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A Historical Ecology of the Limpopo and Kruger National Parks and Lower Limpopo Valley

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ABSTRACT:

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The paper uses new palaeo-ecological data and a selective review of archaeological and written sources to show how social and natural history over the last 1200 years have interacted to form the present day landscape of Limpopo National Park and Northern Kruger National Park. The long-term mosaic of different communities in this landscape, hunter and gatherers, pastoralists, farmers and traders has, over time, contributed to shape and reshape a heterogeneous landscape. While some features in this landscape, such as water scarcity, have remained stable over time, there have also been major transformations in both the physical landscape and social life. The natural mosaics have been utilised and enhanced over time and the combination of natural and cultural mosaics are reflected in the landscape through archaeological sites, the pollen record and in the present day landscape.

KEYWORDS: Archaeology, Historical ecology, history, Limpopo national park, environmental change, paleoecology, socio-environmental dynamics, Southern Africa.

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The paper uses new palaeo-ecological data and a selective review of archaeological and written sources to show how social and natural history over the last 1200 years have interacted to form the present-day landscape of Limpopo National Park and Northern Kruger National Park. The long-term mosaic of different communities in this landscape, hunter and gatherers, pastoralists, farmers and traders has, over time, contributed to shape and reshape a heterogeneous landscape. While some features in this landscape, such as water scarcity, have remained stable over time, there have also been major transformations in both the physical landscape and social life. The natural mosaics have been utilised and enhanced over time and the combination of natural and cultural mosaics are reflected in the landscape through archaeological sites, the pollen record and in the present-day landscape.

Introduction

Few works have discussed the long-term cultural transformations of the lower Limpopo valley, and the Limpopo (PNL) and Kruger National Parks (KNP) landscapes in detail. Archaeological surveys in this area are rare, and to date there have been no palaeo-ecological studies carried out. Using new palaeo-ecological data,[4] together with a selective review of archaeological and written sources, we will attempt to show here how both social and natural histories are embedded in this landscape, and how they have interacted over time. Far from being isolated and marginalised, over time, communities in these areas have

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[4] Most of this palaeo-ecological work have been published elsewhere (Gillson and Ekblom 2009a, Gillson and Ekblom 2009b, Ekblom and Gillson 2010 a, 2010 b, 2010c; however, these publications have primarily focused on the natural dynamics rather than socio-environmental dynamics which will be discussed here.

negotiated their daily lives within the context of an unpredictable climate as well as political and social transformations in southern Africa. There are many ways to present this story. Rather than separating the study into disciplinary areas or based on the character of the source material, we have preferred to construct a coherent story crosscutting such conventional divisions. One reason was that we wanted to condense the text, since much of the source data has already been published or will be published separately, and need not be repeated here. The other reason is that we wish to present as coherent a story as possible. We will therefore follow the traces of people in the palaeo-ecological record, which offers not only the chronological framework, but also the structure to this historical ecology. We will focus on the PNL area and the northern part of KNP in particular, but will also bring into discussion the middle Limpopo valley, more specifically the Shashe-Limpopo confluence (Figure 1).

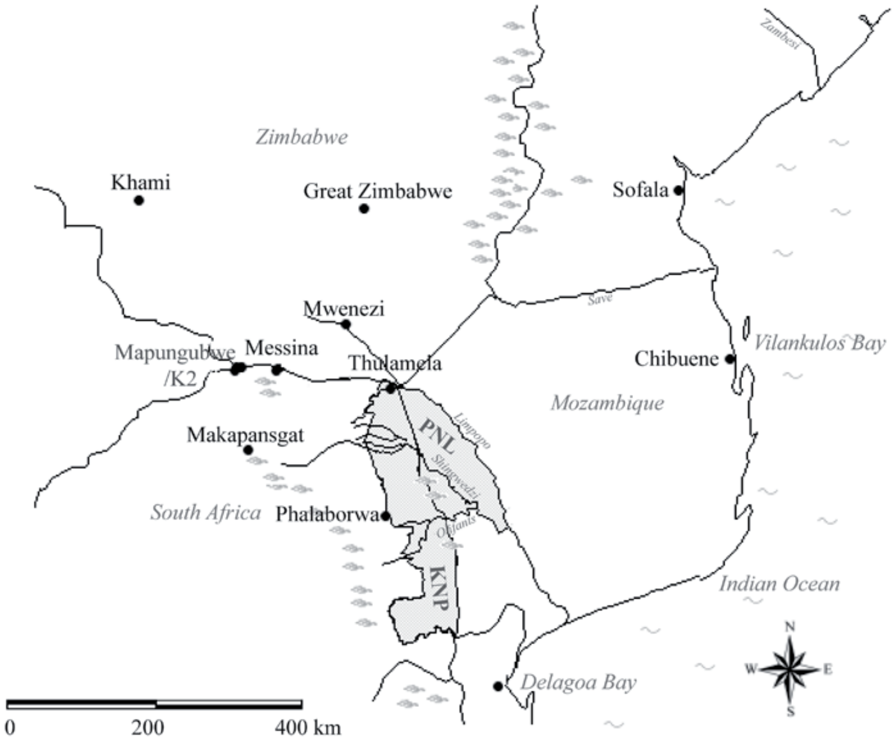

Fig 1. Limpopo valley and the archaeological sites and localities discussed in the text. http://www.arkeologi.uu.se/digitalAssets/65/65091_JAAH_Ekblom_Fig_1.pdf

The landscape

In presenting the landscape of the Limpopo valley, we will borrow the words of the British explorer, Frederick Elton, who described the area between the Shashe-Limpopo and the Elephant-Limpopo confluences in 1872. The landscape near the river was reported by Elton to be fertile and well-populated with surface water throughout the year. The interior region between the rivers was another story. Elton (1873:4) described, how between the rivers:

> Water-pools are few and far between, all those situated away from the rivers drying up during the hot season, and travellers "eat their bread with carefulness, and drink their water with astonishment".

Surface water availability was, and is, of major importance to both people and animals. Rainfall in this region is low, presently ranging from 300 mm/year in the Shashe-Limpopo confluence to 600 mm/year near the Elephant-Limpopo confluence. Rainfall is also markedly seasonal with 95 per cent of the yearly rainfall occurring between October and April, i.e. the southern hemisphere summer, when evaporation is at its greatest. The length of growing season in PNL and the major part of northern KNP today is short, presently 101–110 days, while in the drier western part, the length of growing season is even shorter (91–100 days) (FAO 2003:14). In the days of Elton, as indeed today, cultivation and villages were concentrated along the Limpopo River and its tributaries.

The landscape at this time, as we will show, would have been dominated by grassland savanna in the drier areas interspersed with mopane woodland (*Colophospermum mopane*), much as it is today. Elton vividly describes the dense riparian forests along the Limpopo River. He also describes farming in the area and its produce, listing sesame, maize, sorghum, millet, sweet potatoes, manioc, pumpkins and groundnuts, adding that other plants such as the castor-oil plant, hemp, and tobacco were grown in the valley (Elton 1873:5).

The ethnographic descriptions are, as would be expected, heavily biased by Elton's personal preferences, and the political geography as described by him is somewhat confusing. This may well be a reflection of the actual political and social unrest that afflicted the region. He describes several different groups residing in the area. Along the Shashi Limpopo confluence, there was the Makalaka (most likely Kalanga or Karanga, part of the Shona speaking group). They paid tribute to the Matabele (e.g. Ndebele a breakaway Nguni group) since they had been overrun by Moselikatze (e.g. Mzilikazi, the Ndebele chief whose power expanded in the area in the 1840s). He also encountered Makalaka tribes, who were intermixed with Masaras, in turn described as affluent hunter and gatherers using bow and arrow. Dwellings of the Masaras could also be found in the drier areas away from the rivers (Elton 1873:4,14). Elton describes a typical village, stockaded and consisting of a mix of people from surrounding tribes. He reports on the Knobnuitzen who, similar to the Masaras, were affluent, relied on wild resources and hunted with bow and arrow, but occasionally also planted millet (Elton 1873:29). The Maloios occupied the area below the Livubu River. They were part of the Amatonga (e.g. the Tsonga) that paid tribute to Umseila (e.g. Umzila, ruler of the Gaza state 1862–1884 (Newitt 1995:349). South of the Lipalule, i.e. the Elephant

River, the country was described as well populated by the Amatonga who were under direct control by a governor of Umzila (Elton 1873:35)[5].

The long-term physical formation of the landscape

The Limpopo valley is found on one of the oldest surfaces of the world. The area has had an immensely long period of formation reflected in the metamorphic rocks to the far west of KNP, the Lebombos range that now forms the southern border between KNP and PNL and the sandstones, shales and conglomerates belonging to the Karoo formation found near the Limpopo and east of the Lebombos. The majority of loose soils formed during the Quaternary and they consist of saline to sodic, calcareous, sandy clay loams. These soils formed large plateaus in the landscape, but have since been eroded in places to expose the basal conglomerates of gravel and sands. KNP and PNL is dominated by Regosols (i.e. weakly developed soils with low amounts of nutrients) and Arenosols (i.e. geologically young soils, with a very low capacity for storing water, and low nutrient content). Solonetz soils, i.e. soils with a natrium-enriched horizon that can form sodic crusts, also occur in a belt running north–south in the middle part of PNL (FAO 2004: 23–25).

The long history of formation of bedrock and soils determines the availability of water and, in turn, sets boundaries for vegetation and animal life. Pans, defined as closed seasonal or semi-seasonal water bodies, are present in the drier areas between the permanent rivers. The formation of pans has not been explained; however, it is likely that they were originally formed as part of old drainage lines and they also occur in the Solonetz areas (FAO 2004: 25).

During the last 2000 years, the time period which will be our focus, two centennial scale climatic trends have occurred. A period of warming c. 900–1200 AD, coinciding with the Medieval Warm Period in Europe, resulted in variable but overall wetter conditions in the summer rainfall region, to which PNL and KNP belongs. A globally recognised period of cooling, in Europe referred to as the Little Ice Age, occurred 1400–1800 AD. The speleothem isotopic sequence in the Makapansgat valley suggests that a cooler and drier climate only occurred from c. 1500–1600 AD (Tyson *et al.* 2002; Holmgren *et al.* 2003; Scott and Lee-Thorp 2005; Norström *et al.* 2005; Smith 2005). Based on archaeological data, Huffman (2008) has proposed that the region of the Shashi and Limpopo basin was dry from 1300 AD. The most extreme period of droughts occurred around c. 1750 AD (Tyson *et al.* 2002; Holmgren

[5]Tsonga was originally a Nguni term, designating the peoples who had been conquered and were not incorporated or resisted the incorporation into the Nguni social and political hierarchy (Harries 1981). It designates what today is defined as Tsonga but may in fact in the days of Elton have designated many groups (see also Smith 1973)

et al. 2003) and this is also reflected in a number of reports on droughts and famines in written records. From 1850 AD, rainfall increased again in the summer rainfall region (Holmgren *et al.* 2003). From this time, rainfall has been high overall but with recurring droughts, notably at the beginning of the 20th century and in the 1980s (Young 1977; Nicholson 2000; Tyson & Preston-Whyte 2000; Pikirayi 2003; Ekblom & Stabell 2008).

Alongside these centennial scale variations in rainfall, a c. 20-year cycle of dry and wet years has been present for the last 6000 years. In addition, there is a marked inter-annual seasonality in the region that is partly shaped by El Nino, which generally causes below average rainfall in the summer rainfall region. Sea surface temperatures of the Mozambique current also affects regional rainfall, which is why the Limpopo valley may experience rainfall variations that are not felt in other parts of the summer rainfall region (Tyson & Preston Whyte 2000; Nicholson 1994, 2000; Venter *et al.* 2003).

Plate 1 a) The landscape of the dry interior, near Radio pan, PNL, b) Riparian vegetation near Pafuri, PNL, c) Grasslands near Lake Maludzi, PNL, d) Typical mopane shrub, PNL.
http://www.arkeologi.uu.se/digitalAssets/65/65087_JAAH_Ekblom_Plate_1.pdf

Changes in the physical landscape since the first centuries AD

Pollen, charcoal and spores from the sediments of pans and lakes, shown in Figure 2, are archives of landscape change (for methodology see original publications). As the sequences reviewed here represent different drainage systems, they give an overview over local vegetation changes and possible links between rainfall changes and hydrological systems.

The drier areas represented by sequences from Malahlapanga, Mafayeni and Radio pan show very little variation in vegetation over time (see Figure 1 and 3a–c). They are currently dominated by an open savanna with few mopane trees. In the Malahlapanga case, a sequence that covers the last 6000 years, a shift in vegetation from grassland to savanna can be seen around 800 AD. The Mafayeni and Radio pan sequences go back 1300 and 600 years, respectively, and show stable vegetation during this time, dominated by grasses, with single occurrences of trees/shrubs[6]. The ability of trees to recruit in these areas is most probably restricted by the low water availability. The stability of vegetation in this area indicates a high resilience and we can assume that the vegetation has been similar throughout the last millennia and probably longer (Gillson & Ekblom 2009a, 2009b; Ekblom & Gillson 2010a, 2010b, 2010c).

The vegetation near the rivers has fluctuated over time. The Mapimbi and Chixuludzi sequences, discussed in detail here, are both responsive to the Limpopo River and situated in or close to what is presently a riparian type vegetation (i.e. Moraceae, *Dialium* spp, *Diospyros*) (see Figure 1 and 5a and 5b). The local signatures of these records are variable, in Mapimbi, riparian vegetation and arboreal pollen expanded as rainfall increased from c. 900 AD. The response of vegetation 1400–1800 AD is more complex and will be discussed below. The sequence from Lake Maludzi, a grassland area situated near Pafuri on the plain of the Limpopo River (Plate 1c), illustrates the long-term presence of such grasslands within this riparian-dominated area. This core dates back c. 3400 years and shows very low percentages (7%) of arboreal pollen over time (Figure 3j)[7]. Although there is a temporal gap in the record from 483 AD to the present, the stability of grasslands throughout the sequence, in combination with the presence of grasslands here today, suggests that these grasslands have been present over time.

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[6] The Mafayeni core shows a small-scale variability and a very short decline in trees/shrubs around 1100 AD.

[7] This sequence has not previously been published, which necessitates a brief description. The core show very low percentages of arboreal pollen, very few riparian type taxa (mainly represented by Moraceae) and little variation over time. The trees/shrub group is dominated by the generalist family Combretacea (1.7%), Acacia (0.05%) and Mopane (0.7%) of the pollen-sum (i.e. all pollen excluding aquatics and Cyperaceae). Grasses dominates (67%) throughout the sequence. The concentration of charcoal was high (89.6 cm^2/cm^3) as was the charcoal influx (3 $cm^2/year$), which may suggest that the grassland was maintained by fire (see Ekblom & Gillson 2010a for a comparison with fire histories from the other cores).

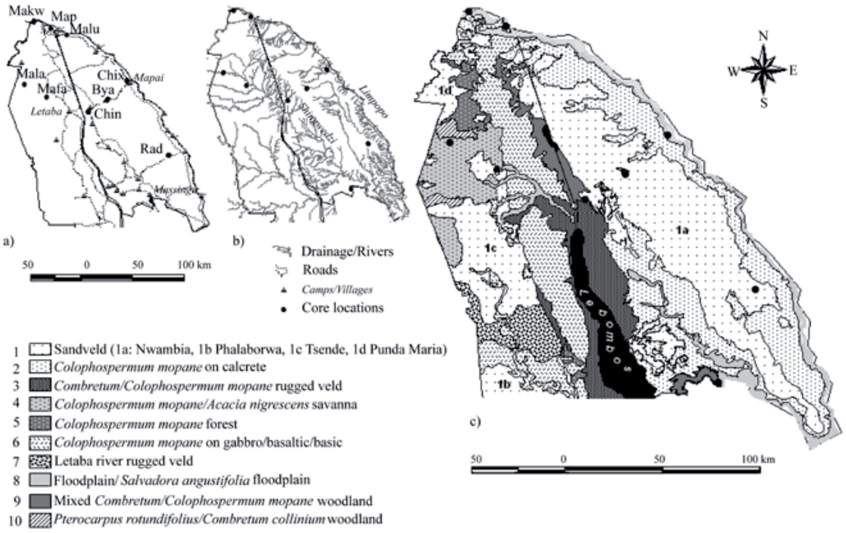

Fig 2. Location of palaeo-ecological sites, core locations abbreviated (left), main rivers (centre) and land use for Limpopo National Park and northern Kruger National Park (right). Photos by A. Ekblom and M. Notelid.
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Socio-environmental interactions

Both social and climatic history is embedded in the physical landscape of KNP and PNL and its traces can be seen in pollen diagrams and at archaeological sites. To hunter-gatherers, the scarcity of water was an advantage, as wildlife aggregated around the pans. The lithic assemblages identified by the pans in the dry interior, as shown in Figure 4, bear witness of the preference for these pans for settlement. These lithic scatters are the result of temporary settlements. They are not dated, but may range in age from historical times, i.e. 1800 AD to 20 000 years. Hunter- gatherer groups were reported by Elton in the 1870s. The interactions of groups of different economic specialisation is a long-term feature of this landscape and in the 1870s, hunter- gatherer groups lived amongst and intermarried with farmers (Elton 1873:4).

Fires have been a continuously present feature in this landscape, as indicated by the adaptation of many of the savanna taxa to fire (Bond 1997). Fire was probably used by hunter-gatherer groups to create fresh grazing for animals, in order to attract them to specific locations. This should be seen not only as a means to facilitate the hunt but also as a kind of environmental management. We have little direct evidence of this practice, however, with

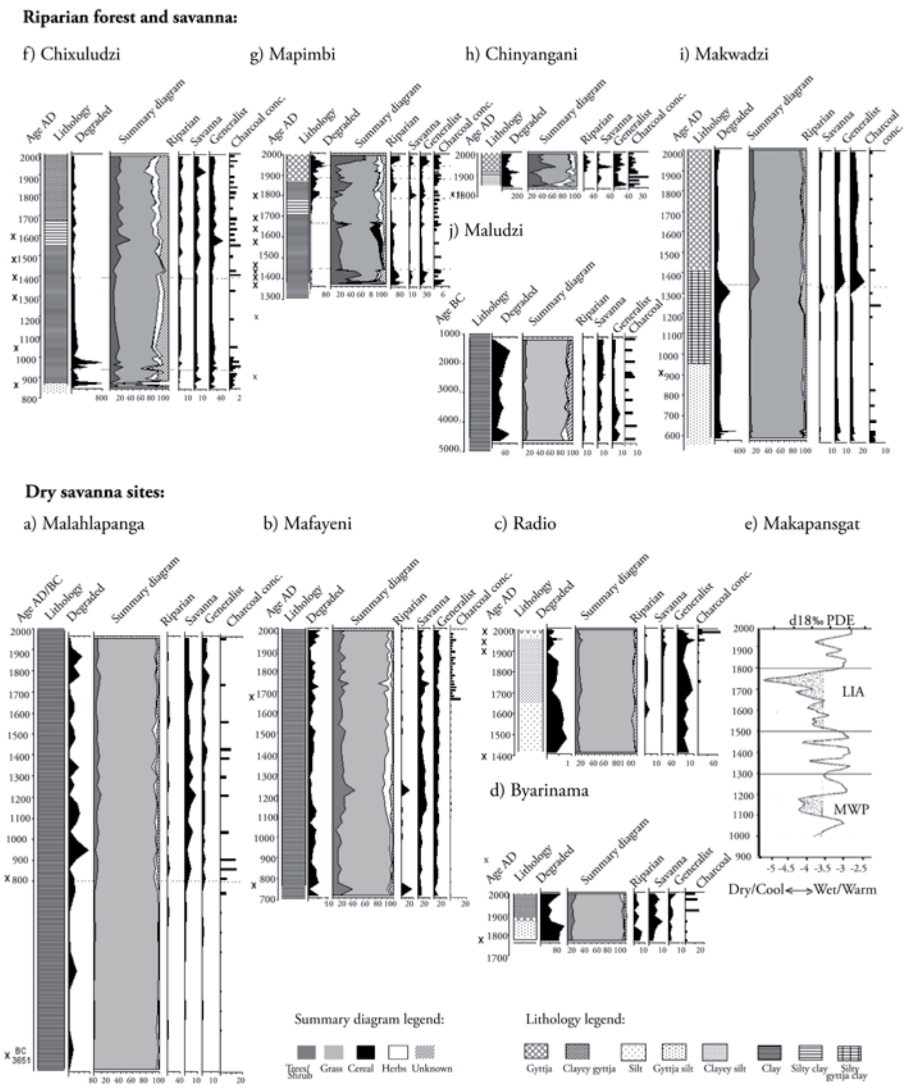

Fig 3. Summary diagrams of all the sequences discussed in the text showing (from left to right) age depth (vertical axes) lithology (column), the number of degraded pollen grains and the percentage distribution of pollen from trees/shrubs (dark grey), grass (light grey), cereals and possible cereals (black), herbs (white) and ungrouped/undetermined (hatched). Main ecological groupings of pollen taxa are also shown. Locations of 14C dates in the profile are marked by x (see also Table 2 in Appendix). Black silhouettes show the contributions of riparian, savanna and generalist taxa in tree tree/shrub group. Black bars show microscopic charcoal concentration. The isotopic sequence from Makapansgat valley (after Tyson *et al.* 2002) and the inferred changes in temperatures/rainfall are shown (upper right) for comparison.
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http://www.arkeologi.uu.se/digitalAssets/65/65095_JAAH_Ekblom_Fig_3_f_j.pdf most palaeo-ecological records going no further back than 500 AD. It is also impossible to separate man-made fires from naturally occurring ones in such records.

In the early first millennium AD, people in the southern African lowveld either experimented with locally available wild grasses of cereal value, or cultivated cereal grasses originating from central Africa (*Pennisetum americanum*, *Sorghum bicolor, Eulusine coracana*), peas (*Vigna sinensis*) and groundnuts (*Voandzeia subterranean*). These early farmers most probably lived by the rivers (Mitchell 2002: 274, 169, 188; Jonsson 1998: 91–93). A few so-called Early Farming Community sites, dated to 350–450 AD, have been located in the Shashe–Limpopo Valley; in addition, undated sites with similar types of pottery are found in KNP (Korfmann *et al.*1986; Meyer 1989; Huffman 2009). The evolvement of farming in the region is not likely to have resulted in a large-scale transformation of the landscape. The earliest farmers probably favoured open grassland areas, such as the region near Lake Maludzi, were the wild edible grasses grew, while they avoided forests near the rivers and woodlands.

THE END OF THE FIRST MILLENNIUM

From the 9th century AD, we may have the earliest traces of people's activities in the pollen records. The sequence from Chixuludzi pan (Figure 5b), situated close to the village Mapai and 1 km from Limpopo, shows high values of charcoal and spores that can be associated with fungi thriving in animal dung (i.e. coprophilous fungi) (Figure 2b). Poaceae pollen <40 µm, which may represent indigenous cereal grasses, are also present[8]. The combination of coprophilous taxa, cereal grasses and charcoal is suggestive of the presence of farmers and domestic stock. This is supported by the Early Farming Community site, Hapi Pan, located close to Mapimbi, dated c. 800 AD (Figure 4). This site yielded bones from both sheep and goat, but no macrofossil remains (Plug 2000).

The communities in the middle and lower Limpopo valley gradually became included in the socio-political sphere of emerging centres around the Shashe-Limpopo confluence. As such, they were highly involved in the cattle economy, where cattle constituted bride wealth and a marker of social status (Beach 1980, 1998; Hall 1990; Pwiti 1991; Huffman 2000, 2009; Calabrese 2000; Mitchell 2002; Kim & Kusimba 2008).

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[8] Unfortunately, pollen grains of the domesticated cereal grasses overlap in size and are morphologically similar to wild grass pollen (Tomlinson 1973). Larger grass pollen (eg < 40 µm) tends to occur in larger numbers later with maize pollen grains, which are easily identifiable on the basis of both size and morphology. Thus, it is likely that they represent indigenous cereal grasses (Ekblom & Gillson 2010b).

By the end of the first millennium, Limpopo River had also become the main trade route between the coast and interior. Long-distance trade goods, glass beads, are found from the 7th century AD in the interior of southern Africa. A trading site has been located in Massingir, PNL, dated to 800 AD. From the 9th century, iron and copper were produced in great quantities in Phalaborwa, just on the border of KNP. Other iron production sites can be found west of KNP. Messina, situated on the Limpopo was another important copper mining centre. Ivory was being processed in the Shashe–Limpopo Valley, as shown from the archaeological assemblages of Shroda and K2. Metals and ivory were most likely traded with the coast via the Limpopo (van der Merwe & Scully 1971; Evers 1982; Evers & van der Merwe 1987; Duarte 1995; Huffman 2000; Wood 2000, 2005; Mitchell 2002:357–358).

The strengthening of socio-political centralised control and long-distance trade relations seen from c. 800 AD may be linked with an agricultural expansion in the Limpopo valley. The high amount of charcoal in the pollen diagram of Chixuludzi could indicate clearances of new areas for farming. Charcoal influx shows high values in the period 800–950 AD compared to later periods. However, overall, there is no correlation between increases in charcoal and decrease of woody taxa. Rather, increases in abundance of woody taxa seem to concur with charcoal peaks. This would suggest that farmers utilised and preferred forest gaps for farming rather than clearing forested areas.

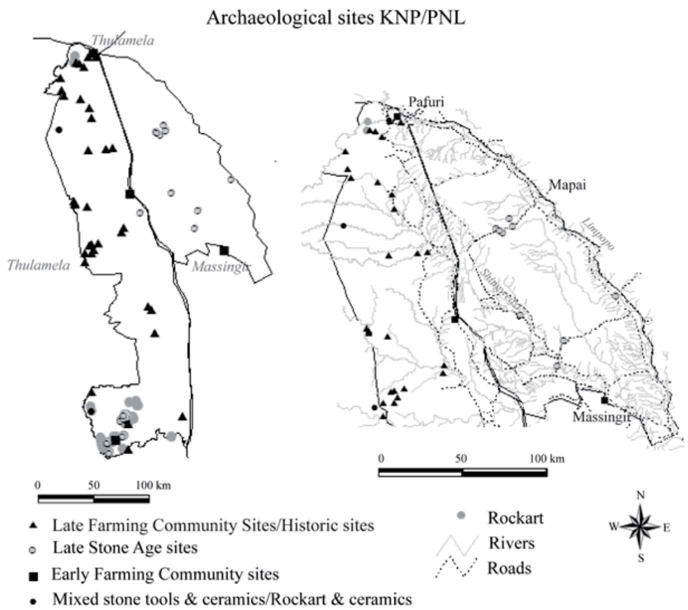

Fig 4. Archaeological sites in KNP and PNL, detail of northern KNP and PNL to the right showing the sites in relation to roads and rivers. Data for KNP were provided by Sanparks, based on rock art inventories carried out by C. de Rosner, and C. de Rosner, and M. English. Note that the surveys by Birkholtz in 1997 in the south-west part of KNP are not shown. Sites listed by Plug (2000) in northern KNP have been added. The PNL sites were located in 2006 during surveys by A. Ekblom and M. Notelid and have not previously been published.
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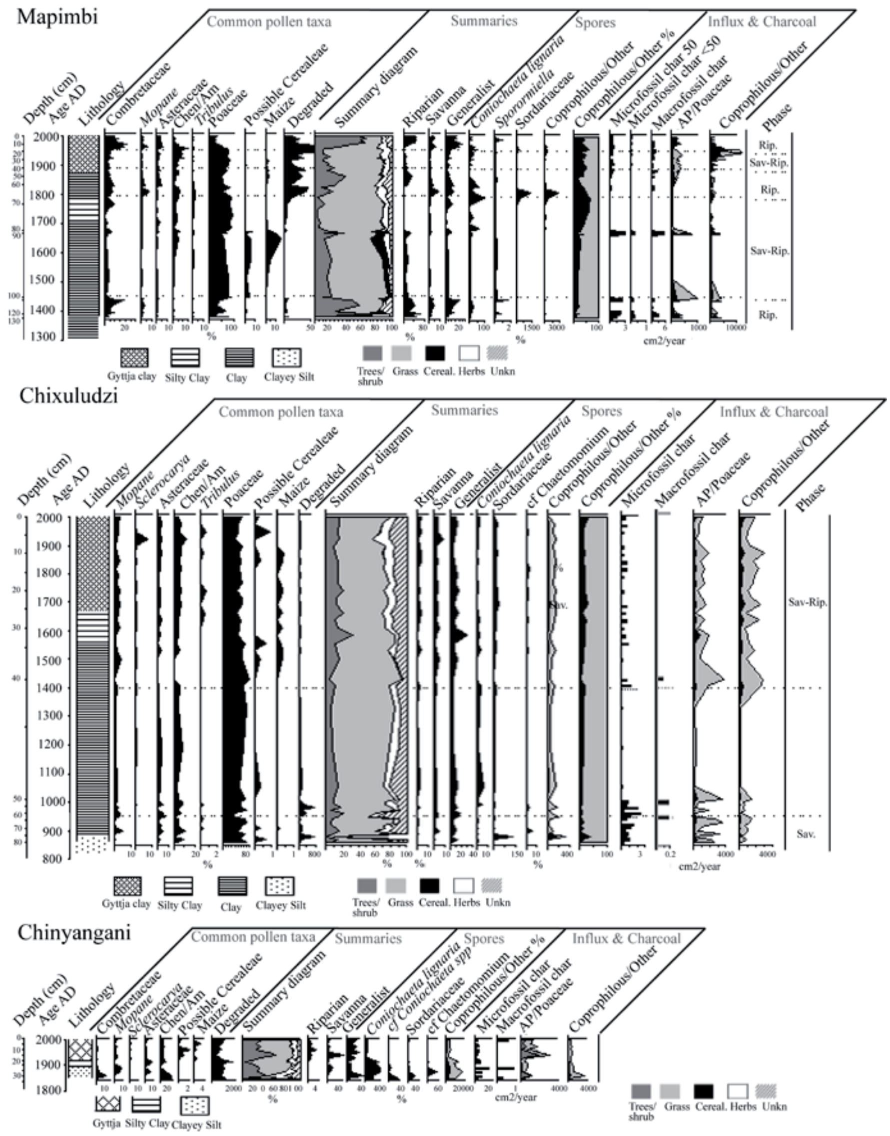

Fig 5a-c. Pollen diagrams of sequences from Lake Mapimbi (a), Chixuludzi pan (b) and Chinyangani spring (c). Vertical axes show (from left to right), dated levels (X), depth (cm from surface), estimated age depth (age AD), and the lithology with legend below. Horizontal axes show the percentage distribution of the more common pollen taxa, possible cereal and maize pollen and degraded grains. A summary pollen diagram displaying the main physiognomy is shown in the centre (dark grey silhouette: AP, grey: grasses, black: cereals, white: herbs, shaded: ungrouped/unknown) with main ecological groupings of tree-shrub taxa; riparian, savanna, generalist. To the right, the more common coprophilous spore taxa are shown and a summary of the distribution of coprophilous/non coprophilous spore types by per cent. Black bars show the influx of microscopic and macroscopic charcoal (cm2/year). The influx of both trees/shrubs (black silhouette) – other pollen taxa (grey silhouette) and coprophilous (black silhouette) – non-coprophilous spore taxa area (grey silhouette) are shown to the right. http://www.arkeologi.uu.se/digitalAssets/65/65085_JAAH_Ekblom_Fig_5a_c.pdf

THE EARLY SECOND MILLENNIUM

The high amount of degraded pollen grains in the Chixuludzi core suggests that the pan was frequently dry before 950 AD (Figure 5b). After 950 AD, there is an overall decrease in charcoal, but potential cereal pollen and spores from coprophilous fungi are still present, leading us to infer that farmers were still present in the area. Sediment accumulation is fast between 950 and 1400 AD, which may be linked to higher rainfall associated with the suggested overall wetter and warmer conditions correspondent with the European Medieval Warm Period (Ekblom & Gillson 2010c).

From 1300 AD, the pollen record from Lake Mapimbi, situated in the northernmost KNP close to the PNL border, shows evidence of human activity in the landscape. The landscape around Mapimbi at this time was a dense forest; riparian taxa were represented by c. 40 per cent, which is very high (Figure 5a). There is also a very high amount of charcoal at the beginning of the sequence, which may be linked with human-induced burning and clearances; however, this was not linked to a significant decrease in trees/shrub taxa. Cereal grains and spores from coprophilous fungi are not well represented in this early part of the core. From 1400 AD, there is an increase in possible cereal grains. This increase can perhaps be linked with the emergence of Thulamela, situated by the Levhuvhu River, c. 7.5 km southwest of Mapimbi[9]. This stone walled settlement was occupied from c. 1250 AD. Walls were constructed from 14th –15th century with its largest extent in the mid 17th century, after which it appears to have been abandoned (Steyn *et al.* 1998). The population of Thulamela has been estimated to represent 3000 inhabitants at its high, and the site has evidence of elite burials, ivory working and trade links with the coast and transoceanic trade (Küsel 1992; Steyn *et al.* 1998; Meskell 2007). People of Thulamela and the Mapimbi area probably took advantage of the Limpopo River to produce floodplain crops. This production was localised, as no large increases in cereal pollen grains in the Makwadzi sequence can be seen (Figure 3i)[10].

The decline of centres in the Shashe-Limpopo confluence and the later Great Zimbabwe resulted in a relocation of power to Khami, situated in southwestern Zimbabwe. This was to the advantage of Thulamela. It is generally assumed that the elites of high status settlements, such as Thulamela, displayed and consolidated status through the ownership of cattle (Pwiti 1991; Beach 1998; Huffman 2000, 2008, 2009; Mitchell 2002:328). Very few cattle

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[9] Other as yet unexcavated stone walled settlements exist in the area. Thulamela is the closest known settlement to Mapimbi, and will be our focus.

[10] The pollen assemblage from the sequences presented here is from small basins, expected to reflect local-scale changes in vegetation (e.g. changes within 20 – c. 300m of the basin edge (Jacobsen and Bradshaw 1981)). Makwadzi has a larger drainage area and reflects landscape-scale changes (Ekblom and Gillson 2010 a).

bones are present in the bone assemblage from Thulamela, which mainly consists of wild game and fish. A similar pattern can be seen in the contemporary settlement of Mwenezi and Malumba, both situated within the Limpopo watershed c. 100 km north of the KNP border in present-day Zimbabwe. Also in these sites, high status indications such as stone walling and ivory handicraft is present, but bone assemblages have a predominance of wild game and very little cattle (Steyn *et al.* 1998; Plug 2000; Manyanga 2006:71). The pollen record of Mapimbi provides some clues regarding the presence/absence of cattle in the area. The amount of spores from coprophilous fungi is higher overall in Mapimbi than in any other KNP and PNL cores, but coprophilous spores are few in the period 1300–1700 AD. This suggests that small herds may have been kept here, but not on a significant scale (Ekblom & Gillson 2010b).

Metalworking has also been suggested as an important item of export from Thulamela. This would have required large amounts of charcoal and cutting of forests. Neither Mapimbi nor Makwadzi show high values of charcoal in this period, which would have been expected if there were large-scale clearing of forests in the area. At 1400 AD, there is a marked decrease in woody taxa and riparian-type taxa in the Mapimbi record. Nevertheless, it cannot be excluded that this is linked to a drier climate, assuming that droughts were felt in this area already at this time, an issue that is yet to be resolved (see discussion above).

THE 16TH–18TH CENTURIES

Maize, a new world crop that is the most important crop in the area today, appears in both the Mapimbi and Chixuludzi records from 1500 AD. In written documents from the east African coast there is no confirmed listing of maize, *milho zaburro,* until the 1560s (Miracle 1963). An earlier document from the Portuguese fort at *Sofala,* probably located at the mouth of the Save River, list *milho* as a crop purchased locally. Hair (1966-1967) has argued that *milho* in this document designates sorghum. João de Barros possibly mentions maize in 1516, although this may in fact also designate other local grains (Dos Santos in Theal 1964, vol II: 127).

Whatever the mode and timing of the spread of maize, it seems to have been earlier and quicker in the region than previously expected. By 1640, people in Mapimbi grew maize on a larger scale (maize representing c. 10 per cent of the pollen sum), and maize pollen exceeds the amount of pollen from other possible cereal grass from this time. In Chixuludzi, maize appears to have replaced local cereal grains from 1560 AD. Pollen representative of possible indigenous cereal grains reappears only from c. 1830 AD. The peak in maize pollen in Mapimbi is preceded by a gradual increase of both indigenous cereal grasses and maize pollen from c. 1560 AD[11]. The Chixuludzi sequence shows smaller peaks in possible indigenous cereal grasses from the same time, and this may perhaps indicate a gradual regional expansion of cultivation.

There is no increase in charcoal or decrease in tree/shrub pollen in any of the cores to indicate that forest areas were cleared for new agricultural land. Interestingly, the peak of maize pollen in Mapimbi is dated to around the time Thulamela was supposedly abandoned (Mitchell 2002:328). After c. 1670 AD, both maize and possible cereal grains are present only in very low numbers, suggesting a lower agricultural activity that can perhaps be linked to the supposed decline of Thulamela. Parallel to the decrease in cereal pollen, there is an increase in arboreal pollen (primarily shown in the generalist taxa Combretaceae). This may perhaps represent an expansion of pioneering woody taxa on old farmlands. Maize cultivation continues in the Limpopo valley after this time, as maize pollen occurs disparately through time in the Chixuludzi sequence.

In the time period 1700–1800 AD, arboreal pollen in the Lake Mapimbi sequence decreases to its lowest ever values (c. 5 per cent), mainly owing to a decline in riparian taxa. This change is probably linked to the extreme droughts experienced in this period, associated with the suggested overall cold and dry conditions corresponding to the European Little Ice Age (Tyson *et al.* 2002; Holmgren *et al.* 2003; Scott and Lee-Thorp 2005). In Mapimbi, there are no indications of farming in the form of cereal grains, but spores from coprophilous taxa increase to very high numbers. With the absence of cultigens, this is not likely to represent an increase in domestic stock, but more likely an aggregation of animals (both domestic and wild) to the river, as water in the interior was very scarce owing to droughts. The Chixuludzi sequence in the same time period show no clear changes in vegetation, but rather an expansion of generalist taxa, and the vegetation composition appears to have been more resilient to drought than that at Mapimbi. Maize pollen occurs in the Chixuludzi record throughout this period, and there is no increase in coprophilous spore taxa similar to Mapimbi. It is possible that the slightly higher rainfall in Chixuludzi Pan compared to that at Mapimbi might have been enough to counter the effects of the droughts, both in relation to vegetation and farming.

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[11] The earliest date for maize in Mapimbi ranges from 1427-1484 AD (95.4 probability) in Bcal and OxCal show a similar range. This is too early and has been interpreted as downward transport of maize in the pollen profile. An upper date ranges from 1508-1583 and 1619-1667 AD (95.4 probability in Bcal). In OxCal, the date falls between 1610 and1680 AD (55.5 probability). This compares to Chixuludzi, where the earliest date on maize in the profile ranges between 1457-1595 AD in Bcal and 1460-1630 AD in Oxcal (95.4 probability). An additional date, just above, ranges between 1503-1602 and 1608-1643 AD in Bcal and 1490-1650AD in OxCal (95.4 probability) (see Table 2 in Appendix).

THE 19TH CENTURY

The 19th century saw an increase in rainfall (Tyson *et al.* 2002; Holmgren *et al.* 2003; Scott and Lee-Thorp 2005), and this is reflected in the Mapimbi core by the increase of riparian taxa and woody taxa overall. In the beginning of the 19th century, conditions for cultivation improved and maize pollen reappears in the Mapimbi pollen record. There is a decline of coprophilous spore taxa to very low numbers c. 1870, and this decrease parallels an increase in woody taxa. While the increase in woody taxa is most likely owing to a wetter climate, the decline of coprophilous spore taxa is similarly linked to the dispersal of wild herbivores in the landscape, as more seasonal water bodies were now available. The depression of coprophilous spore taxa may perhaps also be linked to the cattle raids of Nguni armies. Umzila, ruler of the Gaza state, evidently had effective power in the PNL area (Pélissier 1984:115; Newitt 1995:255–266, 348–351). Elton (1873:23) reported how by Umzila's order villages (possibly in the area near present-day Mapai), for reasons unknown, had been moved from the east bank of the river to the west.

By the end of the 19th century, wildlife in the whole of southern Africa was also severely diminished due to commercial hunting. Additionally, the rinderpest, which struck the area in the year of 1896, took a large toll on both domestic and wild cattle (Young 1977; Carruthers 1995:41; Carruthers *et al.* 2008). Despite the combination of cattle raids and disease, spores of coprophilous fungi are well represented in the pollen diagram of Mapimbi from 1900 AD. We believe this represents an expansion of cattle rearing in the area in the 20th century. The area was known to be tsetse-fly infested in the 19th century, but Elton (1893:25), when discussing this, claimed that local communities did not regard this as a serious obstacle to cattle rearing, as tsetse only affected cattle when they had a low resistance owing to lack of grazing or water.

THE 20TH CENTURY

A decline of woody taxa can be seen in the Lake Mapimbi sequence in the beginning of the 20th century. Again, this may be concurrent with droughts in the early 20th century (Nicholson 1994, 2000; Young 1977). Maize pollen is no longer present in the record. Spores of coprophilous fungi continue to be well represented, and remain so until the present. Charcoal values are high throughout this period. An expansion of woody taxa can be seen from c. 1950, while the amount of coprophilous spores and charcoal remains high. The forced resettlement of local communities by KNP authorities from the Pafuri area in the 1950s (Pollard *et al.* 2003; Carruthers 1995) is not clearly reflected in the diagram; however, the increase in trees/shrubs in the top of the Mapimbi diagram may represent an encroachment of shrub on old fields and grazing lands. Possibly the increase of woody taxa actually represents a colonisation of pioneering taxa on farmlands and grazing lands, but we would then expect a decline in charcoal and coprophilous spore taxa. In the Chixuludzi sequence, the variation in woody taxa is much lower. The irregular

Site/depth	Est. age	Lab no	Age bp	Calibration AD/BC
Bya 30-32	1800 AD*	Poz-25105	125 ± 30	1680-1730, 1803-1921 AD* 1690AD (16.8%) 1730AD* 1800AD (78.6%) 1960 AD*
Chin 42-42.5	1875 AD*	Poz-25112	105 ± 30	1687-1727, 1806-1869, 1876-1923 AD 1690 (13.1%) 1730 AD* 1800 (82.3%) 1950 AD*
Chix 29-30	1625 AD	Ua-38832	346±30	1503-1602 1608-1643 AD
Chix 38-37	1503 AD	Ua-38833	381±30	1457-1595 AD
Chix 40-41	1432 AD	Ua-38834	533±31	1406-1450 AD
Chix 43-44	1401 AD	Ua-38835	605±30	1318-1352,1384-1425 AD
Chix 48.5-49.5	1020 AD	Poz-25104	1065 ± 30	983-1046, 1084-1135 AD
Chix 79.5-80	862 AD	Poz-22197	1270±30	709-748, 764-893 AD
Mafa 46-47	1672 AD	Poz-9956	225±30	1645AD-1696, 1725-1803 AD
Mafa 109-110	679 AD	Poz-2120	1365±35	658AD-731, 736-772 AD
Mahl 72-72.5	3651BC	Poz-9887	4940 ± 100	3936-3861, 3820-3500, 3432-3380 BC
Mahl 55-55.5	795 AD	OxA-15480	1280 ± 25	692-748, 765-883 AD
Mal 8-9	483 AD	Ua-40028	1673±30	383-583 AD
Mal 16-17	Not used	Ua-38838	2964±57	1374BC-1351, 1313B-973, 956-940 BC
Mal 24-25	291 BC	Ua-40029	2222±30BP	362-221, 261-108 BC
Mal 40-40.5	433 BC	Poz-30157	2385±30	513-430, 428-358, 283-258, 347-236 BC
Mal 58.5-59	1471 BC	Poz-22200	3260± 30	1533-1409 BC
Map 65-66	1820 AD*	Ua-38827	103,8±0.4**	1890 (31.8%) 1920, 1810 (63.6%) 1830*
Map 79-80	1675 AD	Ua-38828	211 ± 30	1653-1709, 1720-1809
Map 92-92.5	1665 AD	Poz-9888	245± 30	1639-1684, 1731-1775, 1777-1787
Map 94-95	1644 AD	Ua-38829	294 ± 30	1508-1583, 1619-1667
Map 100-101	1447 AD	Ua-38830	490 ± 30	1427-1484
Map 110-111	1437 AD	OxA-17234	501 ± 30	1413-1452
Map 114-115	1399 AD	Ua-38831	617 ± 30	1320-1353, 1380-1423
Map 116-116.5	not used	Poz-9959	305 ± 30	1503-1592, 1615-1669
Map 128-128.5	1377 AD	Poz-2119	705 ± 30	1284-1328, 1341-1391
Makw 58-59.5	886 AD	Poz-22198	1210±30	778-905, 912-968
Makw 98.5-99.5	628 AD	Poz-22199	1495±30	567-655
Makw 136-136.5	567 AD	Poz-9958	1560±30	440-487, 530-640
Radio 0-0.5	2000 AD	OxLel		Pb 210, CF:CS model
Radio 10-10.5	1980 AD	OxLel		Pb 210, CF:CS model
Radio 20-20.5	1960 AD	OxLel		Pb 210, CF:CS model
Radio 30-30.5	1950 AD	OxLel		Pb 210, CF:CS model
Radio 40-45.5	1925 AD	OxLel		Pb 210, CF:CS model
Radio 35-35.5	1905 AD*	OxA-16674	109.8±0.4**	1810AD (42.3%) 1830AD, 1890AD (53.1%) 1920AD*
Radio 79-80	1394 AD	Poz-25106	690 ± 40	1287-1394

Table 1. Summary of socio-political changes in the coastal Mozambique region and the interior in relation to local events, as suggested by the palaeo-ecological records and archaeology, as well as climate history (Tyson *et al.* 2002, Holmgren *et al.* 2003) and the summary of written documents presented in Ekblom and Stabell (2008). Dates of droughts marked by * refers to written documents.
http://www.arkeologi.uu.se/digitalAssets/65/65089_JAAH_Ekblom_Table_1.pdf

cereal pollen curves (indigenous cereals making a return in the last 200 years) and the small peaks in charcoal reflect a rotation of cultivation. First, a period of cultivation, then a longer period of fallow, when cattle were allowed to graze the area and there was an expansion of woody shrub, and then after 50 years, shrub was cleared with the use of fire and a field was reopened. Cultivation and grazing of domestic stock do not seem to have competed with woody taxa, since there is no decrease in these pollen types that can be linked to peaks in charcoal or cereal grains. A similar rotation may be reflected in a third palaeo-ecological sequence, namely Chinyangani, taken from a spring close to the Shingwedzi, PNL and dating back only to the last 150 years (Figure 2c)[12].

The historical trajectories in the PNL and KNP landscapes

Ecological management

Overgrazing and rapid deterioration of the savanna have been noted in the Limpopo valley, where areas abandoned for 40 years were reportedly denuded of vegetation in the 1980s (Hanish 1980 in Plug 2000). However, the palaeo-ecological analyses reviewed here show the fallacy of such assumptions. The interactions between climatic variability and impact of people are complex, and cause and effect difficult to disentangle. The palaeo-ecological analyses indicate that there is no direct correlation between farming and degradation in the form of loss of arboreal taxa or homogenisation of vegetation. Overall, decreases in arboreal taxa seem to be interlinked with drier periods, rather than expansions of farming.

In the riverine areas, riparian type vegetation is likely to have expanded during periods with high rainfall; there were also natural gaps in the forests. These natural mosaics of forests, forest gaps and open grassy areas were probably utilised by farmers, with open areas used for farming and grazing. The shifting agriculture and rotation of crops and grazing that might be

[12]Despite the short, 150 year time span and the tentative character of the chronology (based on interpolation from only one ^{14}C date), this sequence is important as it provides clues to agricultural practices (Figure 2c). The amount of coprophilous spore taxa is very high in the beginning of the core and this is most likely owing to domestic cattle in the area. After c. 30 years of high herbivore densities, there is an increase of charcoal and a concurrent decrease of woody taxa, which may be linked to clearance of vegetation. Maize and possibly other cereal grains are present in high numbers after this, at the same time savanna tree/shrub elements increase. This suggests that the phase of cultivation also allowed for new woody taxa to colonise the outer limits of the fields.

reflected in the palaeo-ecological sequences would have further encouraged the vegetation mosaics.

Historic records do not go into detail when it comes to agricultural practices and customary laws and regulations regarding use of natural resources. In the late 19th century, Elton (1873) and Erskine (1875:55), who travelled the area from Inhambane to Save, and Junod (1927, vol II: 376–384, 316–322), based in Delagoa bay, all noted how the Tsonga preferred to build their houses and villages amongst trees, in contrast to other groups, who preferred to clear vegetation around the settlement of trees and shrubs. The Tsonga had a tradition of preserving forest areas that today is still in practice in many areas. Junod gives examples of settlements in the coastal region surrounded by forests that were considered sacred, as they contained burials of powerful chiefs. These forests were important for rainmaking practices, since ceremonies where chiefs invoked their dead ancestors to make the rains fall would take place in these groves. The evidence of local incentives for conservation can be seen in the mopane forests by Mapai today. These consist of mature, tall mopane trees, which must be of considerable age, and therefore have been protected over time[13].

Landscape invariables

Droughts have been a recurring feature in this landscape, affecting both the dry interior and river valleys. Both vegetation and animals have built up resilience to, and methods of countering the effects of, water scarcity and irregularity. Similarly, the irregularity of nature is embedded in people's everyday practices. The foundation of social cohesion and political power that emerged in the late first millennium was embedded in the use of ritual power over the elements to provide rain and fertility of the land. A similar role for chiefs was also reported in written documents from the 16th century and later periods (Young 1977; Huffman 2000, 2008, 2009; Ekblom 2004). Rainmaking shrines are common in the area around the Shashe-Limpopo confluence, normally situated on hilltops and used over long periods of time. The use of these and domestic rainmaking ceremonies have been shown to intensify in times of droughts (Huffman 2009). Invariability

A flexible and experimental approach to cultivation is a prerequisite for any successful farmer in this area. The region today is regarded as a high-risk cultivation area, with probable risk crop failure in 45–75 per cent of years (FAO 2004:15). This is owing to the unpredictable nature of the beginning and end of the rainfall season, making it difficult for farmers to decide when to plant. A common practice for families today is to spread risk by having several plots for farming; one in the more fertile river areas for maize, beans,

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[13] We were informed by local residents that the local chief had imposed a ban on cutting these trees, and that anyone breaking this law would be obliged to pay a considerable fine.

groundnuts and manioc, and one in the less fertile higher grounds for more drought-tolerant crops, such as sorghum, millet, pulses (FAO 2004:84). This practice has been suggested to have been in place in the Limpopo valley since 1000 AD (Huffman 2008). Elton (1873:19,32) similarly reported how the low alluvial lands near the Limpopo River specifically were used to grow maize and millet. The quick adoption and expansion of maize farming may be one example of the flexibility of local farmers. Maize requires 624 mm rain/year or 450 mm rain over at least 110 days (Goodman 1976 in Huffman 1996). This means that growing maize in the Limpopo valley region is a calculated risk. By the 17th century AD, when maize cultivation began, the effects of the Little Ice Age droughts were definitely felt in the Limpopo valley and maize cultivation would have been an even riskier venture than it is today. Although a high-risk crop, maize has some advantages to indigenous cereals as it has a quicker growing period, and can be eaten green whilst maturing in the field; thus it could be termed an emergency crop (Crais 2003). Thus, the expansion of maize cultivation could be explained as owing to the onset of droughts[14]. However, the expansion of maize cultivation can also be explained in the context of trade, as maize is easily transported and readily eaten without processing.

Another way of buffering risk is through labour migration; this has been an important part of household economies since the 19th–20th centuries (Harries 1981, Harries 1994; First 1983; Newitt 1995:408). In the 1870s, Elton (1873:20) estimated that half the male population had moved away from the region for work. Although the growing industry in South Africa certainly provided new and unprecedented opportunities for salaried labour, migration for access to resources or exchange networks was not a new phenomenon. Indentured labour to local chiefs or chiefs in other areas had long been practiced. Written sources from the Zambezi valley relate how people contracted themselves to service with chiefs, thus ensuring not only protection and food, but also resources that would otherwise not be available to them, such as cattle, and with that, marriage alliances (Newitt 1995, 233–237).

Reorganisation in nature and society

The importance of small-scale variability in maintaining relative stability is often used to describe the interplay between variability, stability and change in nature. Small-scale variability, continuously going through cycles of build-up, transformation and reorganisation act as a buffer against systemic shifts and creates resilience (Holling 1996, Gundersson 2000, Holling *et al.* 2001, Berkes

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[14] Huffman (1996) associates the spread of maize in Natal at the end of the 18th century with the return of a wetter climate and the end of the Little Ice Age; however, in the Limpopo valley, maize cultivation was earlier than previously thought.

2003). However, larger-scale changes – or disturbances – may cause a systemic shift and a reorganisation into another phase. Fluctuations in rainfall did not lead to any large-scale shifts in vegetation at the sites in this study. The vegetation in KNP and PNL appears to have been resilient to droughts, as the extreme droughts in the 18th century are not clearly visible in the pollen diagrams. Rather, small-scale variations countered any large-scale shifts, which is why we describe these areas as *quasi*-stable. There are, however, also examples of rapid transitions in vegetation (for instance Malahlapanga), once a critical ecological threshold is crossed.

Similarly, in society, small-scale mechanisms for buffering risk, some of which have been exemplified above, would provide a *quasi*-stable state until a threshold is reached. It is tempting to relate the social and political turmoil of the 18th century with the severe droughts in this century and, as such, a systemic collapse. Written sources report droughts in different parts of the summer rainfall region of southern Africa in 1717, the 1740s and 1750s, in 1777 and in the 1790s (see summaries in Pikirayi 2003 and Ekblom & Stabell 2008). From the early 18th century, there were several movements and clashes between population groups, as the Sotho-Tswana groups moved down to the Limpopo valley from west of the Drakensberg, and as the coastal Tsonga chieftaincies expanded, resulting in warfare and social unrest (Smith 1973; Liesegang 1987; Newitt 1995:154–159). Similarly, the early 19th century saw continued droughts and warfare. The initial northward movements of the Nguni created a ripple effect of migrations and warfare from various Nguni groups. As related by Elton above, Mzilikazi, the chief of a breakaway group of Nguni, the Ndebele, expanded in the middle Limpopo region in the 1840s. In the coastal region, there were several expansions and internal strife amongst the Nguni themselves until Shoshongane in the 1830s consolidated the Gaza empire and was succeeded by Umzila in the 1860s (Pélissier 1984:115; Newitt 1995:255–266).

There are many explanations to this long period of instability and most likely, the answer lies in the combination of different factors. The ivory trade expanded from 1750 in response to global demands. This reshaped power relations in the region and some of the movements of chiefs and army bands was probably motivated by the ambition to control or gain direct access to this trade. Both the Tsonga and Nguni political systems were politically and structurally unstable, with frequent conflicts around succession in particular. The ivory trade itself has also been thought to exacerbate political instability, as the power of the new rulers was mainly based on the appropriation of wealth provided by the taxation on ivory trade, rather than agricultural production. As the wealth of the rulers increased the base of their wealth, the elephant herds diminished, leading to increased competition between rulers and groups (Smith 1973; Harries 1981; Liesegang 1987; Eldredge 1995; Newitt 1995:156–157; Carruthers *et al.* 2008). The fact that agricultural production was limited at this time, owing to frequent droughts and to warfare, provided an important incentive for local communities to engage in the ivory hunt. It may also have put additional pressure on political entities to control and expand the ivory trade and commercial hunting in general.

Whatever the combination of different factors and their internal relationships, almost two centuries of recurring warfare in combination with recurring droughts, was detrimental to social life. By this time, cattle herds in the KNP and PNL area had most likely been appropriated by the Gaza state rulers. At the same time, wild life was also severely diminished through commercial hunting by local, European and Boer hunters. Hunting became a less viable option for household subsistence or as a potential source of extra household income in the form of commercial sale (Carruthers *et al.* 2008). Instead, migrant labour became an increasingly attractive option both for buying food and for taking part in the network of alliances that the cattle economy usually provided. In the early 20th century, peaks in labour exports also correlate clearly with droughts and famine (First 1983: 28, 183).

Conclusion

Much of the transformations in the landscapes discussed here, i.e. contraction of riparian type forests, reduction of cover of trees/shrubs, and the expansions of grasslands, have previously been attributed to the negative influences of farming, herding and iron production. However, as shown here, the physical landscape is susceptible to such changes through physical processes that people cannot control. Instead, the long-term geological processes and the century scale trends in rainfall variability together set the physical boundaries within which vegetation, animal life and people interact. While we have shown that some features in this landscape have remained relatively stable, major transformations have occurred both in the physical landscapes and in social life.

From the 9th century AD, we may have the earliest traces of people's activities in the palaeo-ecological record, with the presence of coprophilous spore taxa, charcoal and cereal grasses. There is no correlation between increases in charcoal and decrease of woody taxa, which suggests that farmers utilised and preferred forest gaps. From 1400 AD, there was an agricultural expansion in the Mapimbi area, related to the Thulamela centre. Maize cultivation took place in both the Mapimbi and Chixuludzi area from 1500 AD. The droughts in the time period 1700–1800 AD resulted in a contraction of riparian forest in Mapimbi and there is little indication of cultivation in Mapimbi at this time. The Chixuludzi area appears to have been more favourable during this time, cereal pollen grains continue to be present and there is no reduction in riparian-type vegetation. In the 19th century, climatic amelioration resulted in an expansion of riparian taxa and cultivation in Mapimbi while a decline of woody taxa can be seen in the early 20th century linked, again, with droughts. The higher resolution of the records in the 20th century allows for the identification of a rotation of cultivation.

We have attempted to explain how socio-political changes have interacted with environmental variability to counteract the environmental vulnerability of the region. While many questions remain, it is clear that the PNL area and the northern KNP are far from isolated wilderness areas. This understanding of the landscape is of acute relevance today as the area is in the process of being converted into a national park. The wilderness idea and the modernisation discourse have been used to motivate the relocation of communities to land outside the park area, and one reason for this is the lack of appreciation of the long-term cultural history of this landscape[15]. With this study, we hope to have conveyed that the PNL and KNP landscapes are embedded with cultural history.

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[15] The PNL area will be included in the (36 000 km^2) Transfrontier Natural Park, also incorporating the Kruger National Park (KNP) in South Africa and the Gonarezhou Park in Zimabwe. For critical analyses of the creation of the Limpopo National Park in the present, see Milgroom and Spierenburg (2008) and a discussion on the wilderness idea in relation to PNL see Rogers (2009). For a discussion on the rhetoric behind the creation of KNP (Carruthers 1995) and a comparison between PNL and KNP and the modernisation discourse see Ekblom & Notelid (2010).

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Appendix

Site/depth	Est. age	Lab no	Age bp	Calibration AD/BC
Bya 30-32	1800 AD*	Poz-25105	125 ± 30	1680-1730, 1803-1921 AD* 1690AD (16.8%) 1730AD* 1800AD (78.6%) 1960 AD*
Chin 42-42.5	1875 AD*	Poz-25112	105 ± 30	1687-1727, 1806-1869, 1876-1923 AD 1690 (13.1%) 1730 AD* 1800 (82.3%) 1950 AD*
Chix 29-30	1625 AD	Ua-38832	346±30	1503-1602 1608-1643 AD
Chix 38-37	1503 AD	Ua-38833	381±30	1457-1595 AD
Chix 40-41	1432 AD	Ua-38834	533±31	1406-1450 AD
Chix 43-44	1401 AD	Ua-38835	605±30	1318-1352,1384-1425 AD
Chix 48.5-49.5	1020 AD	Poz-25104	1065 ± 30	983-1046, 1084-1135 AD
Chix 79.5-80	862 AD	Poz-22197	1270±30	709-748, 764-893 AD
Mafa 46-47	1672 AD	Poz-9956	225±30	1645AD-1696, 1725-1803 AD
Mafa 109-110	679 AD	Poz-2120	1365±35	658AD-731, 736-772 AD
Mahl 72-72.5	3651BC	Poz-9887	4940 ± 100	3936-3861, 3820-3500, 3432-3380 BC
Mahl 55-55.5	795 AD	OxA-15480	1280 ± 25	692-748, 765-883 AD
Mal 8-9	483 AD	Ua-40028	1673±30	383-583 AD
Mal 16-17	Not used	Ua-38838	2964±57	1374BC-1351, 1313B-973, 956-940 BC
Mal 24-25	291 BC	Ua-40029	2222±30BP	362-221, 261-108 BC
Mal 40-40.5	433 BC	Poz-30157	2385±30	513-430, 428-358, 283-258, 347-236 BC
Mal 58.5-59	1471 BC	Poz-22200	3260± 30	1533-1409 BC
Map 65-66	1820 AD*	Ua-38827	103,8±0.4**	1890 (31.8%) 1920, 1810 (63.6%) 1830*
Map 79-80	1675 AD	Ua-38828	211 ± 30	1653-1709, 1720-1809
Map 92-92.5	1665 AD	Poz-9888	245± 30	1639-1684, 1731-1775, 1777-1787
Map 94-95	1644 AD	Ua-38829	294 ± 30	1508-1583, 1619-1667
Map 100-101	1447 AD	Ua-38830	490 ± 30	1427-1484
Map 110-111	1437 AD	OxA-17234	501 ± 30	1413-1452
Map 114-115	1399 AD	Ua-38831	617 ± 30	1320-1353, 1380-1423
Map 116-116.5	not used	Poz-9959	305 ± 30	1503-1592, 1615-1669
Map 128-128.5	1377 AD	Poz-2119	705 ± 30	1284-1328, 1341-1391
Makw 58-59.5	886 AD	Poz-22198	1210±30	778-905, 912-968
Makw 98.5-99.5	628 AD	Poz-22199	1495±30	567-655
Makw 136-136.5	567 AD	Poz-9958	1560±30	440-487, 530-640
Radio 0-0.5	2000 AD	OxLel		Pb 210, CF:CS model
Radio 10-10.5	1980 AD	OxLel		Pb 210, CF:CS model
Radio 20-20.5	1960 AD	OxLel		Pb 210, CF:CS model
Radio 30-30.5	1950 AD	OxLel		Pb 210, CF:CS model
Radio 40-45.5	1925 AD	OxLel		Pb 210, CF:CS model
Radio 35-35.5	1905 AD*	OxA-16674	109.8±0.4**	1810AD (42.3%) 1830AD, 1890AD (53.1%) 1920AD*
Radio 79-80	1394 AD	Poz-25106	690 ± 40	1287-1394

Table 2. ^{14}C dates and ^{210}Pb series for all PNL and KNP sequences. All ^{14}C dates have been calibrated in Bcal with the exception of 19th century dates, where OxCal have been used (indicated by an *). Dates marked by ** should be regarded as modern.
http://www.arkeologi.uu.se/digitalAssets/65/65211_JAAH_Ekblom_Table_2.pdf