The implications of biodiversity loss for the dynamics of wildlife in Australia

G. Ward-Fear[1], M. W. Hayward[1,2,3,4,5], F. L'Hotellier[1], K. Herman[1], A. P. Kabat[1] & J. P. Gibbons[2]

[1]Australian Wildlife Conservancy, Subiaco East, WA, Australia
[2]Schoolof Environment, NaturalResources and Geography, Bangor University, Bangor, UK
[3]Schoolof BiologicalSciences, Bangor University, Bangor, UK
[4]Centre for African Conservation Ecology, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa
[5]Centre for Wildlife Management, University of Pretoria, Pretoria, South Africa

*Correspondence to: Matt W. Hayward, Bangor University, College of NaturalSciences, DeiniolRoad, Bangor, LL572UW, Gwynedd, Wales, UK. m.hayward@bangor.ac.uk

Our study aimed to identify the broad effects of native fossorial species on leaf litter, and make inferences about their mechanistic influence on fire behavior using simulation models (Hayward *et al*., 2016). This conceptual link has long been hypothesized, but here we present empirical evidence to support it; our results suggest that native fossorial mammals have fire-suppressive effects because their activity results in higher levels of litter decomposition, and a reduced fuel load across the landscape. The expert commentaries build on this study and raise pertinent points for further consideration.

Both Johnson (2016) and Watson (2016) expand on the interplay between the spatial distribution of fuel loads and fire dynamics. At the finest scale, spatial heterogeneity is achieved when animals scatter soil around localized diggings or turn over organic material into the soil profile. These localized events will aggregate into larger scale, landscape effects, where burrows and diggings occur in discriminate patches across the environment. Watson (2016) points out that these patches of decreased fuel would provide more substantial impediments to fire in the landscape by acting as natural fire breaks. We indirectly measured aspects of spatial heterogeneity, but to incorporate this variable accurately into future predictions, we suggest the following actions: (1) the activity of animals (burrows and diggings) be spatially mapped with GIS software to identify concentrations in the landscape and define natural fire breaks, (2) the relationship between litter heterogeneity and fire in the field be studied directly, either through experimental burns or surveys prior to natural burns, and (3) the input of more detailed data into fire models with finer resolution (as Johnson (2016) suggests). The explicit relationship between litter and fire lies at the core of this concept and thus warrants more accurate demonstration. Additionally, we acknowledge the points raised by Watson (2016) regarding population densities and the influence of floristic components on fire dynamics. As with most ecological studies concerning landscape processes, the complexities of all intra- and inter-species interactions in the system are rarely captured simultaneously (but should be considered) and this study worked within specific logistical constraints.

Due to these constraints, our study could only document the influence of a subset of all fossorial mammals that were historically present in these areas. Further to this, we cannot accurately know whether experimental versus historical densities were equivalent. Thus, we do not know precisely how fire behavior would be influenced by a full assemblage of fossorial species (in realistic densities), or for that matter, a much wider variety of species that were present historically. We cannot rectify the issue of assemblages (some species are extinct) but clarifying the relationship between population density and magnitude of fire suppression would be a very useful line of future research. Understanding how feedback mechanisms between ecosystem engineers and fire play out in the field would also be very insightful, but would require studies over the longer term.

Our experimental plots were large predator-free enclosures, containing populations of fossorial species. Watson (2016) suggests that conservation enclosures may be too rare and small to influence landscape processes at any meaningful scale; however, it is worth pointing out that they are becoming more common in Australia (Long & Robley, 2004). Not including the 3,374 km dingo-proof fence, Dickman (2012) listed 33 of these enclosures across Australia at the time, and we are aware of another two major enclosures that have been constructed since then (by the Northern Territory state government and by the Australian Wildlife Conservancy). Furthermore, most of these enclosures protect areas of high conservation value and represent the only places in which these faunal assemblages can be rigorously studied. These areas serve as arks for some of the most endangered critical weight-range mammals on mainland Australia, but perhaps their most important role in the context of conservation is to facilitate research. These experimental plots enable us to empirically test theories of ecosystem functionality (such as the one presented here) with a subset of fauna that has been largely incomplete since pre-colonial times. Such experimental manipulations present an opportunity for unique insights into the evolutionary underpinnings of ecosystem functionality in Australia. Most importantly, results from these studies provide justification for breeding programs and reintroductions of native mammals (teamed with enhanced suppression of invasive predators).

Ideally, future conservation strategies would be designed in a more holistic manner, incorporating diversity and function. We concur with Petrosillo & Zurlini's (2016) assertion that the target of species reintroductions should become their ecological role in the context of system stability. However, we do not believe that our current knowledge is sufficient to confidently predict all such driving species in all circumstances; thus, we would add that restoring only species for whom ecological function is known would be an opportunity missed. Following the precautionary principle, we would advocate the restoration of as many species as possible.

Restoring long-lost faunal assemblages to Australian ecosystems is no easy feat, but evidence is mounting globally which demonstrates the benefits of ecosystem management based strategically on ecological functionality. We cannot turn back the clock on faunal declines, but we can attempt to understand the historical importance of these faunal assemblages and why they warrant attention and preservation, now. All the expert commentaries speculate that (due to unavoidable constraints) our study likely underestimates the extent to which fossorial ecosystem engineers influence fire dynamics; we agree. More work is required to elucidate the roles that these species have played in the past and can play in the future of Australian ecosystems, but we believe our study provides a valuable contribution to this field and a good basis for future research.

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