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Application of digital photogrammetry to measure a cast of an animal excavation

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Background

Soil disturbance by ecosystem engineers is increasingly being recognised for the influence it has on ecosystem structure and function. To make comparisons of the relative influence of soil disturbance between species and habitats, the volume of soil excavated by each species present must be determined. The problem of estimating soil displacement by ecosystem engineers is a perennial one for ecologists because of the polymorphism of excavations.

The techniques that have been used to estimate their volume have included excavation and measurement, modelling the product of length, width and depth in relation to a known bulk soil density, mathematical modelling via geometric shape projection, and casting. Casting is less likely to damage the excavation and fills the entire space, including the parts which cannot be viewed, accessed and physically measured. However, casts also require significant post processing to measure.

Ideally, casts should be measured via three dimensional (3D), spatially referenced co-ordinates because this eliminates the assumptions and extrapolations that introduce error into the measurement process, using traditional measurement and modelling techniques. Recent advances in photogrammetric software, using standard digital photography, may provide the key component required to accurately model biological casts at an affordable price.

The application and efficacy of close range (≤ 100 m), digital, 3D photogrammetry for modelling a cast of an animal excavation was investigated. A beeswax cast was made of a foraging digging that had been excavated by a lizard in central Western Australia. The cast was photographed using standard digital photography, and photogrammetric software was used to create a digital scale model of the surface. Volume and surface area were calculated using the software. Measurements obtained using the software were compared with those obtained by traditional mechanical means to test the accuracy of the results.

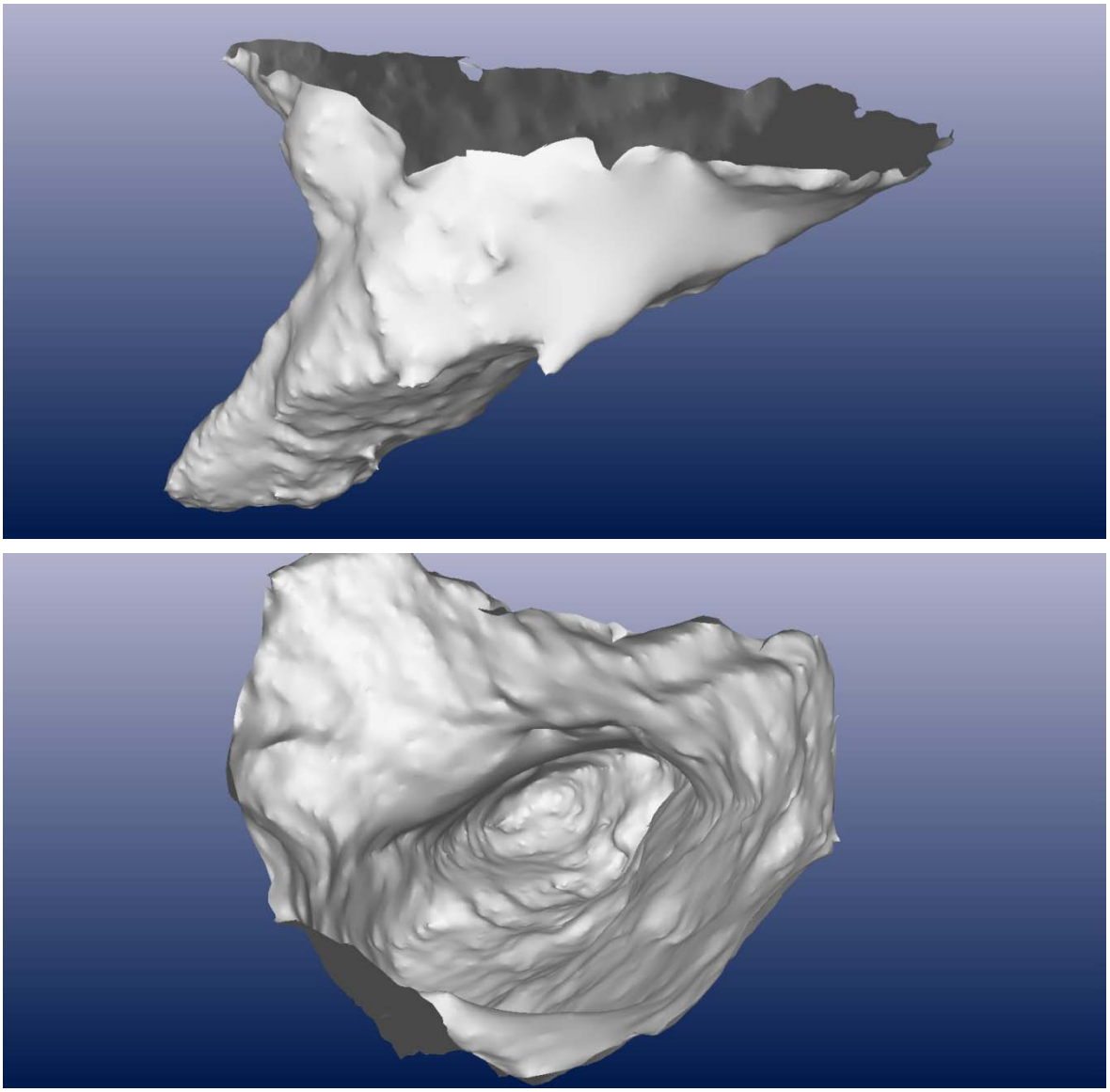
Methods

This study was conducted as part of a study into the effects of ecosystem engineers in arid habitats at ex-pastoral station Lorna Glen in central Western Australia. Lorna Glen is a 244,000-hectare property in arid rangeland, 1100 km northeast of Perth. The property was a rangeland sheep and cattle station established in the 1930s until it was acquired by the Government of Western Australia for conservation in 2000. This project is part of a broader program, Operation Rangelands Restoration, a mammal re-introduction and exotic fauna control program, commenced by the Department of Environment and Conservation in 2000.

A fresh goanna (*Varanus* sp.) foraging digging was found at the base of a *Triodia melvillei* plant in May 2011. Beeswax was melted in a pot on a camp stove, poured into the digging and collected the following day. The cast was weighed and its volume estimated from the known density of beeswax (961 g per 1000 cm^3). It was then placed into a volumetric cylinder containing water, and the volume of water displaced was used to estimate the volume of the cast. The cast was then photographed and modelled using photogrammetry software, which uses light rays to determine 3D co-ordinates from two or more photographs. The volume of the model was estimated using the software, and this figure was compared to the other estimates of volume to assess its accuracy.

Findings

The model of the surface of the digging contained 42,900 points, resulting in a highly detailed model.



Digital model of the digging side view (above) and looking down into the digging (below).

The photogrammetric software calculated the surface area via triangulation at 369.301 cm^2, using 85,300 triangles. In comparison with the mechanical measurements, the volume estimated by photogrammetric measurement was very accurate. The 3D data can be exported to a computer aided drawing (CAD) program for measurement of a range of morphological features.

Comparison of measurement of cast volume using three methods of estimation.

Method	Volume (cm^3)	Difference (%)
Weight to volume based on density	552.5	-
Water displacement	530	-4.1
Photogrammetric software	556.42	+0.71

Research applications

In addition to the detailed visual representation of the digging, photogrammetric modelling of the cast facilitated very accurate measurement of volume. Photogrammetric modelling, therefore, has the potential to make a valuable contribution to the range of tools currently used to study ecosystem engineering by digging fauna.

In habitats like Lorna Glen, where more than one animal excavates soil, it is not always possible to determine which animal has made the excavation. Modelling and characterisation of excavations of

known origin may help establish their key distinguishing features, increasing the number of excavations that can be attributed to a species. For instance, photogrammetric modelling could be used to measure the shape and aperture of the entry of excavations, shape and diameter along its length, and angle of incidence. These measurements could be used to establish the mean and limits for a range of parameters for excavations for each species. It may then be possible to establish the most likely species that made the excavation by fitting measured parameters to quantitatively modelled data.

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