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Can off-river water and shade provision reduce cattle intrusion into drinking water catchment riparian zones?

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ABSTRACT

Cattle defecation into rivers and overgrazing of riparian zones, are major concerns for drinking water catchment managers. Behaviour modification has been proposed instead of fencing for managing impacts, but reported success varies. Our study aimed to resolve whether provision of off-stream water and shade on real working farms could reduce the likelihood of cattle entering watercourses feeding Sydney, Australia's primary water supply, Lake Burragorang (34° S, 150° E). Cattle herds (1.4 and 11 Animal Units ha^{-1}) at two sites were fitted with Global Positioning System (GPS) collars ($n = 12$). Cattle movements were tracked following installation of industry-recommended off-stream water and shade (twelve 2 week duration control + treatment experiments). Some statistically significant differences in movement (Mann–Whitney U Prob. < 0.0001) were observed, as judged by comparisons of riparian, water trough and shade NEAR distances, and riparian zone visit number, duration and frequency. But effect magnitudes were small, inconsistent between different experiments, and insufficient to justify widespread water and shade provision. These findings contrast with the marked reductions in riparian impacts reported for rangeland pastured (>≈1 km^2) cattle, but were not inconsistent with smaller scale grazing studies. Statistically significant correlations (Spearman R) were, however, observed (Goulburn_1, Robertson_2 experiments respectively) between the movement of cattle within the same herd (0.94, 0.85), cattle in adjacent fields (0.7, 0.64), and heat stress related factors (temperature, light, humidity, wind) (0.1–0.5) indicating GPS tracking was sound and other factors more strongly influenced animal location. We hypothesize that our off-stream water and shade did not markedly influence cattle movement because our paddocks were relatively small (1.5 and 20 ha) compared to rangeland pastures. The study's main limitation was that GPS error prevented differentiation of riparian zone interaction from full stream contact. We recommend in future using direct video to overcome this, and differential quantification of these impacts.

1. Introduction

Cattle grazing has significant impacts on the physical, chemical and microbiological quality of streams and riparian areas (Agouridis et al., 2004b, 2005; Line et al., 2000; Meehan and Platts, 1978; Sanderson et al., 2010). Grazing also decreases the resistance of topsoil to erosion and exposes more readily mobilized subsoil (Trimble and Mendel, 1995). Such impacts on the 'Piosphere' "an ecological system of interactions between a watering point(s), its surrounding vegetation and the grazing animals" (Andrew, 1988; Graetz and Ludwig, 1976) are concerning in drinking water catchments. Runoff following heavy rainfall carries nutrients and pathogens into surface waters, degrades source water quality (Sunohara et al., 2012), may lead to higher illness incidence (Curriero et al., 2001) and necessitate expensive downstream treatment. Compared to bare soil, healthy riparian vegetation reduces the loading of contaminated runoff, and entrains particles, nutrients and pathogens (Davies et al., 2004; Schwarte et al., 2011). As a result, restoring and maintaining vegetated buffer strips between grazing land and waterways is promoted for reducing run-off pollutants (Coyne et al., 1995). For its success it is essential to reduce cattle utilization of the riparian zone, protect stream bank structure, and reduce direct defecation to streams (Davies-Colley et al., 2004).

The simplest riparian management option is fencing (Line et al., 2000). However, the dispersed nature of run-off requires expensive fencing of both major watercourses and higher order streams, which feed many drinking water catchments. Resources are also

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required for maintenance and weed suppression, and fencing reduces the available grazing area. Alternatives to fencing include off-stream watering and shade structures, and altering forage availability (Agouridis et al., 2005). Our paper reports an evaluation of off-stream water and shade provision trials.

That stock impacts may be managed by varying water availability and stress has been known for 100 years and precedes fencing as a tool (Williams, 1954). Further empirical observations and numerous pilot studies suggest it is effective (Bishop-Hurley et al., 2009; Byers et al., 2005; Clawson, 1993; Ganskopp, 2001; Miner et al., 1992; Pinchak et al., 1991; Sheffield et al., 1997; Trimble and Mendel, 1995). For example when off-stream water was provided Godwin and Miner (1996) reported cows spent 75% less time within 4.5 m of a stream and Tomkins and O'Reagain (2007) observed significant attraction to watering structures and reduced riparian visit frequency using GPS tracking.

Some reports, however, cast doubts that benefits always accrue. Agouridis et al. (2004a, 2004b) concluded that benefits in their systems were minimal. Porath et al. (2002) and Miller et al. (2011) reported some statistically significant effects, but improvement was marginal compared to the former reports. Bagshaw et al. (2008) observed no significant effect at all. Agouridis et al. (2005) suggested cattle might behave differently in response to the local environment e.g. arid pastures versus humid areas, and concluded "there is (still) a lack of scientific information regarding the effectiveness of several commonly implemented grazing BMPs".

As water and shade provision still involve significant capital outlays we concluded that validation trials were needed before recommending wide application in Sydney's drinking water catchments. Our study's primary aim was to assess whether farmers' installing industry standard off-stream cattle water supplies and shading under commercial grazing conditions could significantly reduce the interaction of cattle with riparian zones in a temperate Australian drinking supply catchment. Its secondary aim was to evaluate Global Positioning System (GPS) technology for monitoring grazing impacts. To address the primary aim and facilitate statistical analyses, we monitored the behaviour of 6 herds (6 trackers per herd) in 12 experiments comparing controls against 3 different treatments at 2 sites during summer and winter (2007/2008) over the maximum time ethically allowable (2 months per herd intervention).

2. Materials and methods

2.1. Field sites

Two study sites were selected within the Lake Burragorang (34° S, 150° E) drinking water catchment supplying Sydney (http://www.sca.nsw.gov.au/__data/assets/pdf_file/0006/4299/SCA-Drinking-Water-Catchments-Map-November-2012.pdf). The sites were located 5 and 2 km respectively from the towns of Goulburn (34°48′ S, 149°40′ E) and Robertson (34°36′ S, 150°36′ E). Rainfall differed markedly between sites (530 versus 960 mm a^{-1} respectively) but grazing was common at both. To ensure data reflected realistic grazing practice, two local farmers were selected from interested landholders. Then in discussion with the study team they were requested to decide where and how much land was appropriate for the project, provide appropriate fields, implement stocking densities reflecting local cattle (*Bos taurus*) grazing practice, and establish representative water and shade. Control versus intervention arrangements were similar to those of Turner et al. (2000).

At the Goulburn site a 42 ha field was split into 17 ha (northern) and 25 ha (southern) pastures (Fig. 1). The Mulwaree River and a road formed the western and eastern boundaries. Both paddocks had a scattering of Hawthorne trees, with thicker stands along the river verge. Pasture comprised ryegrass (*Lolium perenne*), clover (*Trifolium repens*), cocksfoot (*Dactylis* sp.) and some sub-clovers (*Trifolium subterraneum*). As sowing occurred just prior to project commencement, the landholder was unwilling to heavily graze the paddocks until the pasture was well established. Stocking density (twenty 550–650 kg, 3–6 year-old Devon cattle, equivalent to ≈1.4 Animal Units ha^{-1}) was slightly less than normally practiced on the property. At Robertson, medium-sized Murray Grey beef cows (adult weight 500–700 kg) were reared. Supplementary feeding (0800–1200 h) occurred during winter or when pasture growth (rye grass and clover) was slow, allowing a higher stocking density (≈11 Animal Units ha^{-1}) than otherwise sustainable. An area with scattered trees and slight undulation adjacent to a creek was split into two 1.5 ha paddocks (Fig. 2). Terrain was moderately sloped from east (6 m higher) to west at both sites. No obstacles prevented cattle accessing the riparian zone or river other than metre scale banks.

2.2. Off-stream water and shade

A concrete trough was installed at Goulburn in each paddock (Fig. 1) and filled automatically using a pump/bob-cock system, or secured when not required. At Robertson a mobile trough was filled from the stream and transferred between paddocks. For additional shade, metal frames (37 m^2, Speedy Sheds, Bringelly, Sydney) sufficient for 30 (Goulburn) and 10 (Robertson) head were erected supporting shade cloth (90% reduction: 3.7 m^2 $animal^{-1}$), in line with industry recommendations (Meat and Livestock Australia, 2006; NRCS, 2006).

2.3. Experiment design

Two experiment series (successive experiments on same herd) were undertaken at Robertson in the Austral winter (Robertson_1, 25 July 2007–19 September 2007) and Austral Summer/Autumn (Robertson_2, 27 February 2008–17 April 2008). Only one experiment series was undertaken at Goulburn (Goulburn_1, 28 November 2007–23 January 2008) due to equipment acquisition delays. For Robertson_1 each paddock was stocked with 12 Murray Grey cows and their calves at the commencement of winter. In the Robertson_2 series, eight Murray Grey cows with calves were stocked in each paddock. Because of the high Robertson_1 stocking rates supplementary feeding was undertaken (two hay biscuits, 07:30 and 11:00, 4 kg d^{-1} $animal^{-1}$).

Cattle movements were tracked over four 2 week experiments: an initial non-intervention baseline measurement period, followed by three control + treatment experiments. The four comprised: (1) characterization of cattle behaviour in the absence of any treatment; (2) provision of off-stream water only; (3) provision of alternative shade only; (4) provision of water and shade concurrently. Duration reflected animal ethics approval requiring cattle be collared for ≤2 months. It was initially planned to operate dedicated 'treatment' and 'control' paddocks. Preliminary analysis of the Robertson_1 data, however, suggested differences in cattle movement between the paddocks. To minimize this variance source, treatment and control paddocks were switched halfway during the Goulburn_1 and Robertson_2 series i.e. each treatment was applied in either the north or south paddock for one week after which the active structure locations were reversed.

2.4. Tracking with GPS collars

Twelve Sirtrack New Zealand, Ltd. GPS collars (540 g G2C 191) were purchased. GPS receivers were located in an injection moulded package at the neck apex with battery pack and data storage underneath. Each control and treatment group was fitted