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Going the distance on kangaroos and water: A review and test of artificial water point closures in Australia

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ABSTRACT

Grazing by overabundant herbivores can cause land degradation and reduce biological diversity. Across arid and semi-arid Australia, predator control, pasture improvement, and artificial water points (AWP) have contributed to increased populations of kangaroos and wallaroos (*Macropus* spp.). Control efforts (e.g. culling, predator reintroduction, fertility control) can be expensive, controversial and/or unsustainable in the long term. Closure of AWP is an alternative. We reviewed closures in Australia and found experimental tests have been few, and results unconvincing for two main reasons. Firstly, no study has tested AWP closures over distances influential to kangaroos. We identified seven AWP closure experiments in Australia. Five did not generate areas beyond 5 km from water and two used a method ineffective for excluding kangaroos. Secondly, post-closure monitoring has frequently been too short to detect changes amongst natural environmental fluctuations. Our own experimental AWP closure did not influence kangaroo populations and reaffirmed that kangaroo densities are dictated by food availability in Australia's water rich rangelands. Larger experiments are needed with systematic AWP closures that generate water remote landscapes, preferably exceeding 10 km from water. Monitoring must span dry, hot periods of below average rainfall when kangaroos are most likely dependent on drinking water.

1. Introduction

Changes to natural grazing regimes are a major threat to terrestrial ecosystems globally (e.g. Garrot et al., 1993; Dexter et al., 2013). Overabundant native herbivores can monopolize resources, alter the structures of habitats, contribute toward landscape degradation and drive biodiversity declines (Cote et al., 2004; Colman et al., 2014). In Australia, the environmental equilibrium of rangelands has been steadily disintegrating in response to changed land management (Woinarski and Fisher, 2003). One aspect of this altered equilibrium has been surges in kangaroo populations. In high densities, grazing by kangaroos can reduce the diversity and cover of plants, with flow-on effects for overall quality of habitat, and abundance and diversity of sympatric fauna (e.g. Howland et al., 2014).

Central to this imbalance have been modifications associated with the advance of pastoralism. Firstly, control of dingoes (*Canis lupus dingo*) to protect livestock has removed or at least reduced the top down regulation of large macropod populations (Pople et al., 2000; Letnic et al., 2011). Secondly, widespread vegetation clearing, and pasture improvement has created a landscape highly suited to kangaroos. Grazing by sheep and cattle serves to maintain pastures in a subclimax state that further increases their suitability (Newsome, 1975).

The provision of artificial water points (AWP) is often considered a third legitimate cause of kangaroo overabundance (Ealey, 1967a; Newsome, 1975; Dawson et al., 2006). Prior to European settlement, permanent surface waters in arid and semi-arid Australia were rare (Bird et al., 2016). As development within the Australian pastoral zone progressed, the provision of AWP to support livestock ensued. Today, few grazing regions are beyond 2–3 km from water in sheep country or 6 km in cattle grazing regions (James et al., 1999). Kangaroo grazing dynamics that may have once been influenced by the availability of drinking water are now instead governed almost exclusively by rainfall and pasture quality (Bayliss, 1985). Water-remote landscapes are now rare, as are refuges for species reliant on low grazing intensity (Montague-Drake, 2004; Fensham and Fairfax, 2008; Letnic et al., 2014a).

Controlling herbivores to restore natural disturbance regimes is a high conservation priority (Mori, 2011). Traditionally, kangaroo control has focused on culling, reproductive control and fencing vulnerable areas (Descovich et al., 2016). More recently, the reestablishment of

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predator populations has gained support (Letnic et al., 2011). These methods are politically and/or financially costly and can be difficult to sustain in the long-term. Closing AWP in Australia's arid and semi-arid environments has long been proposed as a viable alternative (Freudenberger and Hacker, 1997; Pople and Page, 2001; Montague-Drake, 2004). However, practical application of the idea has gained limited traction. This is partly because of the importance of AWP to kangaroo survival and population dynamics remains uncertain. Furthermore, manipulative experiments to test AWP closure have been few, and results seemingly inconclusive.

Here we review past studies that used both pre-existing contrasts and AWP closures to explore the influence of AWP on kangaroo populations in Australia's rangelands. Incorporated into this review is our own experiment to determine the influence AWP closure on vegetation and large macropod densities in central Queensland. We aim to identify the merit of AWP closure as a method for macropod control, and identify inadequacies that may have limited the outcomes of past experiments. From this we propose a system for more informative experiments and aim to stimulate further discussion around AWP closure as a method for restoring Australia's rangelands.

2. Kangaroos and artificial water points – a review

Our study compiled data from peer-reviewed journals, books, government reports, unpublished reports, protected area management plans, conference proceedings and unpublished research theses using electronic databases (Web of Science, Scopus, Google Scholar). Our searches used the key words: artificial, closure, grazing, distance, kangaroo(s), macropod(s) and water point(s). References cited in the resulting papers were examined for additional sources.

We considered only large macropod species (greater than 5500 g in weight) and defined a water point closure as any method used to deny these species access to AWP. Studies that combined AWP closure with a second method of population control (i.e. shooting) were not included. Integrated within the review is our own case study of an AWP closure experiment in semi-arid Queensland, used to reiterate our conclusions drawn from the wider literature. Data compilation was conducted through April 2017.

2.1. Pre-existing contrasts

The degree to which AWP influence kangaroo distributions and population dynamics remains unclear. Numerous studies have concluded that macropod densities are not dictated by water availability (Table 1). Instead, combinations of pasture quality, landscape structure, shelter availability, and predation pressure are more commonly cited as critical factors (Newsome, 1965; Freudenberger and Hacker, 1997; Letnic et al., 2014a).

Caughley (1964) and Gibson (1994) found higher densities of kangaroo dung closer to bores in southern Queensland (Table 1). During three years of monitoring at Glencoban Station in southern Queensland, Cowley (2011) found that kangaroo density (again determined via dung counts) was more often dictated by food than by water. On rare occasions, density was related to water and increased with distance away from the water point (Cowley, 2011). Similarly, Andrew and Lange (1986) found kangaroo dung increased with distance from a dam near Whyalla in South Australia. Antilopine wallaroos (*Macropus antilopinus*) and wallaroos (*M. robustus*) were positively related to the availability of permanent water across the tropical savannas (Ritchie et al., 2008). At the same sites, eastern grey kangaroos (*M. giganteus*) demonstrated a negative association. Interactions with domestic stock may further complicate patterns. Following the removal of sheep and cattle, kangaroos can increase in abundance, especially with access to AWP (Norbury and Norbury, 1993).

2.2. Distances relevant to kangaroos

Under hot and dry conditions the survival of individual kangaroos can be contingent on drinking water (Ealey, 1967a; Underhill et al., 2007). Water availability therefore has potential to influence kangaroo distributions and densities. With comparatively large home ranges and lower water requirements than domestic herbivores (Munn et al., 2013, 2016), the distances over which these influences manifest are probably large. Furthermore, physiological water requirements and thus the importance of AWP vary according to individual body size, vegetation water content, and rainfall (Underhill et al., 2007). In the case of wallaroos, eastern grey kangaroos and western grey kangaroos, home range estimate diameters indicate movements of 1 km, 3.9 km and 3.3 km from water may be feasible (Clancy and Croft, 1990; McCullough and McCullough, 2000). Estimates of red kangaroo home range diameters are in the order of 5–10 km (Norbury et al., 1994; McCullough and McCullough, 2000).

Fensham and Fairfax (2008) synthesized aerial count data of red kangaroos from the MacDonnell Ranges (Newsome, 1965) to estimate grazing threshold distances. The authors identified that 95% of red kangaroo populations occurred within distances of 6.8 km (dry season) and 7.8 km (wet season) from water. They also highlighted an absence of any relationship between red kangaroo densities and proximity to water over distances of less than 6 km, a conclusion supported by Montague-Drake and Croft (2004) and Fukuda et al. (2009).

Pastoral development has converted much Australia's arid zone landscape and vast areas once remote from natural permanent water now lie well within the 6.8 km dry season limit of AWP (Fig. 1). Importantly, studies aiming to determine the influence of water on kangaroos have been within water rich regions of the rangelands where monitoring sites have been within this 6.8 km threshold (Table 1, Fig. 1).

Only two studies since Newsome (1965) have examined relationships over distances greater than 6.8 km (Freudenberger and Hacker, 1997; Letnic and Crowther, 2013). Over a 6–10 week study, Freudenberger and Hacker (1997) used Finlayson's troughs to control access to AWP. The intent of these devices is to allow sheep to drink at water troughs but exclude large species of kangaroos using an electrified wire suspended about 5 cm above the ground at a distance of approximately 1.1 m from the trough. The study design extended water remote distances of between 0.5 and 9.6 km from water to between 1.8 and 13.2 km. Monitoring sites 10 km from water had moderately high dung counts and the authors suggested kangaroos feeding in those areas might have gone without drinking water. Letnic and Crowther (2013) estimated macropod abundances across eighteen sites in southern Australia, most of which were within a 12.5 km radius of water. Dingo predation and food availability were the key influential factors. Artificial water points had no bearing on kangaroo abundance although the authors acknowledged AWP were more common in areas where dingoes were absent.

Water remote landscapes are now relatively rare in Australia. Water requirements vary between kangaroo species (Munn et al., 2013, 2016) and interact with climate, habitat, predators, and pasture quality to determine ranging behaviour. The influences of AWP on kangaroo population distribution and abundance are therefore difficult to disentangle using pre-existing contrasts. In order to better understand the role of AWP in kangaroo overabundance, manipulative experiments are essential.

2.3. AWP closure experiments

Seven AWP closures have been conducted in Australia between 1995 and 2004 (Fig. 1c). Three were undertaken in Queensland, three in New South Wales and one in Western Australia. The majority of