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Applying palaeoecology to conservation: a long-term perspective for informed management of a fynbos nature reserve

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Appendices:

Appendix 1: Environmental History of Southern Africa and the Western Cape.

The most recent epoch in geologic time, the Holocene (past c.10 Ka), bears particular relevance to contemporary environmental issues, owing to relatively narrow climatic parameters since its inception (Mann, 2007; Holden, 2005; Wanner, et al. 2008). However, comparisons of modern environments with those evidenced in Holocene proxy records becomes problematic due to unspecified levels of human operation in the landscape, and thus, perturbation of natural environments (Froyd and Willis, 2008; Jackson and Johnson, 2000). This has significant implications for applied palaeoecology studies, and is intricately bound to the '*What is natural*?' debate. As a pretext to the above investigation, the following text provides a basis - or 'build-up'- to the palaeoecological record obtained, as well as a commentary for land use change during its likely temporal extension. In doing so, Holocene environmental change and archaeology are discussed.

The Holocene has been a relatively warm interglacial period, characterised by short cool (stadial) and warm (interstadial) oscillations, with various associated moisture patterns (Mann, 2007). A number of studies from southern Africa have documented these fluctuations (Repinski, et al. 1999; Scott, et al. 2006; Scott and Woodbourne, 2007), which have occurred on decadal and millennial timescales (Grove, 1995). Of these climatic variables, moisture has been the most significant in the Western Cape, given its general aridity (Scott and Lee-Thorp, 2004). In the Early Holocene North Africa was favourably wet, while Southern Africa was unfavourably cool and arid. This meant northern populations developed to a greater extent than those in the south of the continent. However, mesic conditions in Southern Africa, initiating in the Iron Age, may have encouraged the southward migration of agro-pastoralists (Scott, 1999).

The early Iron Age farmers may have arrived in the Cape landscape some 2Ka B.P., bringing sheep, cattle and increased burning (Cowling, 1995). Already persisting in the landscape were aboriginal hunter-fisher-gatherers (H-F-Gs). These people likely lived subsistence lifestyles, hunting game and sea-foods while practicing transhumance (Smith, 1999). Environmental and ecological perturbation was likely low; however significant impacts on faunal composition have been noted in South Africa since c.12Ka BP (Klutton-Broak, 1995). Moreover, the use of fire to propagate geophytes and hunt animals has resulted in perturbation to fire regimes since >125Ka B.P. (Cowling, 1995; Scott, 1999). The arrival of agro-pastoralists in the Early Iron Age, then, seems a likely point in which the environmental impacts of human persistence in the landscape were heightened. Indeed, by the late Iron Age (post A.D.1000), socio-economic and demographic development on the sub-continent was adequate for statehood and lager settlements (Smith, 1999).

In the last millennium, considerable human and natural changes occurred in the Western Cape region. From around A.D.1000-1400, an interstadial oscillation occurred, known as the Medieval Warm Period (MWP). Climate was warm and moist (Mann, 2007), favourable to occupation of the interior by pastoralists; although archaeological evidence suggests transhumance still took place (Smith, 1999). Thus, agriculture was likely low intensity, as was ecological impact. Between A.D.1400-1800, a cool, dry stadial period occurred, often referred to as the Little Ice Age (LIA)

(Mann, 2007; Jones, et al. 1999; Repinski, 1999; Wanner, et al. 2008). The likely effects on landuse would be to increase stress from agriculture as resources dwindled under increased aridity; though, increasing reliance on coastal resources may have alleviated this. Colonial arrival at this point, however, complicates the situation.

The arrival of Europeans in the Cape from c.A.D.1650 (Cowling, 1995; Meredith, 2007) saw a dramatic change in human - environment interactions. Colonial expansion at the frontiers brought with it changing land use practices. Notably, this was a transition from low technology and intensity subsistence pastoralist activity, to high technology and intensity agriculture. Although the pre-colonial peoples may have possessed large herds of cattle, the methods and types of agricultural practice used were significantly less ecologically damaging than those which succeeded in the colonial period (Coates, 1998; Crosby, 2004; Smith, 1999). This is evidenced in the palaeoecological record from the Western Cape, which notes significant decreases in landscape-scale biological diversity contemporaneous with the colonial period (Meadows and Baxter, 2001; Meadows, et al. 1996). Climatic conditions ameliorated c. AD 1850, becoming more mesic until present, although water availability is currently a problem for both people and plants on the Cape (Mucina and Rutherford, 2006).

From the eighteenth century settlements were founded on the Western Cape, close to the Wildcliff site. Swellendam, located some 56km west-southwest of Wildcliff, was founded in 1743, and became a regional centre for agriculture and trade. Farming of cattle, sheep, grains and fruit took place in the surrounding landscape. Other towns in the Wildcliff area were established later, notably Heidelberg, some 17km S.E. of the reserve site, in 1885 (Giddy, 2008). Conceivably European agricultural practice in the landscapes surrounding these towns occurred for a considerable period before these official dates of declaration of settlement, and corresponding alterations to the areas flora had been made. Invasive trees of the genera *Pinus, Acacia and Eucalyptus* were introduced to the region in the mid-nineteenth century (Robertson, 2005; Scholtz, 1986). However, it appears apparent in various palaeoecological records (Meadows and Baxter, 2001; Meadows, et al, 1996) that such land use was sporadic, and mountainous areas such as the Langeberg Range may have been spared significant degradation until later in the colonial period.

The arrival of Europeans in the Cape was also followed by the first efforts to document fynbos, and study it in a scientific manor. Early plant hunters explored Cape botany following the establishment of Cape Colony by the Dutch in 1652 (Cowling, 1995; Meredith, 2007). Pioneering botanists, such as Rudolf Marloth, sought to understand fynbos natural history and systematically describe its diversity. However, it is important to recognise a number of shortcomings in early studies of fynbos. Firstly, records of fynbos ecology are limited in temporal extension, and have only been kept since the European arrival. Indigenous knowledge has largely been lost in the transition to modernity. Secondly, early understanding was often inaccurate, which means records may be unreliable and past conservation efforts were sometimes misguided. For example, until the latter half of the twentieth century fire was viewed as destructive, and suppressed (Cowling, 1995). Thirdly, data lacks spatial resolution, and thus records for specific conservation sites are lacking. This is certainly true of the Wildcliff area.

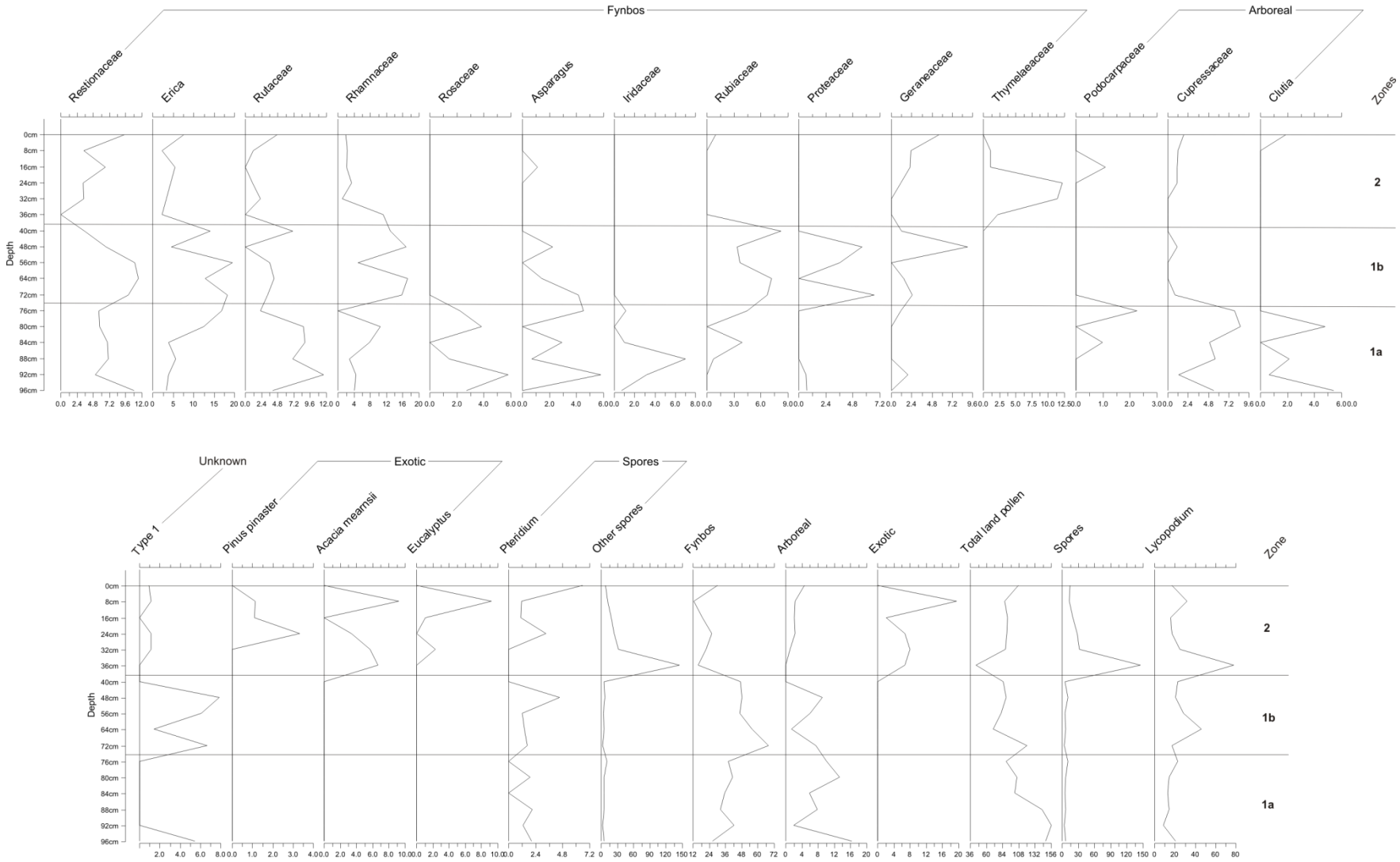
In summary, the Holocene period has seen significant environmental changes, both anthropogenic and natural; although the two have been interlinked. Perturbation of fire regimes and faunal composition in the Western Cape has occurred for many millennia, however noteworthy increases in land use intensity occurred c.2000 BP and markedly so through the colonial period (largely due to changes in agricultural practice and population change). Climatic changes influenced the lifestyles of pre-colonial peoples, whose nomadic culture may have had limited ecological impacts. The arrival of European farming practice likely intensified land use and further perturbed fire regimes; though, the occurrence of colonial ecological degradation may have been temporally and geographically variable across the landscape. The arrival of Europeans also led to the scientific exploration of fynbos; however this data has limited use in the context of this investigation due to scientific inaccuracies and spatial resolution.

Appendix 2: Troels-Smith (1955) Sediment Description.

Table 10: Troels-Smith (1955) sediment description of core lithology.

Unit:	Depth:	Troels-Smith (1955) sediment description:
E	16-0 cm	As4. Nig 1; Strf 0; Elas 0; Sicc 2; Humo 3.
D	40-17 cm	As 4. Nig 3; Strf 0; Elas 0; Sicc 3; Humo 4.
C	69-41 cm	Gs^2, A^2. Nig 3; Strf 1; Elas 0; Sicc 3; Humo 4.
B	79-70 cm	Gs^3, Gg $(min)^1$, A+. Nig 1; Strf 1; Elas 0; Sicc 3; Humo 4.
A	96-80 cm	A^2, Gs^2, Gg (min)+. Nig 4; Strf 1; Elas 0; Sicc 3; Humo 4.

Appendix 3: *Figure 22: Pollen diagram with no miscellaneous taxa.*



Appendix 4: DCA Alternative Plots.

Figure 23: DCA samples plot of axis 1 (~33% of variance) verses axis 3 (~12% of variance). The general trends observable support those identified in the axis 1 verses 2 plot. Some disagreement occurs, but this is largely along axis 3 (the least significant).

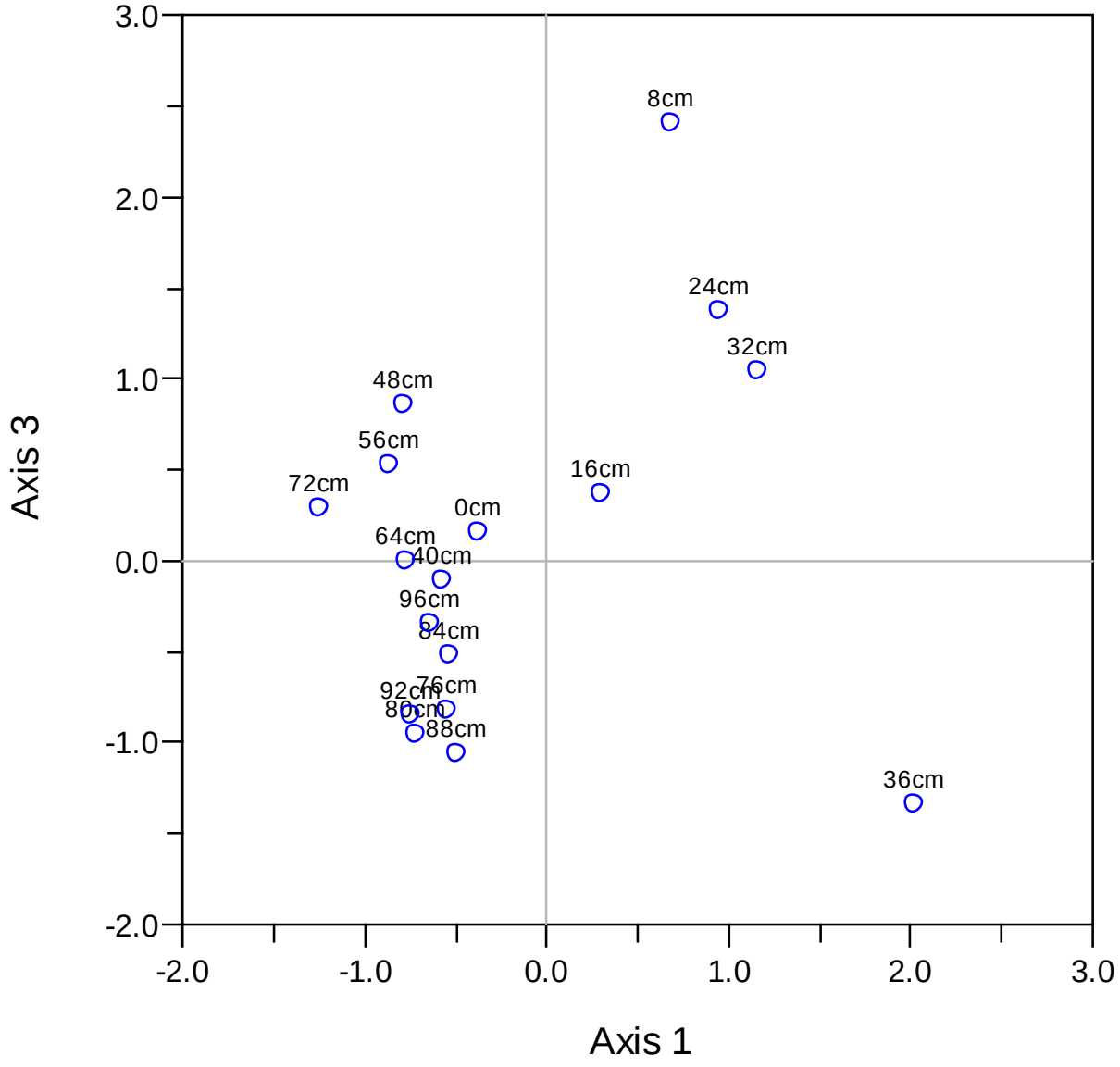


Figure 24: DCA taxa plot of axis 1 (~33% of variance) verses axis 3 (~12% of variance). The general trends observable support those identified in the axis 1 verses 2 plot.