction from Mpumalanga Province (South Africa) inferred from geochemical and biogenic proxies. *Review of Palaeobotany and Palynology* 246, 264–277. <https://doi.org/10.1016/j.revpalbo.2017.06.011>
- Skead, C.J., 1980. Historical mammal incidence in the Cape Province. Department of Nature and Environmental Conservation of the Provincial Administration of the Cape of Good Hope, Cape Town, pp. 11–17.
- Smith, A.B., 1987. Seasonal exploitation of resources on the Vredenburg Peninsula after 2000 BP. In: Parkington, J.E., Hall, M. (eds), *Papers in the Prehistory of the Western Cape, South Africa*. British Archaeological Reports International Series 332, Oxford, pp. 393–402.
- Smith, A.B., 1992. *Pastoralism in Africa. Origins and Development Ecology*. Hurst and Company, Ohio University Press/Witwatersrand University Press, London/Athens/Johannesburg.
- Smith, A.B., 2008. Pastoral origins at the Cape, South Africa: influences and arguments. *Southern African Humanities* 20, 49–60.
- Smith, A.B., 2017. Why would southern African hunters be reluctant food producers. *Hunter Gatherer Research* 2, 415–435. <https://doi.org/10.3828/hgr.2016.28>
- Staver, A.C., Bond, W.J., Stock, W.D., Van Rensburg, S.J., Waldram, M.S., 2009. Browsing and fire interact to suppress tree density in an African savanna. *Ecological Applications* 19, 1909–1919. <https://doi.org/10.1890/08-1907.1>
- Tabares, X., Mapani, B., Blaum, N., Herzsuh, U., 2018. Composition and diversity of vegetation and pollen spectra along gradients of grazing intensity and precipitation in southern Africa. *Review of Palaeobotany and Palynology* 253, 88–100. <https://doi.org/10.1016/j.revpalbo.2018.04.004>
- Tomlinson, R.W., 1973. *The Inyanga Area: An Essay in Regional Biogeography*. University of Rhodesia Occasional Paper 1, 1–67.
- Turner, S., Plater, A., 2004. Palynological evidence for the origin and development of late Holocene wetland sediments: Mdlanzi Swamp, KwaZulu-Natal, South Africa. *South African Journal of Science* 100, 220–229.
- Tyson, P.D., Preston-Whyte, R.A., 2000. *Weather and climate of southern Africa*. Cape Town. Oxford University Press.
- Valsecchi, V., Chase, B.M., Slingsby, J.A., Carr, A.S., Quick, L.J., Meadows, M.E., Cheddadi, R., Reimer, P.J., 2013. A high resolution 15,600-year pollen and microcharcoal record from the Cederberg Mountains, South Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* 387, 6–16. <https://doi.org/10.1016/j.palaeo.2013.07.009>
- Van Asperen, E.N., Kirby, J.R., Shaw, H.E., 2020. Relating dung fungal spore influx rates to animal density in a temperate environment: implications for palaeoecological studies. *The Holocene* 30, 218–232. <https://doi.org/10.1177/0959683619875804>
- Van Valkenburg, J.L.C.H., Ketner, P., 1994. Vegetation changes following human disturbance of mid-montane forest in the Wau area, Papua New Guinea. *Journal of Tropical Ecology* 10, 41–54. <https://doi.org/10.1017/s0266467400007707>
- Verdú, A.M.C., Mas, M.T., 2006. Cohort-dependent seedling recruitment, survival and reproductive capacity of *Tribulus terrestris*. *Weed Research* 46, 371–378. <https://doi.org/10.1111/j.1365-3180.2006.00521.x>

- Vogelsang, R., Eichhorn, B., Richter, J., 2002. Holocene human occupation and vegetation history in northern Namibia. *Die Erde* 133, 113–132.
- Voigt, E.A., 1980. Reconstructing Iron Age economies of the northern Transvaal: a preliminary report. *The South African Archaeological Bulletin*, 39–45.
- Voigt, E.A., 1984. The faunal remains from Magogo and Mhlopheni: small stock herding in the Early Iron Age of Natal. *Annals of the Natal Museum* 26, 141–163.
- Wadley, L., 1978. Later Stone Age hunters and gatherers of the southern Transvaal: social and ecological interpretation (Vol. 25). *British Archaeological Reports*.
- Wadley, L., 1996. Changes in the social relations of precolonial hunter-gatherers after agropastoralist contact: an example from the Magaliesberg, South Africa. *Journal of Anthropological Archaeology*, 15(2), 205–217. <https://doi.org/10.1006/jaar.1996.0008>
- Walther, S.C., Neumann, F.H., 2011. Sedimentology, isotopes and palynology of late Holocene cores from Lake Sibaya and the Kosi Bay system (KwaZulu-Natal, South Africa). *South African Geographical Journal* 93, 133–153. <https://doi.org/10.1080/03736245.2011.591982>
- Wang, K., Goldstein, S., Bleasdale M., Clist, B., Bos-toen, K., Bakwa-Lufu, P., Buck, L.T., Crowther, A., Dème, A., McIntosh, R.J., 2020. Ancient genomes reveal complex patterns of population movement, interaction, and replacement in sub-Saharan Africa. *Science Advances* 6(24), eaaz0183. <https://doi.org/10.1126/sciadv.aaz0183>
- Wei, H., Zhao, Y., 2016. Surface pollen and its relationships with modern vegetation and climate in the Tianshan Mountains, northwestern China. *Vegetation History and Archaeobotany* 25, 19–27. <https://doi.org/10.1007/s00334-015-0530-2>
- Whittington, G., Edwards, K.J., Caseldine, C.J., 1991. Late-and post-glacial pollen-analytical and environmental data from a near-coastal site in north-east Fife, Scotland. *Review of Palaeobotany and Palynology* 68, 65–85. [https://doi.org/10.1016/0034-6667\(91\)90058-B](https://doi.org/10.1016/0034-6667(91)90058-B)
- Whitelaw, G., 1991. Precolonial iron production around Durban and in southern Natal. *Southern African Humanities* 3, 29–39.
- Whitelaw, G., 1994. KwaGandaganda: settlement patterns in the Natal Early Iron Age. *Southern African Humanities* 6, 1–64.
- Whitelaw, G., Moon, M., 1996. The distribution and ceramics of pioneer agriculturists in KwaZulu-Natal Natal Museum. *Journal of Humanities* 8, 53–79.
- Wood, E.T., Stover, D.A., Ehret, C., Destro-Bisol, G., Spedini, G., McLeod, H., Louie, L., Bamshad, M., Strassmann, B.I., Soodyall, H., 2005. Contrasting patterns of Y chromosome and mtDNA variation in Africa: evidence for sex-biased demographic processes. *European Journal of Human Genetics* 13, 867–876. <https://doi.org/10.1038/sj.ejhg.5201408>
- Young, R., Thompson, G., 1999. Missing plant foods? Where is the archaeological evidence for sorghum and finger millet in East Africa? In: van der Veen, M. (ed.), *The exploitation of plant resources in Ancient Africa*. Plenum/Kluwer, New York, pp. 63–72. [https://doi.org/10.1007/978-1-4757-6730-8\\_6](https://doi.org/10.1007/978-1-4757-6730-8_6)