A Late Holocene pollen and microcharcoal record from Eilandvlei, southern Cape coast, South Africa

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18.1 SITE DETAILS

Eilandvlei forms part of the Wilderness Lakes system located along the southern Cape coast of South Africa (Figure 1A, B). These lakes are located behind Pleistocene dune ridges that run parallel along the coastline. Situated within South Africa's aseasonal rainfall zone, climate is influenced by both temperate and tropical circulation systems.

The regional vegetation (Figure 1B, C) is most noteworthy for the extensive development of Southern Afrotemperate Forest (generally *Afrocarpus falcatus*, *Podocarpus latifolius*, *Ocotea bullata* (Lauraceae) and *Olea capensis* spp. *marcocarpa* (Oleaceae)), which is found in valleys and on the south-facing slopes of the adjacent river catchments A variety of fynbos types occupy

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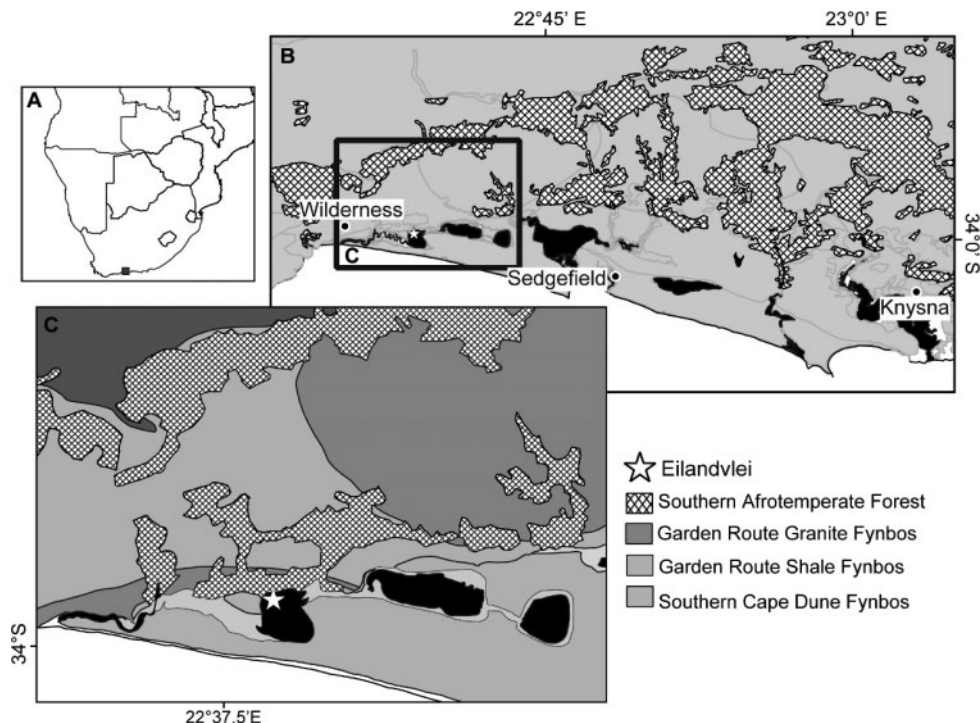
Figure 1. (A) Map of Africa showing the location of the southern Cape coast. (B) A section of the southern Cape coast between the towns of Wilderness and Knysna indicating the location of Eilandvlei and the current extent of Afrotemperate forest in the region. (C) The location of sediment core EV11 and the contemporary distribution of the dominant vegetation types (Mucina and Rutherford 2006).

this region including Garden Route Shale Fynbos (distinguished by ericaceous and tall dense proteoid fynbos), Knysna Sand Fynbos (primarily *Erica curvifolia*, *Metalasia densa* (Asteraceae) and *Passerina rigida*) and Southern Cape Dune Fynbos (predominantly *Olea exasperata*, *Phylica litoralis* and a variety of *Searsia* species).

18.2 SEDIMENT DESCRIPTION AND METHODS

The EV11 core (33°59′23.10″S, 22°38′17.60″E, 0 m asl) was retrieved using a portable vibracorer mounted on a floating platform. The final core length measured ~1.54 m. The mean grain size varies from 5.89 to 7.27 φ with the standard deviation ranging from 1.85 to 2.33 indicating very poorly sorted, fine to coarse silts to be the principal sedimentological components of EV11.

Forty-seven subsamples, with a minimum weight of 2 g, were analysed using standard palynological methods as per Faegri and Iversen (1989) and Moore *et al.* (1991) with adaptations for dense media separation (Nakagawa *et al.* 1998). Pollen grains were examined and counted using a Zeiss Axiostar Plus microscope. Identifications were achieved through comparison with reference material from the Environmental and Geographical Science department at the University of Cape Town and published material (Van Zinderen Bakker 1953, Van Zinderen Bakker and Coetzee 1959, Welman and Kuhn 1970, Scott 1982). Charcoal particles were counted together with

the pollen grains using the particle count method (Tinner and Hu 2003). Fragments were classified according to size: 10–50 μm and 50–100 μm. The exotic marker *Lycopodium* was added during preparation to enable pollen and charcoal concentrations to be calculated (one tablet per sample; Lund University, Batch # 483216, 18583 ± 1708 spores per tablet). Two samples were omitted due to insufficient pollen concentrations; depths 80 and 138 cm. A total pollen sum of 500 grains, or three slides, was achieved for each sample. On considering the results, it was deemed appropriate to remove the local aquatic components and Amaranthaceae from the pollen sum. Pollen assemblage zones were determined by the use of cluster analysis by the application of CONISS (Constrained Incremental Sum of Squares) (Grimm 1987) – all identified taxa were included in this analysis.

18.3 DATING

Seven organic sediment samples were selected for AMS-^{14}C dating at Beta Analytic Inc (USA) (Table 2). The two top samples returned pre-bomb ages and were calibrated using CALIBomb

Table 1. Sediment description for core EV11.

Depth from surface (cm)	Sediment colour	Munsell notation	Sedimentology
0–16	very dark brown	10YR 4/2	sandy clay
16–36	dark greyish brown	10YR 3/2	fine sand and silt
36–82	very dark greyish brown	2.5Y 4/1	fine sand and silt
82–115	very dark grey	2.5Y 3/1	fine silt, sand and clay
115–154	very dark grey	2.5Y 3/1	fine silt, sand and clay

Table 2. Radiocarbon and calibration details for EV11. Samples were data at Beta Analytic Inc. as indicated by the laboratory identification.

Lab ID (Beta-)	Depth (cm)	[14]C age (yr BP)	1 σ error	Calib. data set	ΔR	2σ cal age range (cal BP)	Median probability (cal BP)
EV11-1	0	–	–	CALIBomb	–	–	−58.7
EV11-2	20	–	–	CALIBomb	–	–	−4.8
EV11-3	40	470	30	Marine13	252 ± 64	340–352 451–526	497
EV11-7	78	1290	30	Marine13	252 ± 64	1072–1192 1206–1268	1171
EV11-4	102	2140	30	Marine13	252 ± 64	2002–2154 2276–2287	2074
EV11-6	134	3300	30	Marine13	252 ± 64	3397–3568	3485
EV11-5	151	3620	30	Marine13	252 ± 64	3726–3751 3791–3794 3820–3980	3880
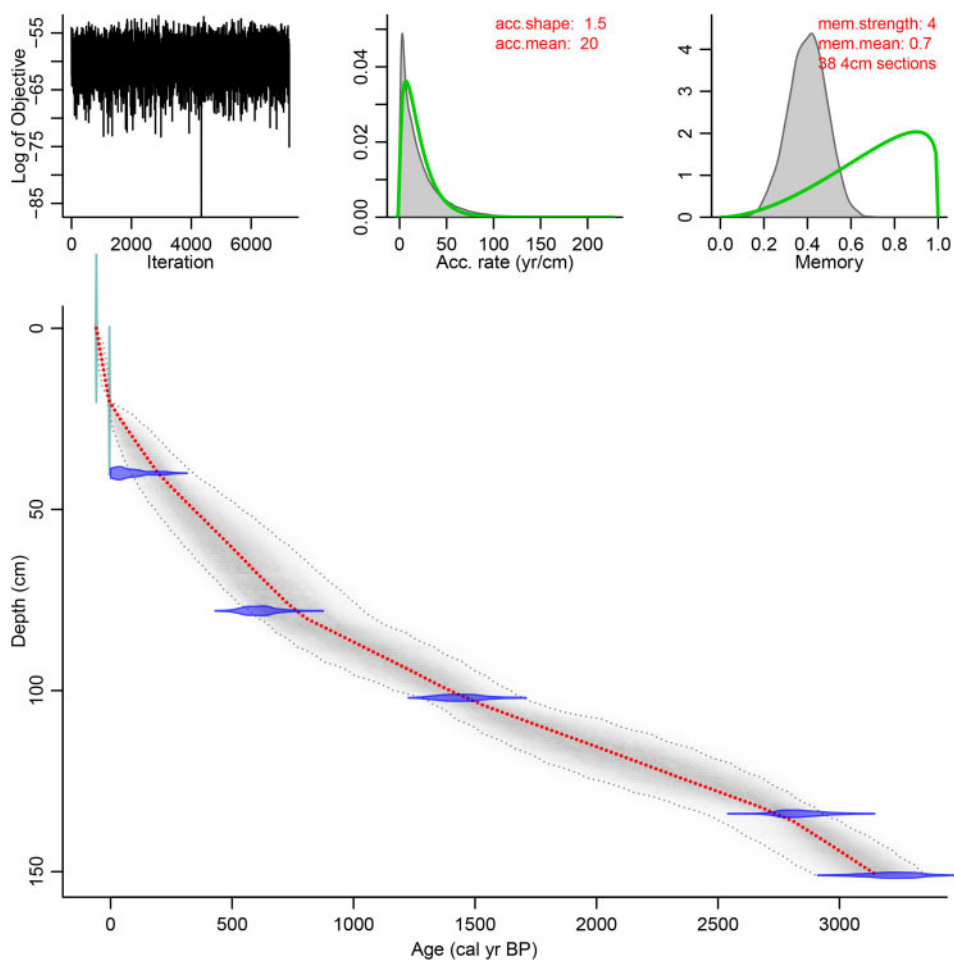
Figure 2. The EV11 age-depth model. The 2σ probability distribution of calibrated ^{14}C ages is presented in blue and the 95% confidence intervals are represented by the grey dotted line. The red line represents the best model according to the weighted mean age at each depth.

(Reimer *et al.* 2004). The remainder of the samples were calibrated with the Marine13 data set (Reimer *et al.* 2013) with a marine reservoir correction of $\Delta R = 252 \pm 64$ (Wündsch *et al.* 2016). The age-depth model (Figure 2) was developed with the R software package Bacon (v2.2) (Blaauw and Christen 2011).

18.4 INTERPRETATION

In total 65 taxa were identified. Pollen concentrations range from 6.26×10^3 grains·g^{-1} near the base, to a maximum of 7.86×10^4 grains·g^{-1} around the top of the assemblage, with an average of 2.72×10^4 grains·g^{-1}. The EV11 record extends from *c*. 3100 cal yr BP to present.

The sequence is divided into five pollen zones labelled EV11-A to E as set out below.

18.4.1 EV11-A (3100 − 2560 cal yr BP; 148−130 cm; 8 samples): Drought resistant – Afrotemperate forest taxa

Elevated levels of drought resistant taxa (i.e. Aizoaceae, *Pentzia*-type and *Euphorbia*) are seen at the onset of record, with *Euphorbia* present throughout the zone. *Stoebe*-type percentages are similarly increased, though decline towards the top of zone. Ericaceae pollen percentages are somewhat higher, at an average of 5.1%, in comparison to the zone above. Afrotemperate forest pollen (primarily *Podocarpus/Afrocarpus*) increase after 3000 cal yr BP, from 7.9 to 12.7% at the top of the zone, with coastal thicket taxa (mostly *Olea, Searsia* and *Euclea*) well represented from the start of the record with values ranging from 12 to 19.8%. The maximum number of large charcoal fragments (50–100 µm), interpreted to be indicative of a large more local fire event, is noted at 2600 cal yr BP. These trends suggest that moisture availability was fairly limited, but rainfall was likely gradually increasing over this period.

18.4.2 EV11-B (2560 − 1560 cal yr BP; 128−106 cm; 11 samples): Amaranthaceae

Zone EV11-B is strongly dominated by the halophytic taxon Amaranthaceae with a distinct increase after 2600 cal yr BP from 13.7 to 43.7%. This could be representative of expanding salt marsh vegetation in response to lower sea levels. Fluctuating forest pollen percentages are noted from around 2400 until 1600 cal yr BP with maximum charcoal concentrations concomitant with the increased presence of *Podocarpus/Afrocarpus* at 2260 cal yr BP. Restionaceae is more prominent in this zone than elsewhere in the record.

18.4.3 EV11-C (1560 − 670 cal yr BP; 104−76 cm; 9 samples): Afrotemperate Forest

Podocarpus/Afrocarpus pollen is more prominent in comparison to the zones below, likely representing a phase of increasing forest expansion. At the same time, fynbos (largely Ericaceae) show a moderate decline towards the top of the zone, from 32.9 to 24.5%, indicating a shift towards a more mesic environment with reduced rainfall seasonality.

18.4.4 EV11-D (670 − 70 cal yr BP/AD 1880; 70−30.5 cm; 13 samples): Afrotemperate forest – drought resistant taxa; *Stoebe*-type

Forest development continues until 360 cal yr BP, with a sudden break in this trend around 620 cal yr BP. After 360 cal yr BP a rather abrupt decline in Afrotemperate forest pollen is noted – from 17.5 to 10.7% in a period of *c*. 50 years. Drought resistant taxa (mostly *Euphorbia*) become more prevalent from this point with a rapid increase in *Stoebe*-type pollen (13.6%) around 130 cal yr BP. These vegetation responses are likely a result of the cooler and drier conditions experienced in the region during the latter part of the so called Little Ice Age (650 − 100 cal yr BP) (Jones *et al.* 2001; Matthews and Briffa 2005).

18.4.5 EV11-E (70 to −30 cal yr BP/AD 1880 to 1980; 26−12 cm; 4 samples): *Pinus*

The most recent part of the record is characterised by the appearance of *Pinus* pollen *c*. AD 1910 marking the onset of the anthropogenic influence in the region.

These results are broadly consistent with the pollen record from EV13. For a fuller discussion on the palaeoclimatic inferences please see (Quick *et al.* 2018).

Figure 3. Relative pollen percentage diagram for EV11 organised according to ecological affinity, with charcoal concentrations and charcoal fragment counts. Pollen taxa occurring at less than 5% are not shown. Exaggeration curves are 2x for the taxa presented here. Charcoal and pollen concentrations were calculated in the same manner using *Lycopodium* counts.

DATA AVALIABILITY

The pollen and microcharcoal data presented here is available at:
http://apps.neotomadb.org/Explorer/?datasetid=48877

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REFERENCES

Blaauw, M. and Christen, J.A., 2011, Flexible paleoclimate age-depth models using an autoregressive gamma process. *Bayesian Analysis*, **6**(3), pp.457–474, 10.1214/ba/1339616472.

Faegri, K. and Iversen, J., 1989. *Textbook of Pollen Analysis*, Chichester: John Wiley & Sons Ltd.

Grimm, E.C., 1987, CONISS: A Fortran 77 program for stratigraphically constrained cluster analysis by the method of incremental sum of squares. *Computers & Geosciences*, **13**, pp.13–35, 10.1016/0098-3004(87)90022-7.

Jones, P.D., Osborn, T.J. and Briffa, K.R., 2001, The evolution of climate over the last millennium. *Science*, **292**(5517), pp.662–667, 10.1126/science.1059126.

Matthews, J.A. and Briffa, K.R., 2005, The' Little Ice Age': Re-Evaluation of an Evolving Concept. *Geografiska Annaler. Series A*, *Physical Geography*, **87**(1), pp.17–36.

Moore, P.D., Webb, J.A. and Collinson, M.E., 1991, *Pollen Analysis* 2nd edition, (Oxford: Blackwell Scientific Publications).

Mucina, L. and Rutherford, M.C., 2006, *The Vegetation of South Africa, Lesotho and Swaziland*, (Pretoria: South African National Biodiveristy Institute, Sterlitzia).

Nakagawa, T., Brugiapaglia, E., Digerfeldt, G., Reille, M., De Beaulieu, J.L. and Yasuda, Y., 1998, Dense media separation as a more efficient pollen extraction method for use with organic sediment/deposit samples: comparison with the conventional method. *Boreas*, **27**, pp.15–24, 10.1111/j.1502-3885.1998.tb00864.x.

Quick, L.J., Chase, B.M., Wundsch, M., Kirsten, K.L., Chevalier, M., Mäusbacher, R., Meadows, M.E. and Haberzettl, T., 2018, A high-resolution record of Holocene climate and vegetation dynamics from the southern Cape coast of South Africa: pollen and microcharcoal evidence from Eilandvlei. *Journal of Quaternary Science*, **33**(5), pp.487–500, 10.1002/jqs.3028.

Reimer, P.J., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Ramsey, C.B., Buck, C.E., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T.J., Hoffmann, D.L., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., Manning, S.W., Niu, M., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Staff, R.A., Turney, C.S.M. and van der Plicht, J., 2013, IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years cal BP. *Radiocarbon*, **55**(04), pp.1869–1887, 10.2458/azu_js_rc.55.16947.

Reimer, P.J., Brown, T.A. and Reimer, R.W., 2004, Discussion: Reporting and Calibration of Post-Bomb ^{14}C Data. *Radiocarbon*, **46**(3), pp.1299–1304, 10.1017/S0033822200033154.

Scott, L., 1982, Late Quaternary fossil pollen grains from the Transvaal, South Africa. *Review of Palaeobotany and Palynology*, **36**(3–4), pp.241–278, 10.1016/0034-6667(82)90022-7.

Tinner, W. and Hu, F.S., 2003, Size parameters, size-class distribution and area-number relationship of microscopic charcoal: Relevance for fire reconstruction. *The Holocene*, **13**(4), pp.499–505, 10.1191/0959683603hl615rp.

Welman, W.G. and Kuhn, L., 1970, *South African Pollen Grains and Spores*, Volume VI, (Amsterdam-Cape Town: AA Balkema).

Wündsch, M., Haberzettl, T., Meadows, M.E., Kirsten, K.L., Kasper, T., Baade, J., Daut, G., Stoner, J.S. and Mäusbacher, R., 2016, The impact of changing reservoir effects on the ^{14}C chronology of a Holocene sediment record from South Africa. *Quaternary Geochronology*, **36**, pp.148–160, 10.1016/j.quageo.2016.08.011.

Van Zinderen Bakker, E.M., 1953, *South African Pollen Grains and Spores*, Volume I, (Cape Town: AA Balkema).

Van Zinderen Bakker, E.M. and Coetzee, J.A., 1959, *South African Pollen Grains and Spores*, Volume III, (Cape Town: AA Balkema).