What faecal pellet surveys can and can't reveal about the ecology of koalas *Phascolarctos cinereus* II: an interim response to Woosnam – Merchez *et al*. (2013).

Stephen Phillips & John Callaghan
Biolink Ecological Consultants
PO Box 3196 Uki NSW 2484
www.biolink.com.au

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Biolink Ecological Consultants
PO Box 3196 Uki NSW 2484, Australia.
(Corresponding author: Stephen Phillips, steve@biolink.com.au)

Preamble

The information and material detailed in this report essentially reflects the contents of a letter sent by us to the editors of *Australian Zoologist* (AZ) following publication of a paper by Olivia Woosnam – Merchez and colleagues in Vol. 36(2) of *Australian Zoologist*. Rather than publishing our initial response in letter format, AZ editors suggested that the information we had provided be used as the basis for one or more publications in rebuttal, a process that we are now working on in collaboration with colleagues. While this happens however and because the processes leading to publication can be protracted, we considered that the core elements of our response should be known and available to the many practitioners and/or organizations that rely on faecal pellet-based field survey techniques to inform koala conservation and management programs; hence this interim response.

The response

While claiming to present a new approach for detecting koalas, much of the content of Woosnam – Merchez *et al*. (2013) attempts a critique of the *Spot Assessment Technique* (SAT) of Phillips and Callaghan (2011). Given our respective roles in developing and applying the SAT since its inception in 1994, we feel obligated to respond. To this end and having now discussed Woosnam – Merchez *et al*. (2013) with colleagues and SAT practitioners, we are confident in a collective view that the authors do not understand key elements of the approach while also being unaware of the extent of its contribution to knowledge of koala ecology and management across the species' range. Most importantly, Woosnam – Mercez *et al*. (2013) fails in it's central theme of delivering a useful alternative.

As detailed in Table 1 of Phillips and Callaghan (2011) the SAT was developed and refined on the basis of a dataset comprising over 10,000 trees from more than 400 field sites assessed during the course of Koala Habitat Atlas mapping projects from representative habitats across the geographic range of the koala. The SAT has now become an important and widely used tool for confirming the presence and distribution of koalas within study sites and for gauging aspects of habitat use by way of faecal pellet-based activity levels. In contrast Woosnam – Merchez *et al*. (2013) do not present any data to support their concerns about the SAT, nor is any data offered to support the authors' claim that the Koala Rapid Assessment Methodology (KRAM) they propose as an alternative is more effective at locating koala faecal pellets. The absence of any supporting data relegates the KRAM to little more than a set of principles by which to sample koala habitat, most of which are already embedded in the SAT approach.

In the third paragraph of their *Introduction*, Woosnam – Merchez *et al*. (2013) argue against the use of appropriately collected and interpreted faecal pellet data (as might be derived from a SAT site) to provide evidence of tree use by koalas. Specifically, they claim that:

"*…pellet deposition under trees has been purported by some authors to provide evidence of browse consumption, but has been clearly shown to be an unreliable indicator of diet or even tree preference (Ellis et al. 2002, Matthews et al. 2007*)".

The preceding assertion is a misleading claim that disregards other peer-reviewed studies. In fact, the work of Phillips *et al*.

(2000) and Phillips and Callaghan (2000) clearly demonstrated that such outcomes are possible, the former isolating Swamp Mahogany *Eucalyptus robusta* and Parramatta Red Gum *E. paramattensis* as two tree species (from amongst a suite of others) most preferred by koalas on Quaternary sand deposits in the Port Stephens LGA, the latter identifying Grey Gum *E. punctata* and Blue-leaved Stringybark *E. agglomerata* as preferred food trees in the Campbelltown LGA. Important outcomes in both studies were that tree species not previously recognised as preferred by koalas (i.e. *E. parramattensis* and *E. agglomerata* respectively) were identified through analyses of data collected using SAT protocols, most notably the presence/absence of koala faecal pellets within a 100cm search area around the base of trees. In the case of Phillips *et al.* (2000) and contrary to the claims of Woosnam – Merchez *et al.* (2013), our findings were supported (not repudiated) by the work of Mathews *et al.* (2007) who reported that while over half of daytime koala sightings for Port Stephens on the central coast of New South Wales involved either *E. robusta* or Smooth-barked Apple *Angophora costata*, at night time *E. robusta* and *E. parramattensis* were preferred by koalas for feeding purposes. The work of Phillips and Callaghan (2000) was also the first to identify and promote – solely by way of SAT data - the importance of *E. agglomerata* as a preferred food tree for koalas in the Campbelltown area. Importantly, Woosnam – Merchez *et al.* (2013) failed to acknowledge independent verification of this result by Sluiter *et al.* (2002) who used radio-tracking data and analysis of leaf cuticles in koala faecal pellets to test the veracity of our findings. The claims by Woosnam – Merchez *et al.* (2013) that the methodological basis for faecal pellet surveys has not been well established in the literature is also untrue, as demonstrated by peer reviewed publications such as Phillips *et al.* (2000), Phillips and Callaghan (2000), McAlpine *et al*. (2006a, 2006b, 2008), Callaghan *et al.* (2011) and Lunney *et al.* (2000).

Selective referencing along with a misunderstanding and/or misrepresentation of the work of others detracts from the legitimacy of Woosnam – Merchez *et al.* (2013) as a meaningful contribution to the process of koala habitat assessment. Can faecal pellet depositional data reveal details relating to habitat occupancy and the tree species most preferred by koalas? Yes, it can and does so very well, subject to an appropriately designed methodology governing the collection, analyses and interpretation of the associated data.

Woosnam – Merchez *et al.* (2013) then proceed to postulate a number of weaknesses of the SAT that supposedly go to matters of randomness, replication, reproducibility and limitations of the 100cm search area. The sections that follow demonstrate that these concerns similarly lack substance and supporting data.

On randomness

One of the underlying motivations in designing the SAT was to be able to inform potential conflicts between development interests and koala conservation by being able to answer the following question(s): What is the ecological significance of a) koala faecal pellets being found beneath a tree and/or b) a koala located in a tree within or near to an area that is otherwise proposed for development? These seem like reasonable considerations that arise during the course of ecological assessments and we are comfortable that they can be answered by a single SAT assessment, more so if interpreted in the context of the activity level thresholds in Table 2 of Phillips and Callaghan (2011). Regardless, Woosnam-Merchez *et al*. (2013) claim the SAT to be flawed because of the potential for bias in the selection of a focal tree which they consider violates the principle for randomness. The last of the 3 SAT site selection criteria appears to be the main bone of contention here, specifically "*any other tree known or considered to be potentially important to* (koalas), *or of interest for other assessment purposes*". There are two elements to this criterion, the first of which (…*any other tree* *known*…) introduces the Bayesian concept of "priors" by allowing existing knowledge to be applied such that if there is a reliable basis for considering a particular tree species to be important for koalas in a given area, then a tree of this species could be a focus for koala activity and hence a good place to start a SAT search. Contrary to the suggestions of Woosnam-Merchez *et al*. (2013), the SAT does not avoid areas that do not contain preferred koala trees, nor does it dismiss such areas and/or assume they are unlikely to be utilized by koalas. Once practitioners arrive at a predetermined survey site and select an initial tree to act as the centre tree for a SAT assessment, it makes sense to select a known preferred koala food tree species if one is available, the alternative being any other tree species if not. With respect to fine-scale replication of central tree selection protocols for SAT sites by different practitioners, generally accepted lists of preferred koala food trees are available for all regions that support koalas.

The second element of this criterion (… *or of interest for* …) is there to accommodate large-scale SAT assessment programs such as those that are increasingly underpinning planning decisions at the landscape (e.g. Local Government Area) scale. In order to produce an activity-informed (meta-) population distribution model such as that illustrated in Figure 1, the field survey component employs a grid-based approach with potential field sites generated at regular intervals across the landscape. Where this is not a requirement a randomized and stratified approach to sampling can be undertaken. This latter approach is more orthodox but appears to rest easier with Woosnam-Merchez *et al*. (2013), notwithstanding that it will limit outcomes in terms of an ability to contextualize koala activity across the assessment landscape. In any case, locations for SAT sites are typically generated by use of either a grid overlay or by random stratification (if features such as specific vegetation communities and/or soil landscapes are to be targeted). Coordinates for such sites are uploaded into hand held GPS devices whereupon SAT practitioners navigate as close as possible to the site coordinates and then simply select a suitable tree as the point around which the SAT can be focused (i.e. the centre tree) and which also falls within the margin of error of the GPS. In our view there is nothing wrong with this approach which (on top of the original site selection process) more than satisfies the element of randomness.

On replication and reproducibility

In the case of modern landscape-scale SAT assessments, conforming landscape units of vegetation, soil and disturbance history are invariably replicated through the assessment process and an ability to *post-hoc* partition data sets based on these and other variables can form a key component of analyses. As long as it is clearly marked and the coordinates accurately recorded, there are few difficulties in navigating back to SAT sites at a later date, contrary to the suggestions of Woosnam – Merchez *et al*. (2013). Indeed, when sites are to be revisited for monitoring purposes, a more permanent marker can be used to denote the centre point for the SAT site once the GPS indicates arrival at the specified coordinates. Indeed, the SAT has proven to be very adept at monitoring koala activity over time, a process enabled by flagging or pegging the centre tree in order to relocate it over subsequent visits. As detailed in Figure 2, the application of SAT methodology to long-term koala population monitoring has already informed the success of translocation programs. Elsewhere, monitoring over longer (4 - 5 year) time frames has provided spectacular evidence of koala recovery in areas such as the southeastern forests of New South Wales where practitioners remain independent and thus lack any site placement idiosyncrasies or 'arbitrary preconceptions' that Woosnam – Merchez *et al*. (2013) imply may be unique to us.

On the 100cm radial search area

The SAT is a multi-faceted koala habitat sampling tool, which when applied either

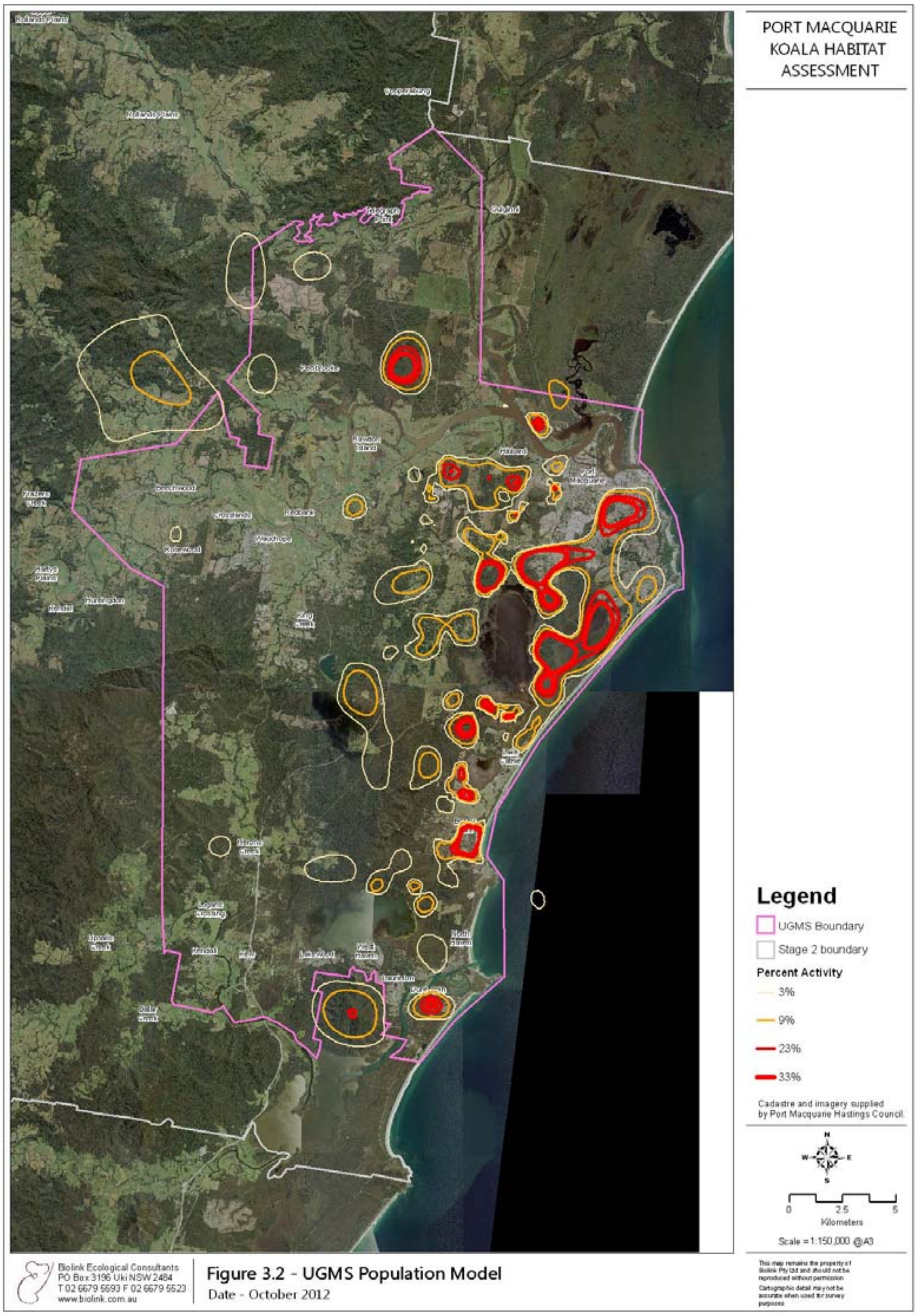

Figure 1. Distribution of koala activity across a 36,860ha area identified for purposes of the NSW Government's Urban Growth Management Strategy (UGMS) for the Port Macquarie Hastings Local Government Area on the mid north coast of NSW. Modelling utilized SAT data collected at 1km, 500 and 250m intervals, thereafter interpolated using the splining and contouring tools of ArcGIS' Spatial Analyst extension. Modeled boundaries such as those above and which are based on activity thresholds specified in Table 2 of Phillips and Callaghan (2011) effectively capture 100% of the breeding koala population in a given area (Source report: Phillips, S. 2013. *Port Macquarie – Hastings Koala Habitat and Population Assessment*. Final Report to Port Macquarie Hastings Council. Biolink Ecological Consultants).

Figure 2. Changes in koala activity over a 2 year period from August, 2011 (top image) through to August 2013 (bottom image). Koala activity model results from interpolation of koala activity arising from SAT data collected at 18 monitoring points, the precise locations of which were identified by permanent markers that were relocated on an annual basis using GPS navigation. 3%, 10% & 13% activity contour intervals are illustrated (Source report: Phillips, S. 2013. *Translocation of koalas from habitat in the path of the approved Oxley Highway Deviation to the Lake Innes State Conservation Area*. Final (Stage 5) Monitoring Report to NSW Transport, Roads and Maritime Services. Biolink Ecological Consultants).

on the basis of a random, stratified approach or uniformly across the landscape by way of a regularised grid, capably answers critical questions associated with the distribution and abundance of koalas such as:

(i) Koala presence/absence (*i.e.* Occupancy) data – determined by recording one or more koala faecal pellets at a site;
(ii) Koala Activity data – measured by the proportion of trees beneath which koala pellets are recorded within the 100cm search catchment (as a function of the total number of trees sampled, generally standardized at 30); and
(iii) Koala food tree preference data, the extent to which (through a process of replicated sampling and pooling of pseudo-replicates) analysis of SAT data can be used to inform local knowledge regarding tree species selection by koalas; and
(iv) Koala density data – while not directly associated with the 100cm search area, ongoing refinement of the SAT approach now includes a fixed 25m radius search for koalas at each field site. This value adding can now be shown to reliably estimate koala density when applied at regularly spaced intervals across the landscape and so enables robust population estimates to be provided as a direct outcome of the field survey process. Transect searches (*sensu* Dique *et al.* 2003) can also be incorporated into the survey design so as to increase the probability of finding koalas. At the landscape scale with an appropriate number of replicates the two techniques provide statistically identical results (Phillips *et al.* 2007).

Despite the fact that the efficacy of the 100cm search area has been repeatedly validated in the peer-reviewed literature, Woosnam – Merchez *et al*. (2013) remain concerned about the 50% faecal pellet detection probability issue, perceiving it (without any supporting data we note) to be a failing and not a strength. In the context of points (i) and (ii) above, we remain mindful that using trees as *defacto* sampling points within a field site is akin to throwing 30 random quadrats around the same area, while further enhancing the overall reproducibility of the technique. Aside from the fact that koala faecal pellets most commonly occur close to the base of trees (and thus this is a good place to look for them), the greatest value of the 50% detection probability outcome relates to its already proven values in facilitating the process of identifying koala food tree preferences. In terms of probability theory it is useful to know that when a sample proportion of a given tree species "*x*" containing one or more koala faecal pellets within the prescribed 100cm radial search area is approximately 0.5 (50%), then the true proportion of trees that are likely to have been used by koalas is 100% (Appendix in Phillips & Callaghan (2011) refers). Hence, when a properly designed field survey returns such a result we can conclude with confidence that the tree species in question is important and so the concept of a primary food tree representing a finite resource for free-ranging koalas can be demonstrated (Phillips *et al.* 2000).

Woosnam – Merchez *et al*. (2013) argue that previous studies involving a radial search catchment for pellets around the base of trees may diminish the chances of pellet detection. One of the strengths of the SAT is that it relies upon detection of a single koala pellet in order to record a positive result for a given tree, rather than on pellet counts. We recognize that some trees that contain koala pellets beneath their canopies will occasionally record a negative result by focusing search effort around the base. However, this shortfall is offset by the fact that more than one tree is sampled in a given site and that sites are replicated across a given study area. In practical terms, it is just not feasible to search beneath the entire canopy of each tree and if it were possible, the confidence that a detected pellet had been deposited from that tree would be greatly diminished for most situations with overlapping tree canopies. The alternative approach suggested by Woosnam – Merchez *et al*. (2013) of commencing faecal pellet searches at the base of each tree, but not be limited to that is neither standardized, reproducible or feasible if the objective is to achieve effective survey coverage across large areas.

Some of the unpublished reports and other "grey" literature referred to by Woosnam-Merchez *et al*. (2013) are at the forefront of koala conservation where robust koala habitat assessment techniques are required in order to address real-world koala conservation issues. In New South Wales this commonly manifests itself in the preparation of Individual and Comprehensive Koala Plans of Management, both of which impose a statutory requirement for koalas and their habitat to be assessed. It is in this arena that the SAT has been applied and refined since first being released for discussion purposes in 1995. The supporting tree-use data set now numbers in the hundreds of thousands of surveyed trees distributed across many parts of the koala's geographic range and so continues to inform and improve our understanding of habitat use by koalas. Importantly, much of the work disparagingly referred to as "grey literature" is in the public domain, has been peer-reviewed as part of the reporting process and thus serves to provide important information that may have assisted Woosnam – Merchez *et al*. (2013) in their deliberations.

Concluding comments

A great deal has been achieved since the formative work for the SAT commenced in the mid-90s, as those who use it will attest. In the spirit of seeking a better future for koalas, the SAT has always responded positively to constructive feedback and suggestions when these have been well-founded and offering real advances in application and/or interpretation. To this end it is disappointing that Woosnam-Merchez *et al.* (2013) have attempted to undermine an established method with a proven track record in habitat and population assessment. Surely there needs to be a greater level of collaboration and respect amongst koala ecologists if we are to collectively advance the cause of sustainable koala management in the face of increasingly widespread population declines and a future made more uncertain by climate change. We would much prefer to collaborate than to divert energy responding to unconstructive and poorly founded criticism. Regardless, we remain confident that the many SAT practitioners out there will continue to apply and test the method and so further improve our collective understanding of the distribution, habitat preferences and conservation needs of koalas.

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