Remote Sensing of Environment 211 (2018) 196–203

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Using satellite imagery to assess the distribution and abundance of southern hairy-nosed wombats (*Lasiorhinus latifrons*)

Michael J. Swinbourne*, David A. Taggart, Alyce M. Swinbourne, Megan Lewis, Bertram Ostendorf

University of Adelaide, School of Biological Sciences, Waite Campus, Adelaide 5064, Australia

ARTICLE INFO

Keywords:
Burrowing
Distribution
Satellite imagery
Limitations

ABSTRACT

Monitoring of the southern hairy-nosed wombat (*Lasiorhinus latifrons*) population via satellite imagery was first proposed in 1980. However, the imagery that was available at that time was inadequate for the task as it did not permit the direct observation and counting of warrens. Since then, advances in the availability and resolution of satellite imagery mean that it is now possible to map the entire distribution of southern hairy-nosed wombats and to estimate their population abundance using very high-resolution imagery (≤ 1.0 m). However, other landscape features such as rabbit warrens can make the identification of wombat warrens problematic, and not all wombat warrens are visible, even in the best resolution imagery. By comparing data that we collected from field surveys conducted between May 2015 – May 2017 with satellite imagery we could identify that many wombat warrens have visible trails linking warrens with each other. Whilst this allowed us to differentiate between wombat and rabbit warrens in most circumstances, the lack of visible trails in some instances highlighted the need for ground truthing surveys to be conducted as part of any broad scale wombat population survey. Based on the difference between the number of warrens that we marked during our ground surveys with the number which were visible in the satellite imagery, we calculated a range of indices which can be used to correct future broad-scale population estimates based on satellite imagery, to account for warrens which may be obscured by vegetation and other confounding factors.

1. Introduction

The remote sensing of wildlife species using satellites has undergone significant development since their use was first mooted in the 1960s (NAS, 1969; Buechner et al., 1971). Early uses were largely restricted to the collection of radio-tracking and telemetry data from tagged animals (Fancy et al., 1988). However, by the 1980s satellites were also being used to map potential wildlife habitat, which could then be correlated with populations of animals (Saxon, 1983; De Wulf et al., 1988; Miller and Conroy, 1990).

One of the first uses of satellites to observe animals and their effects on the ecosystem, rather than using telemetry data, was undertaken in the late 1970s (Löffler and Margules, 1980). The study involved using Landsat imagery to map the warrens of southern hairy-nosed wombats (*Lasiorhinus latifrons*) on the Nullarbor Plains in South Australia by detecting the grazing damage that wombats caused (grazing "halos") around large clusters of warrens. The southern hairy-nosed wombat was thought to be an ideal candidate species for satellite monitoring. They generally inhabit open landscapes with little to no canopy cover, so their warrens can be readily visible from above. However, the relatively poor resolution of the imagery which was available in the 1970s meant that even the largest warrens could not be directly detected. Consequently, unless grazing halos were present around warrens in all locations where wombats could be found – something which ground surveys showed was not the case (Tiver, 1981) – the technique would have had only a limited application.

Southern hairy-nosed wombats are one of the largest burrowing species in the world, growing up to a metre in length and weighing up to 40 kg. They inhabit a fragmented distribution across the semi-arid regions of south-central South Australia and the south-eastern corner of Western Australia (Fig. 1). Southern hairy-nosed wombats construct large warrens which can be up to 1 ha in area and contain up to 70 burrow entrances (Taggart and Temple-Smith, 2008), and each wombat uses multiple warrens within a relatively small home range (Finlayson et al., 2005; Walker et al., 2007). The burrowing and grazing habits of wombats can cause significant damage to agricultural land and infrastructure (Stott, 1998), and dealing with their impacts is one of the major concerns expressed by farmers in regions where wombats are

* Corresponding author.
E-mail address: michael.swinbourne@adelaide.edu.au (M.J. Swinbourne).

https://doi.org/10.1016/j.rse.2018.04.017
Received 5 November 2017; Received in revised form 5 April 2018; Accepted 8 April 2018

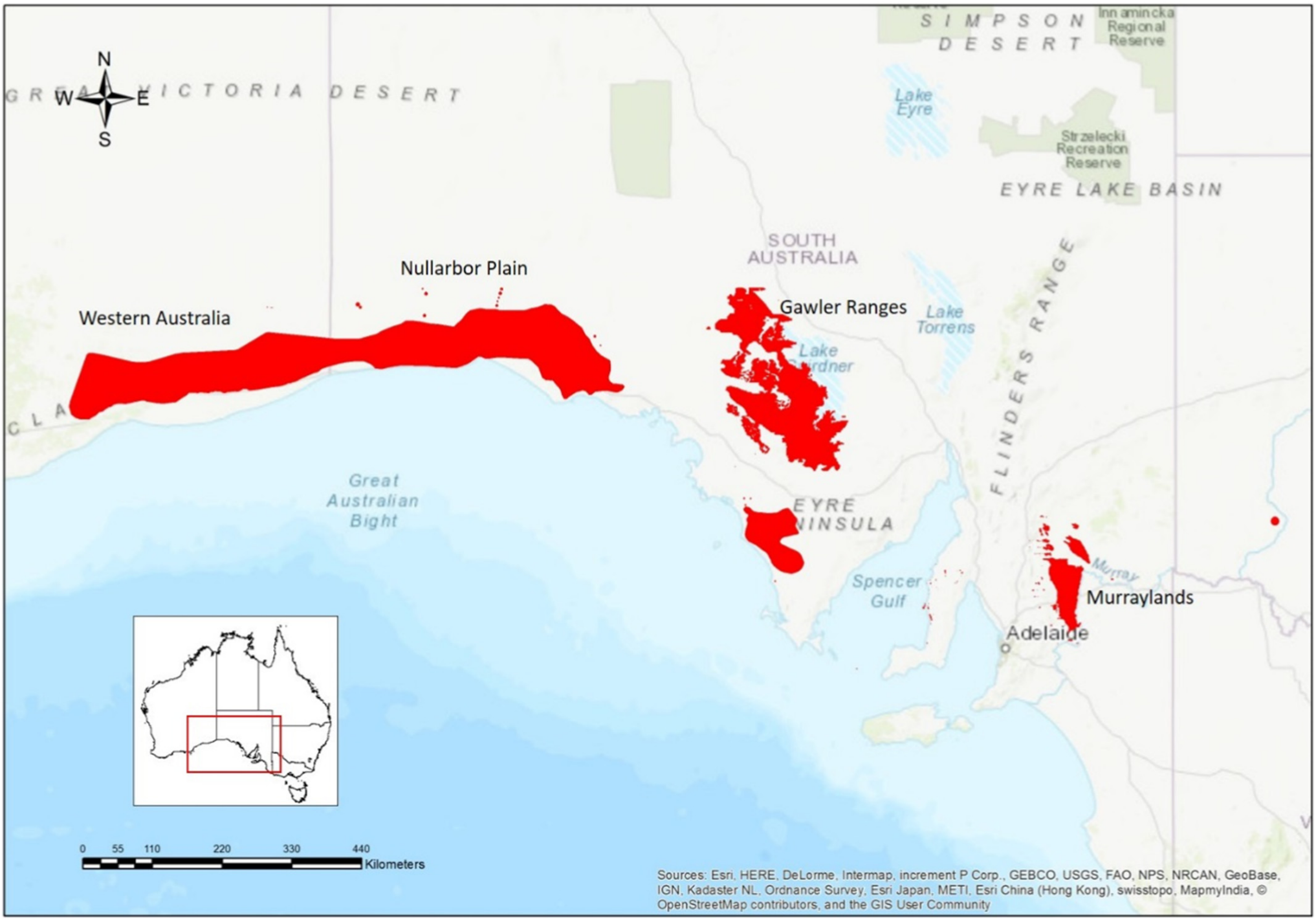

Fig. 1. Current distribution of southern hairy-nosed wombats. Using the techniques described in this paper, we have been able to update the extant distribution maps (Wells, 2015), which have not been revised in some areas for over 30 years. In that time, the population in the Gawler Ranges region (centre of image) has expanded markedly, and we have mapped the full extent of the previously undescribed wombat population in Western Australia.

present (Sparrow et al., 2011; Taggart and Ostendorf, 2012). These regions are also predicted to experience increased temperature and decreased rainfall due to anthropogenic climate change (Suppiah et al., 2006), and consequently southern hairy-nosed wombats are identified as a species at risk (Marshall et al., 2017). Therefore, an accurate understanding of wombat distribution and abundance is essential for effective management of this species. Unfortunately, their fossorial and nocturnal nature makes studying wombats difficult, and estimating their abundance relies on a proxy measure of counting the number of burrows which are currently being used by wombats (active burrows) (Tiver, 1980, 1981).

Since the 1980s, the resolution and availability of satellite imagery has increased dramatically. Commercial organisations now offer worldwide coverage of up-to-date, high-resolution imagery (< 1.0 m) for sale, whilst on-line applications such as Google Earth and Bing Maps freely provide almost global-wide coverage of imagery which was collected within the last few weeks or months. Satellite imagery can now be used for a range of wildlife management applications, from monitoring populations of a fossorial species at a local scale (black-tailed prairie dogs, *Cynomys ludovicianus*; (Sidle et al., 2002)), to directly detecting individuals in a bird colony (albatross, *Diomedea* spp.; (Fretwell et al., 2017)). Given recent increases in technology and availability of imagery, it is now appropriate to revisit the potential for satellite imagery to be used as a tool to help monitor and manage the southern hairy-nosed wombat population.

2. Method

During field surveys conducted between May 2015 and May 2017 across three of the four main southern hairy-nosed wombat sub-populations in south eastern Western Australia and the Nullarbor Plains and Gawler Ranges of South Australia, we collected data on wombat warrens in each region (Fig. 1). Warren positions were marked with a handheld GPS (Garmin eTrex 10) and warren sizes were measured by pacing across the diagonal axis. The total number of burrows and the number of active burrows were also recorded. Burrows were assessed as active if there were signs of recent digging (within the past few days), wombat footprints, fresh scats, or visual or audible signs of a wombat in the burrow. Warrens were divided into four size classes based on their diameter: small (1–5 m); medium (> 5–15 m); large (> 15–35 m); and extra-large (> 35 m) (Tiver, 1980, 1981; McGregor and Wells, 1998; Taggart and Ostendorf, 2012).

The warren data was converted to KML format and uploaded onto Google Earth Engine and the SAS·Planet (version 160707) satellite image and map viewing programs. The images were initially examined to determine any features of wombat warrens which would enable them to be positively identified from other landscape features such as rabbit warrens.

We examined the imagery to determine whether the warrens marked during the ground survey were visible, and compared the total number of warrens in each size class in the uploaded data with the number of these warrens which we could see in the highest resolution satellite imagery in both open grassland and scrubland. We defined