Final Report: Near surface geophysics as a tool to help manage the southern hairy-nosed wombat in South Australia

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Abstract

Ground penetrating radar (GPR) was used to map the warrens of southern hairy-nosed wombats (*Lasiorhinus latifrons*) at four sites in South Australia in different soil types: sandy loam, clay and calcrete limestone. Although GPR is used extensively for many geophysical applications, it has had limited use in wildlife research to date, with most previous studies not making full use of the post-survey processing features available. We successfully produced 3D maps of the wombat warrens at three of the four sites surveyed, with the heavy clay soil at the fourth site being too conductive for any useful radar data. The study provided the first data on wombat warrens obtained by non-invasive means, and was the first time that a warren under a layer of calcrete limestone has been mapped. The information obtained on warren morphology expands our knowledge of wombat population dynamics, and demonstrated the effectiveness of GPR as a useful tool for wildlife research. Until this project, the only method available to map the underground extent of wombat burrows was to dig through them with a front-end loader, thereby destroying them both for use as habitat for the wombat and for any future research use.

Background info

Within the marsupial family Vombatidae, there are three extant species of wombat endemic to Australia; the northern hairy-nosed wombat (*Lasiorhinus krefftii*), the southern hairy-nosed wombat (*Lasiorhinus latifrons*) and the common, or bare-nosed, wombat (*Vombatus ursinus*). Wombats are herbivorous, and are the largest burrowing mammal in the world. This project is focused on southern hairy-nosed wombat (SHNW) which is found predominantly in South Australia (SA) on agricultural properties. SHNWs live in large burrow systems, which are vital for their survival in the harsh SA climate, however it is these warrens that often lead to conflict with the agricultural sector. The digging behaviour of this species can, in some settings, cause significant damage to properties

Recently there has been more community concern and media attention regarding the management of SHNWs, which is predominantly done by culling, when numbers get too large in a given area. Farmers worry about increased damages caused by wombats, and the associated viability of their land, whereas the general public and some conservation groups are concerned that current practices will see the SHNW reduce in number, or become locally extinct. The differing stands on the issue of culling are based from various anecdotal reports which suggest SHNW numbers are increasing in some regions, and dramatically declining in others. However, the last actual population census of SHNWs in SA was conducted in 1989.

This project is part of a large-scale project aimed at developing a technique to model SHNW abundance at several different scales (state-wide, regionally and/or property specific). This model will be an important tool for SHNW managers and policy decision makers, and will assist in alleviating all areas of conflict and ensure the long term survival of this species.

Up-to-date abundance estimates of a species are a fundamental parameter for determining their conservation status and management policies, and for SHNWs, there is a large gap in knowledge on population numbers. One of the biggest driving forces behind the conflict and angst between stakeholders is that management and policy decisions are currently being made without solid scientific knowledge on abundance as a basis. Government officials require this gap to be filled to assist in making more informed management decisions and therefore help in mitigating the conflict between all the stakeholders involved (especially the wombat/human conflict aspect).

The nocturnal burrowing nature of SHNWs makes them a cryptic species and notoriously challenging to study, therefore determining abundance can be difficult. Given that wombats make conspicuous burrows in relatively open habitat, surveys of active burrows are the most common method of determining wombat presence. However, the remoteness of some populations means ground-truthing across the whole distribution can be complicated. In recent times the most feasible method for calculating burrow abundance over a large scale is a mixture of satellite imagery and on-ground work. Initial research has been conducted on the detectability of wombat burrows using satellite imagery across various soil and habitat types. The next step of this research is correlating the number of individual wombats with the number of active burrows. SHNWs are known to use more than one burrow at any given time, and more than one wombat per burrow has been observed historically. Therefore, 10 active burrows does not necessarily equate to 10 wombats. Remote sensor cameras have been set up in the Far West Coast and Murraylands of South Australia to assist in determining the average number of wombats per burrow, in different soil and habitat types. However, many SHNW burrows are not single entities, but instead part of a warren system and connectivity of burrows within the warrens is largely unknown. It is therefore important to determine the internal structure of warren systems to assist in understanding how connectivity of burrows will influence the number of wombats per active burrow.

The aim of this project was to better understand the population and habits of the cryptic southern hairy-nosed wombat (SHNW) in South Australia by:

1. Using shallow geophysical techniques, specifically ground penetrating radar (GPR), to help map the areal extent of underground burrows dug out by SHNWs on agricultural land in the far west of South Australia.
2. Estimate the number of wombats that live in a given burrow network.

This information will ultimately be used to develop appropriate management tools and policy to ensure the long term survival of this iconic Australian species.

The research program had two principal outcomes:

1. To determine the location and distribution of SNHW burrows in the specific burrow systems chosen for this work;
2. To develop a methodology for imaging these burrows so that this work can be extended to other, similar sites;

Geophysical Need

Determining the trace of animal burrows is difficult without destroying the burrow. A limited number of studies have shown that it is possible to trace burrows using GPR, when ground conditions are conducive to the use of radar.

Field Studies

GPR data were collected from 2 to 10 April, 2014 using a Mala X3M GPR system paired with Mala 250 MHz and 500 MHz shielded antennas mounted on a rough terrain cart. Positional data were recorded directly to the radar system using a Hemisphere 320 RTK differential GPS system. Prior to GPR data collection, we surveyed each area with a GF Instruments CMD-4 Conductivity Meter to determine the conductivity of the soil in the survey area to ensure that the ground was not too conductive for a GPR survey and to assist with antenna selection and later data analysis.

Before using the radar we visually inspected the warrens to determine the most likely orientation of any tunnels. A rectangular or square survey area was then marked out and the site was gridded with nominal 0.5 m line spacings with data collected on orthogonal grids. We collected two sets of data for all sites except Site 3 - one set each for the 250 MHz and 500 MHz antennas. Because of high soil conductivity at Site 3 only the 250 MHz antenna was used.

Interpretation of Data

GPR data were processed using the ReflexW GPR processing package (version 7.5). For each site, a representative radar line was selected from the entire grid for 2D processing using the following steps:

- Static correction to move start time for first arrivals.
- Subtract mean to remove low frequency field signals (de-wow).
- Manual gain correction (decrease shallow gain and increase deep gain to highlight target returns).
- Velocity analysis and conversion of time to depth.
- Kirchhoff migration to convert hyperbolic images to correct target shapes.
- Background noise removal.
- Amplitude envelope to highlight burrow locations.

Once the best possible image was obtained, all remaining 2D slices from the site were batch processed using the same processing parameters. The 2D slices were then stitched together into a 3D cube, which was analysed by adjusting the amplitude scale, zero level and colour palette to increase the signal to noise ratio and to highlight target images. Time slices (z-axis) were then extracted at different depths for publication and to help determine the areal extent and layout of the warrens.

Photos from remote sensor cameras were downloaded and individual wombats identified from the collected photos using morphological markers such as ear notches, body size, scars and nose patterns.

3D models of the wombat warrens were prepared for data collected at three of the four sites surveyed. Site 3 – Bookabie - was located in hard packed claypan soil which had very high ground conductivity readings; ranging from 150 - 250 mS / m. At this site we decided to forego the 500 MHz antenna and concentrate on the 250 MHz antenna only. However, even the lower frequency antenna did not produce any usable burrow information. The following describes our findings:

Site #1. Figure 1 shows a slightly oblique view of the tunnel arrangements at the first site we surveyed in sandy loam soil. The tunnel arrangements at this first site were simple, with one long and one short single-entrance tunnel detected. The tunnels in the image are processed radar imagery with the spoil mound and inactive burrow drawn in to show overall layout. For clarity the first 0.5 m of depth has been removed from the image to eliminate noise from the surface layer (this shows as a sliced-off appearance for the tops of the tunnels). The north-western burrow leads to a 5 m tunnel which descends to a maximum depth of 0.8 m and which opens into a chamber or short branching tunnel part-way along its extent. There is also a short 'through tunnel' associated with this burrow, which is probably a short section of the tunnel which has collapsed part-way along its length, causing the wombats to use a new entrance. A longer tunnel extends to the east of the spoil mound; curving to the north-east for 12 m and descending to a maximum depth of 1 m. This tunnel remains level for the first 8 m of its length, then descends to a depth of 1 m over the last 4 m. There was no tunnel extending to the south-west of the spoil mound, which suggests that the relevant burrow either leads to a tunnel which has collapsed and been abandoned by the wombats, or is a new tunnel in the early stages of construction.

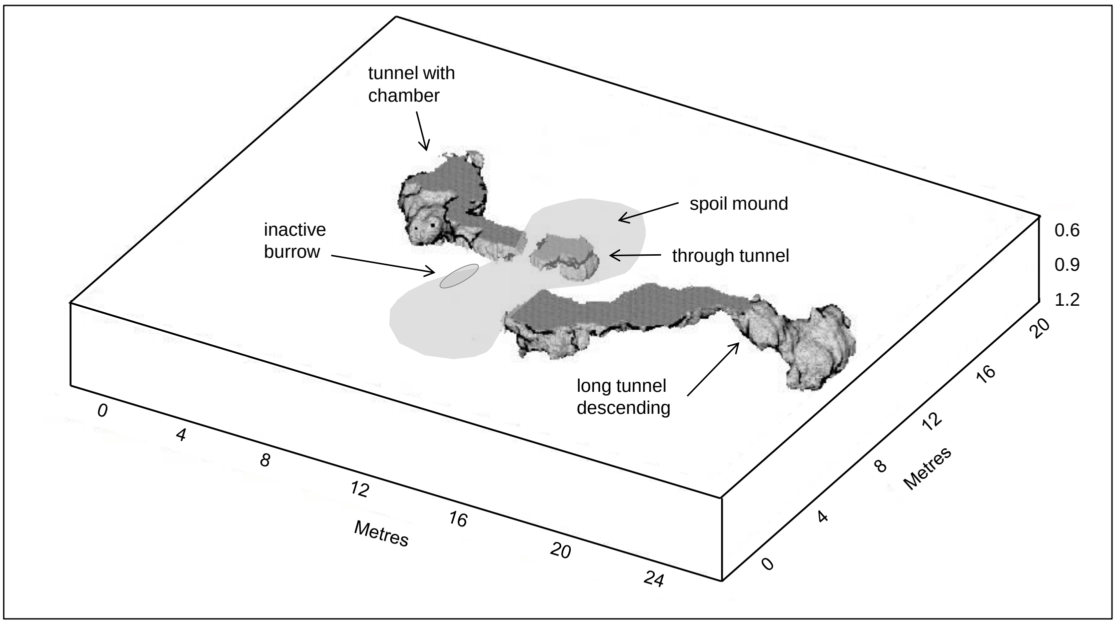

Figure 1. Radar imagery and warren arrangement from Site #1 in sandy loam soil

Site #2. Figure 2 shows an overhead view of the tunnel arrangements at the second survey site, also in sandy loam soil. There was a complex array of tunnels detected at this site, with three closely spaced spoil mounds all having short tunnels less than 3 m in length leading to an area in the centre of the warren complex. The tunnels in this central area curve back on each other and form a ring. A fourth burrow (north-western burrow, southern spoil mound) also leads towards - but does not connect with - the central area via a 7 m long curving tunnel which descends to 0.9 m in depth. Although there is no connection apparent in the radar imagery, a short section of tunnel leads away from the ring suggesting that they may either have once been connected or are is in the process of being connected. In addition to the tunnels leading to the central chamber complex, there was a short (2 m) blind tunnel extending westwards from the southern spoil mound at a depth of 0.5 m. There was a 2 m blind tunnel extending to the east of the northern spoil mound originating from the large double burrow. We also detected an underground chamber 2 m to the east of the southern spoil mound that appears to have become isolated from the burrow entrance by a section of collapsed tunnel.

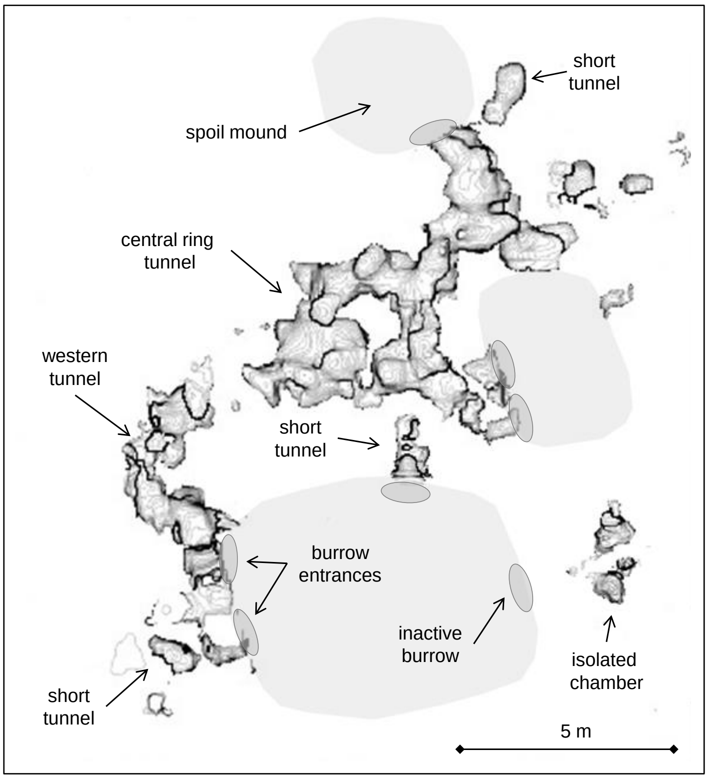

Figure 2. Overhead view of the warren tunnel arrangement as Site #2

Site #4. The fourth site that we worked on was dominated by a very hard calcrete limestone layer immediately under the ground surface. The wombats exploit natural breaks in the calcrete limestone to occupy and modify cavernous areas underneath and between the layers of limestone. The entrance in the image on the left of Figure 3 is indicated with a red arrow on the radar image on the right, which is a horizontal slice (z-axis) through the full 3D model at a depth of 0.6 m. Note the large open areas, which are shown in white in the radar imagery, with the burrow entrances shown in black. For scale, the survey site is 50 m x 50 m.

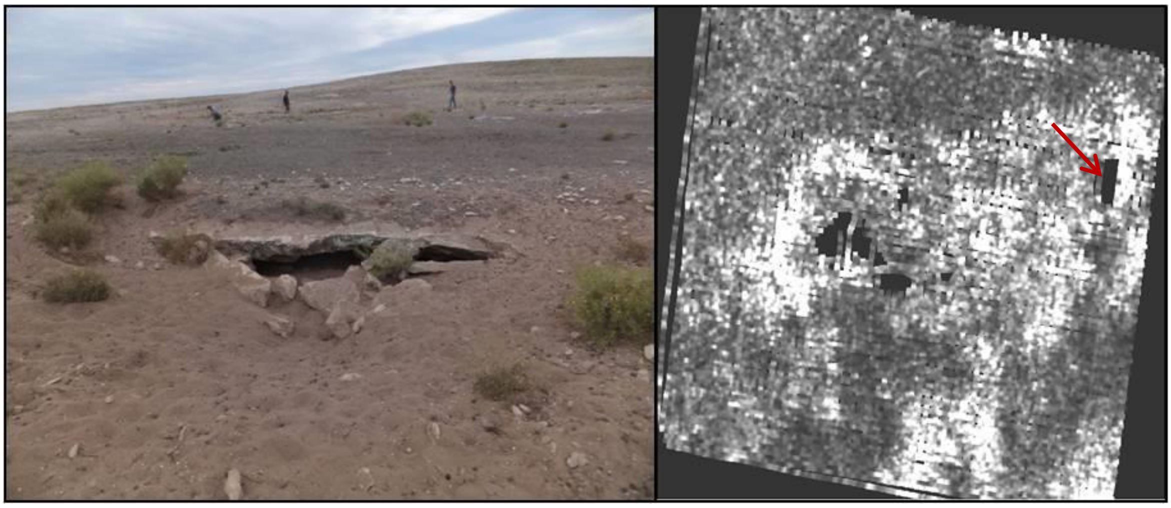

Figure 3. Warren entrance and radar imagery from the calcrete warren at Site #4

The Human Element

Involvement and awareness-raising by all participants was very good on this project. Local farmers, often considered the “natural enemies” of wombats were always cooperative, offering us sites to work from on their properties, and were always willing to talk to us about wombats and issues with them. Elisa and other ZooSA personnel have worked very hard over the years to maintain a good relationship with farmers and other land users in this area.

Our group of students and university personnel was always up for the challenges that we faced on this project. Mike Hatch was the only geophysicist on the project, so needed to keep the technical side of the project (at least in the field) going. The rest of the participants (both University personnel and students) were from the biological side of sciences, and worked hard to get Mike up to speed on what is known about the life and times of wombats in this part of the world. Overall, much was learned by all about wombats and their habits.

Lessons Learned

The lessons learned on this project tended to be more positive than negative.

- Technically the equipment worked well, was appropriate for the work. Overall good quality data were collected.
- GPR data processing is now understood by the participants to be possibly more of an art than originally anticipated. There is a great deal of science that goes into the various potential processing steps; the art comes into choosing the right steps (or is it that the stubbornness comes in – the processor needs to spend enough time testing various algorithms to get the settings right, etc.?).
- Yes, when used in the right setting GPR can image wombat tunnels. That is the biggest lesson learned from this work.
- It was worth bringing a soil conductivity meter along to get some idea of what the local soil conductivity was and correlate that with survey success. As noted we knew from the start that Site 3 (heavy clay soil – very conductive readings with the conductivity meter) was unlikely to produce good images. Our low expectations were realised and nothing useable was produced. A worthwhile experience for the students to see, but no need to collect more data in that setting.

Conclusions

Our research was focussed on developing a range of measures which could be used to estimate wombat abundance at a range of different spatial scales (state, region, individual property) in order to provide a scientific underpinning for management decisions. The work with GPR was an important step in this process as it provides valuable information on how warren complexity is affected by soil type and how this influences population abundance.

Until now the only effective way to map a complex wombat warren was by destroying it, which would prevent any further research aimed at examining how the structure of a warren may vary over time. The use of GPR has provided us with the first opportunity to examine a range of warrens using non-invasive means and the first opportunity to conduct follow on research on the same warrens in the future. When coupled with related research using satellite imagery and motion activated cameras, we are confident that it will be possible to develop much better models and tools to assist with the management of southern hairy-nosed wombats in South Australia.

The issue of management of SHNWs on agricultural properties is extremely controversial given the many factors in play (i) the damage that can be caused, the financial implications and how this influences a farmer’s livelihood, (ii) the contradictory reports that numbers are both increasing and decreasing, (iii) issuing of destruction permits to a native species, and (iv) many gaps in knowledge of this species. The result is many different levels of conflict that have been outlined in the “Background” section of this proposal. Members of the farming community, representatives from some conservation groups/NGOs, as well at the general public, all feel that the government does not listen to, or take into account, their concerns regarding SHNW management. Government representatives, however, are in a difficult position, due to a limited understanding of this species. This research is part of a large-scale project to assist in addressing the large gaps in knowledge and therefore alleviate the conflicts by ensuring species management (both on-ground and policy) is based on sound scientific knowledge, rather than anecdotal evidence.

One of the main benefits of a project like this is the student experience aspect. There is little doubt that a fourth year undergraduate honours project that combines aspects of field work with data processing and interpretation is a valuable experience for a young geophysicist. This project combines all of these attributes with an interesting biological / environmental aspect that potentially makes it a truly worthwhile experience for the student.