23. Using high definition aerial photography to search for Malleefowl mounds – A case study for Mount Gibson's Extension Hill

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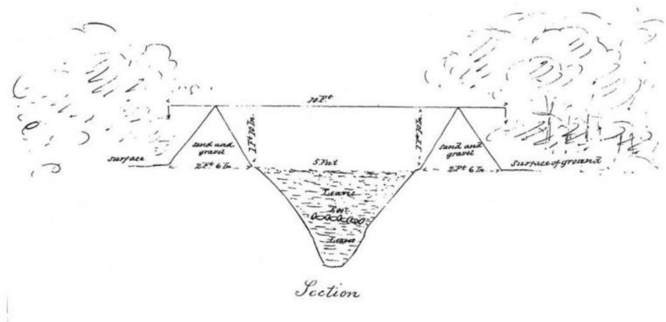
Abstract

This presentation will provide the results of a case study on the use of very high definition aerial photography to search for Malleefowl mounds at Mount Gibson Mining's Extension Hill mine in the midwest of Western Australia. An aerial survey captured approximately 7,000ha with a ground sample distance (GSD) was 4cm and horizontal accuracy of 0.08m. This very high definition photography was post-processed to produce stereo images that were searched using 3D Vision Glasses. The survey recorded 237 mounds in total. Of the 108 Malleefowl mounds (i.e. active and inactive) known from earlier on-ground surveys, 91 (84.3%) were recorded during the aerial searches. Mounds not found were all old and weathered, and many barely above ground level and some with vegetation growing in the centre of the crater. Approximately 11.4% of the mounds identified from the aerial photography that we considered 'confidently mounds', were false positives, and approximately 64.2% of the mounds identified in the aerial photography that were considered to be a 'potential mounds' were indeed mounds. Twenty-two of the newly discovered mounds were either recently active or currently being worked. The cost of searching for Malleefowl mounds using high definition aerial photography and subsequently examining these areas on the ground is appreciably cheaper than on-the-ground grid searches. Based on this case study the use of high definition aerial photography to search for Malleefowl mounds is cost effective.

Preface



The nest was described and sketched. *Leipoa ocellata*, *Malleefowl*. 'gnow, gnow-ow, knowow, Know-ow (sic), native pheasant'. Sanford's claim that the nest is 'probably new to naturalists, as far as the detail is concerned' is incorrect. Sanford was evidently unaware of Roe's description of October 1836, Gilbert's description of September 1842, and the sketch made in December 1842 by George Grey. The information collected by Gilbert and Grey was published by Gould in 1840. Handwritten annotation: "Thicket around Cowcowing, 12 miles N. of Poison Rock – and in thickets on the Murchison below the great bend."

Introduction

Malleefowl (*Leipoa ocellata*) are listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and as a Schedule 1 (Fauna that is rare or is likely to become extinct) under the WA Wildlife Conservation Act 1950. The geographic distribution of Malleefowl includes much of the southern half of Australia from the Great Dividing Range to the west coast (Blakers *et al.* 1984), and originally as far north as the Tanami Desert (Kimber 1985). Its geographic range has contracted in recent years, particularly in arid areas and around the periphery of its distribution (Benshemesh 2000). This is mostly attributed to clearing of habitat (Benshemesh 2007). Figure 1 shows the recorded location of Malleefowl in the Department of Parks and Wildlife NatureMap database since 2000.

Figure 1. Malleefowl records reported since 2000 in the Department of Parks and Wildlife NatureMap.

With the contraction of the geographic distribution of Malleefowl over the last century (Parsons *et al.* 2008), in Western Australia they are now mostly found in areas of dense vegetation as this provides the best protection against potential predators, with the fox (*Vulpes vulpes*) being one of the most significant predators (Priddel and Wheeler 1996, Priddel *et al.* 2007).

There are a multitude of mines and potential mines in the known current geographic distribution of Malleefowl (Figure 1). Prior to submitting a Native Vegetation Clearing Permit application or an Environmental Impact Assessment (EIA) for an expansion of an existing mine or a new development a Malleefowl survey is required. Surveying for this species is complicated by the fact that Malleefowl are relatively cryptic, mobile and spend a considerable amount of time during the day on the ground, making them difficult to find and count. The presence of active mounds is used as a proxy for their presence and relative abundance in a particular area (Brickhill 1985, Benshemesh and Emison 1996, Priddel and Wheeler 2003, 2005). Any area that could potentially support Malleefowl must be searched to determine presence/absence, and if present, indicate relative abundance and the location of all recently active mounds. A more cost-effective solution to assessing potential impacts of developments on Malleefowl is very relevant to the mining industry in Western Australia where this work was undertaken, and elsewhere in Australia.

Mount Gibson Mining Limited currently operated the Extension Hill Hematite Operation – an iron ore mine in the Mt Gibson Range, approximately 350km north east of Perth, where mining commenced in late 2010. A number of grid searches were conducted in the project area in 2004/2005 to establish baseline data, prior to the commencement of mining activities and regular monitoring of the known mounds is conducted, pursuant to the project Malleefowl Management Plan. In 2013, the requirement to re-search the project area was recognised and an effective and efficient methodology to achieve this using aerial imagery was developed.

Typical Malleefowl country in the mid-west of Western Australia.

Finding Malleefowl!

Existing survey techniques

The detection of active Malleefowl mounds in an area is generally used as a proxy for their presence (Brickhill 1985, Benshemesh and Emison 1996, Priddel and Wheeler 2003, 2005). This is a relevant proxy to confirm their presence in an area and provides a very rough estimate of the number of Malleefowl in the area, as it directly relates to the number of reproductively active birds in the area, which can be a useful indicator of survival of the local population, although the number of Malleefowl that breed each year varies which reduces its usefulness.

Traditionally, Malleefowl mounds have been located by grid searching suitable habitat on the ground. This means a group of people walk in a line, spaced at a distance so that they can see all of the land between two adjacent searchers. Typically, groups of four to ten people are used.

The National Manual for Malleefowl Monitoring (Hopkins ed.) suggested two search procedures: a) grid searching an area on foot, and b) aerial surveys. The Commonwealth Government Guidelines (Department of Sustainability, Environment, Water, Population and Communities 2010) suggested that in semi-arid and agricultural areas searches in suitable habitat for active mounds, tracks and sightings is the best method of detection. They also indicate that aerial surveys may be useful in extensive areas of relatively open habitat. These guidelines also indicate that in arid regions transect searches for footprints in sandy areas are most effective.

Benshemesh and Emison (1996) reported on the usefulness of airborne thermal scanners to identify active Malleefowl mounds. Their methodology successfully detected up to 36% of active mounds on cloudy mornings in mid-October and 25% of active mounds in mid-November and about 15% in mid-summer. They suggested that repeated scans would have substantially increased detection rates. They concluded that the methodology was feasible, cost-effective and capable of covering vast areas, although further development was required for broad-scale application. Since then the technology has improved, and may have the potential to record active mounds over a significant area (e.g. mine site, control and adjacent areas). Thompson and Thompson (2008) used more recent technology and explained how thermal imaging could be used to record active mounds. This more recent technology consisted of a tri-camera system of an ultraviolet sensitive camera, infrared long wave radiometric camera and a hi-res digital video camera working in unison. This system worked well when mounds were open and there was a significant heat differential between the centre of the mound and the adjacent area. Thermal imaging is only successful in identifying active mounds when they are open, and is not useful for inactive, and in particular, disused and old mounds.

Aerial photography

In this case study very high definition aerial photography was used to search an area around Mount Gibson Iron's Extension Hill mine in the mid-west of Western Australia (Figure 2). This area is central to the presence of Malleefowl in Western Australia (Figure 1) and had been searched on multiple occasions and the location of many of the Malleefowl mounds is known (ATA Environmental 2005). This example therefore provides an opportunity to compare the results from aerial photography with previous ground transect searches.

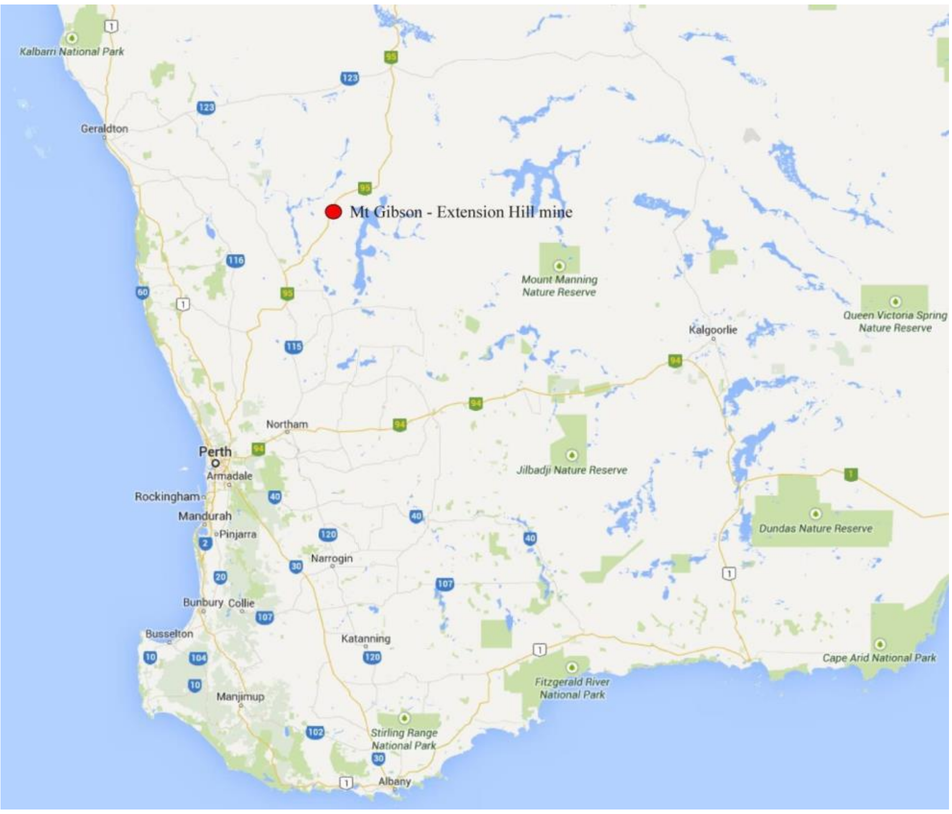


Figure 2. Location of the Extension Hill mine site and project area.

Methods

During 8-16 March 2004 a vertebrate fauna survey was undertaken around the proposed Extension Hill mine and areas were incidentally searched for Malleefowl and their mounds (ATA Environmental 2005). Then during 20-24 September 2004 and 13-21 January 2005 eight people walked parallel lines through an area of vegetation (Figure 3) searching for Malleefowl and Malleefowl mounds. The distance between each observer varied depending on vegetation density but ranged between 5 and 50m. Malleefowl mounds in open areas were easily located, however; those in dense vegetation were often cryptic and difficult to see, particularly those that were weathered over a period of many years. The status (i.e. active or inactive) and a GPS location were recorded for each Malleefowl mound.

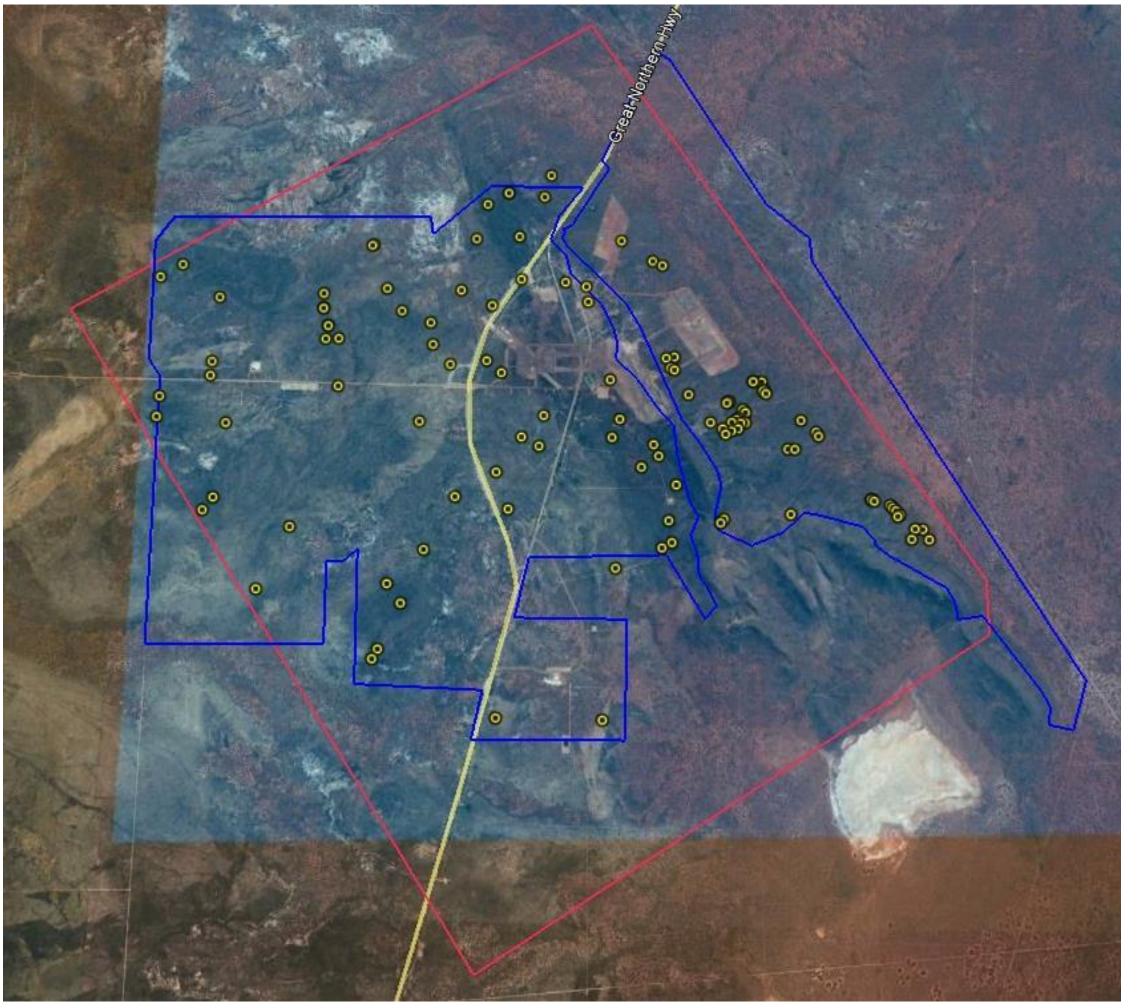


Figure 3. On ground and aerial photography search areas.
NOTE: Blue lines enclose on the ground search areas during 2004-05, red lines enclose the 2013 aerial search area and yellow dots are mounds known from on-ground searches.

In October 2013 Aerometrex flew an area of approximately 7x10km (7,014ha; Figure 3) using a Microsoft Ultracam D large format camera mounted in a Shrike Aero Commander 500 to capture the area. Aerometrex used a forward overlap of 70% and a side overlap of 60% to provide stereo imagery suitable for searching in 3D on the computer. Cross strips were added to the flight paths to aid in determining vertical accuracy (Figure 4). The resolution of the imagery was 4cm GSD (ground sample distance = pixel size).

Figure 4. Flight path with 70% front to back overlap and 60% sidelap.

Aerial photography was then post-processed and aerotriangulated with photogrammetric block adjustment to provide images able to be searched on a computer and then loaded and examined in DTMaster (INPHO). Stereo images were examined using NVIDIA 3D Vision Glasses. Drs Graham and Scott Thompson of Terrestrial Ecosystems spent two days in the Aerometrex laboratory examining the aerial photography and developing a search procedure for detecting Malleefowl mounds. The location of mounds known from previous on-the-ground searches were examined so that a 'search image' of a mound could be developed by the viewer, then areas were searched that contained mounds to determine whether they could be found. This procedure was repeated on multiple occasions using both black and white and colour aerial photography, and various distances above the ground (i.e. scaling).

Coloured images were superior to black and white images. Lines running north-south that were 40m apart on the ground were overlain on the aerial photography, the height above the ground was then adjusted so that these lines were the width of a 23" screen providing a scaling of 1:80. The aerial images were then systematically moved vertically down the screen to search each 40m wide strip until the entire 7,014ha had been searched (Figure 5). These parallel lines ensured the aerial photography was moved vertically and all areas were searched.

All potential identified mounds were rated as: 'confident it was a mound' and 'potentially a mound'.

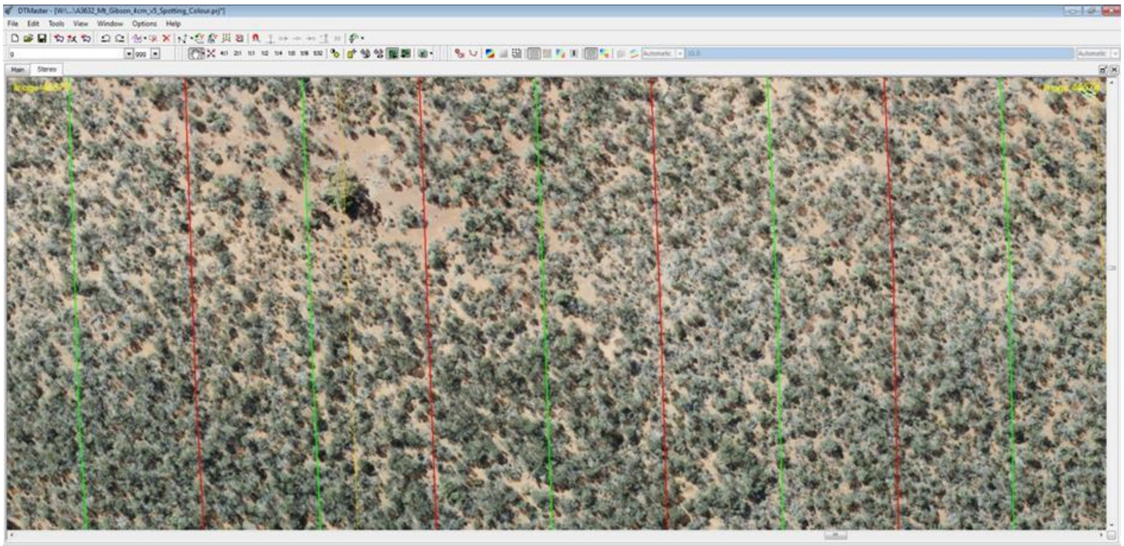


Figure 5. Screen grab of the parallel lines developed for the computer search.

Results

Habitat

Areas searched for Malleefowl mounds included woodlands, mallee and sand plain vegetation communities. Bennett Environmental Consulting (2000) identified five woodland communities, four mallee communities, 12 thicket communities and two heath communities within the Mt Gibson mining leases. Typically, the area below the banded ironstone formation (BIF) was *Acacia* thickets with emergent *Eucalyptus* spp. and *Callitris glaucophylla*. The most common *Eucalyptus* sp. was *E. loxophleba* (York Gum) and *E. brachycorys* which grew on the flat and along the gullies of the hillsides. *Callitris glaucophylla* was the dominant tree on the sandy soil but was often associated with *Ecdeicolea monostachya*. Vegetation on the top of the BIFs varied considerably and the dominant species on the hill slopes were *Allocasuarina acutivalvis*, *Melaleuca nematophylla* and *Grevillea obliquistigma*.

Coverage of on-ground and aerial searches

Sections of the areas searched in 2004-05 were outside the area covered by the aerial photography and parts of the area covered by the aerial photograph were not searched on the ground in 2004-05 (Figure 3). However, all of the Malleefowl mounds located during on-ground searches in 2004-05 were within the aerial search area. Some of the Malleefowl mounds identified in 2004-05 have been subsequently cleared for mining infrastructure and the mining pit.

Mounds located by aerial survey

All 24 mounds known to have been recently active (i.e. they were found or checked in March/September 2005, November 2008, January 2010, November 2010 and December 2012) were found in the search of the aerial photography. In addition, five more active mounds that were not recorded in ATA Environmental (2005) and subsequent surveys were recorded. Of the 108 mounds known from previous on ground searches, 94 (87 %) were recorded during searches of the aerial photography. The 14 mounds not identified by aerial photography were old and weathered, and many were barely above ground level and some had vegetation growing in the crater. The average height of mounds not found was 7.64 cm (se ±1.460; range 1-20 cm). The average height all mounds measured was 26.27 cm (se ±1.952; range 1-110cm).

Mount Gibson Mining has completed ground truthing the mounds by searching the GPS positions provided on the ground and photographing the located mounds. Of the 207 mounds recorded as 'confident mounds' during the search of the aerial photography, 94 were previously known and 100 were previously unrecorded mounds; thus 93.7% of the areas recorded as 'confident mounds' were actual mounds and there were 6.3% false positives. Most false positives were small cleared areas that had a substrate of pebbles or rock in an area that was surrounded by vegetation, or were piles of sand/organic matter created by machinery. Of the 123 areas recorded as ‘potential mounds’, 80 (65%) were actual mounds and 35% were false positives.

Mt Gibson Extension Hill Project	**2004–12 Ground Searches**	**2013 Aerial Search**
Area searched	4941 ha	7014 ha
Previous Active mounds found	24	24+5 = 29
Number of previously known mounds	108	94 (87%)
Previously unrecorded mounds		65
Average height of mounds measured		26.27 cm
Average height of mounds not found		7.64 cm
Aerial photography search ratings*		
Total number of ‘confident’ mounds identified		207
Number of ‘confident’ mounds confirmed by ground truthing and comparison with existing data		194 (93.7%)
Total number of ‘potential’ mounds identified		123
Number of ‘potential’ mounds confirmed by ground truthing and comparison with existing data		80 (65%)
Costs		
Cost – paying all the costs	$21.36/ha	$9.55/ha
Cost – using aerial photography flown for another purpose		$6.70/ha

**All areas identified as possible Malleefowl mounds were rated as either ‘confident’ (i.e. it was a mound) or ‘potential’ (i.e. it was possibly a mound).*

Aerial photography search protocol

The two days spent developing an effective protocol for searching the aerial photography resulted in a methodology that was demonstrated to be effective. We took a very conservative approach and tended to record false positives instead of failing to record a mound. The task of searching aerial photography can be tedious for most people, with the consequence that many people will lose concentration and then miss recording Malleefowl mounds. It is our experience that this process requires a particular type of person to maintain the required level of concentration for an extended period in order that all mounds are located.

Innovation

This is the first occasion where high definition aerial photography has been used to search for Malleefowl mounds. Data provided above indicate that this method is able to record all recently active mounds and a majority of the inactive mounds. This new and innovative methodology is able to achieve the objectives for an EIA, specifically it can determine presence/absence, and if present, indicate relative abundance and the location of all recently active mounds.

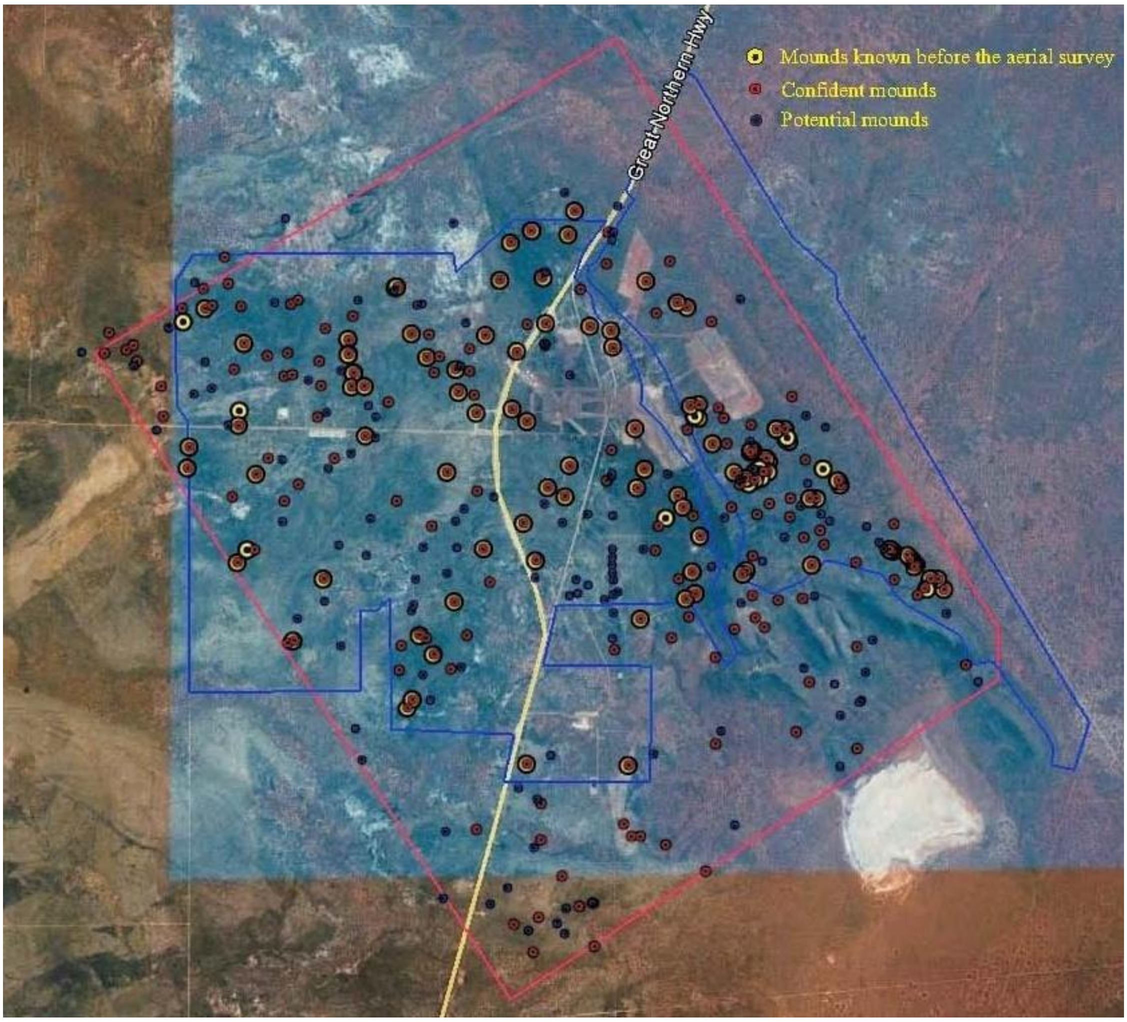


Figure 6. Malleefowl mounds recorded during on-ground and searches of aerial photography. Areas bounded by blue lines were searched on-ground in 2004-2005 and the area bounded by red lines was searched using aerial photography in 2013. Yellow circles with a black centre are known mounds from the on- ground searches (see Figure 3), red dots with a black centre are areas recorded as 'confident mounds' and dark blue dots are areas recorded as 'potential mounds' during a search of the aerial photography).

Costs

Cost savings are a significant benefit of the application of the technology. In the 2004-05 search approximately 100 person days were spent conducting ground searches for Malleefowl mounds in an area of interest of 4,941 hectares (ha) at a cost of approximately $105,000 or $21.36 per ha (calculated using 2014 figures) with the mine providing all food and accommodation. In comparison, the 2013-14 search, took 90 hours to search 7,014 ha of aerial photography. The total cost for the capture and the searching of the aerial photography was approximately $47,000 plus $20,000 if environmental consultants were engaged to ground-truth the identified mounds giving a total of $67,000 or $9.55 per ha.

There is an additional significant saving if the environment survey can be combined with aerial photography flown for another purpose such as end of quarter volumes with only one plane mobilisation and shared triangulation costs. Reporting costs have been excluded.

To put these costs into perspective cheaper and better methods of searching for Malleefowl mounds have been explored by Brickhill (1985), Benshemesh and Emison (1996) and Thompson and Thompson (2008). Brickhill (1985) undertook an aerial survey using an Aerospatiale Gazelle 341G helicopter flown at about 76m above ground at about 90kmh-1 over 20,800 ha of the Round Hill Nature Reserve in New South Wales and the adjoining land. Search transects were about 400m apart followed by a similar pattern at right angles. The search area was relatively flat country with mallee growing to 5-6m high. Most of the surveyed area had been burnt in 1957 and the aerial surveys were undertaken between August 1977 and January 1984. Four of the nine surveys were flown in August, the time when active mounds are piled high with litter in preparation for breeding and where therefore likely to be more visible. Brickhill (1985) concluded that even with a relatively slow flying speed, the ground survey showed that many transects were necessary before half of the mounds were found.

Benshemesh and Emison (1996) examined the feasibility of using thermal scanning during aerial surveys with subsequent ground-truthing to detect active Malleefowl mounds. Four areas were flown in Victoria with sites between 300 and 500 ha in size. These four areas contained 39 active mounds during the trial. Survey sites were characterised by a relatively thick canopy of mallee and variable understorey of shrubs. A Daedalus 1240/60 thermal scanner mounted in a Queenair plane was flown at about 250kmh^{-1} at an altitude of 305m above ground level. The thermal scanning technique recorded between 14 and 60% of active mounds. Thompson and Thompson (2008) examined the possible use of a tri-camera system (i.e. ultraviolet sensitive camera, infrared long wave radiometric camera and a hi-resolution digital video camera working in unison) to detect active mounds, but this approach was also limited to mounds that were open during the survey. The use of thermal imaging is limited to active mounds and when mounds are open (i.e. when the centre of the mound had a higher thermal footprint than the surrounds) when surveyed.

Malleefowl frequently use already constructed mounds instead of building a new mound each year (Priddel and Wheeler 2003). In the mid-west breeding activity is influenced by winter rainfall (Firth 1959) and in the occasional years when winter rainfall is very low, breeding activity can be non-existent or very low. Insufficient rain results in the organic matter in the centre of the mound not decomposing at a rate sufficient to generate enough heat to incubate the eggs (Firth 1956). The use of thermal imagery is therefore limited to identifying active mounds during the breeding season and is predicated on appropriate decomposition rates, heat generated in the mound and therefore the frequency it is opened. Thermal imagery is therefore not a suitable methodology for searching for Malleefowl mounds for the purposes of an EIA.

Safety and Convenience

Historically, habitat potentially supporting Malleefowl is grid searched by environmental consultants in areas for future development. In relatively open areas, searchers can be up to 50m apart, but in areas of dense vegetation the distance between searchers can be reduced to 5m. It is the experience of Terrestrial Ecosystems, the environmental consultant on the Mount Gibson project that Malleefowl in the mid-west and the goldfields of Western Australia are more likely to be found in areas of dense vegetation. Grid searching dense vegetation is difficult, time consuming and expensive. Because of the denseness of the vegetation, searchers are continually protecting their faces and eyes from branches, twigs and leaves as they push their way through the vegetation. Often the head is lowered to force your way through particular thickets and mounds can be missed in these searches. Unused mounds progressively weather over many years, with very old mounds often having a bare circular shape perhaps with a shallow depression in the centre. Old weathered mounds can also support vegetation growth with the consequence that they are easily missed in searches.

The task of searching aerial photography can be extremely tedious for many people, with the consequence that they will lose concentration and then miss recording Malleefowl mounds. The Aerometrex innovation largely minimises the risk of human error/lack of concentration experienced in photo-interpretation by allowing for the data to be methodically searched by any number of people over any period of time. However there is still an advantage in using skilled and experienced photo-interpreters who are accustomed to maintaining the required level of concentration for an extended period in order that all mounds are located.

Conclusion

This innovation in searching very high-definition aerial photography is able to record all recently active mounds. About 13% of all mounds were not detected, but most of these were old and weathered and unlikely to provide useful information in the context of an EIA, other than the area once supported Malleefowl. A minor drawback of this approach is the number of false positives recorded.

Approximately 6% of areas that were rated as a confident mound were not mounds, and about 65% of the areas rated as 'potential mounds' were actually a mound. In almost all cases a false positive was a cleared area 3 - 5m wide in a vegetated area that often contained gravel or rock substrate, a substrate of a different colour to the surrounds or another human disturbance.

It is therefore important that all possible mounds are recorded in the search of the aerial photography, and each potential mound identified is subsequently ground-truthed. Ground truthing is necessary to determine whether each area recorded is an actual mound, whether the mound has been recently used and to collect other data in accordance with the National Malleefowl monitoring protocol.

Based on this first example, searching high-definition aerial photography for Malleefowl is an effective method of recording recently used Malleefowl mounds in relatively densely vegetated areas on sand plain and thickets in undulating areas.

The cost of aerial searches and the subsequent ground-truthing of each of the mounds located is cheaper than grid searching the entire area. If there is another purpose for preparing the aerial photography and this can be used to off-set the cost, then the cost of aerial searches for Malleefowl mounds is appreciably cheaper than on-the-ground grid searching. Because of the cost of aircraft mobilization and post-data analysis, there are economies of scale that can further reduce the costs.

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