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Offstream watering points for cattle: Protecting riparian ecosystems and improving water quality?

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ABSTRACT

A healthy riparian ecosystem is essential to maintain instream water quality, decrease stream bank erosion, increase bank stability and prevent soil loss within river systems, which in turn may affect coastal water quality. The presence of cattle within the riparian zone is a common feature of grazing ventures, but can negatively impact on the functionality of riparian ecosystems. Therefore, the provision of offstream watering points (OSWPs) as an alternative watering source for cattle may lessen or prevent the impact cattle have on the riparian zone. A systematic review was conducted to identify: 1) which factors influence how cattle use OSWPs, and 2) if the provision of an OSWP is an effective best management practice to reduce the time cattle spent in riparian zones, potentially limiting the impact cattle may have on instream water quality and riparian habitat particularly stream bank vegetation. A total of 37 from 1135 research papers satisfied the initial selection criteria for the review with seven providing sufficient information to conduct a meta-analysis. Out of the 37 papers a total of seven factors and five sub-factors influencing cattle's use of OSWPs were identified. There is evidence that OSWPs did reduce the time cattle spent in riparian zones, however with great variation (63.7%) among studies. The review further highlights that substantial knowledge gaps exist within the literature linking the interaction of cattle, OSWPs and riparian habitats indicating the need for further research.

1. Introduction

Cattle grazing can adversely affect the ecology of riparian habitats, changing stream bank vegetation, soil structure and channel morphology, as well as, instream water quality (Bagshaw et al., 2008; Carline and Walsh, 2007; Franklin et al., 2009; Pandey, 2007; Rolfe et al., 2006; Schwarte et al., 2011; Tastad, 2014; Tufekcioglu et al., 2013; Zaimes et al., 2008). When cattle spend time in riparian zones, they often defecate and urinate into water bodies sometimes contributing to excessive nutrient inputs such as phosphorus and nitrogen, as well as, pathogen loads such as *Escherichia coli* (*E. coli* 0157:H7) and *Cryptosporidium parvum* (Bagshaw et al., 2008; Pandey, 2007; Wagner, 2011). However, the transport of viral pathogens in relation to runoff remains unclear (Schwarte et al., 2011). Excess nutrients may lead to eutrophication and deoxygenation of water, while the introduction of pathogens can be harmful to livestock, humans and receiving ecosystems (Bremner, 2008). Other common impacts of cattle grazing in or near waterbodies are: increased erosion and runoff, increased soil bulk density, leading to poor water quality which may negatively affect ecological communities and human health downstream (Bremner, 2008).

In the United States, Canada and Australia an attempt to minimise these impacts has led to the development and implementation of Best Management Practice (BMP) actions and programs for graziers. One recommended BMP action to improve water quality and riparian habitats is the complete exclusion of stock from the riparian area via fencing. However, fencing can be costly due the large geographic scale often associated with rangeland cattle (Bagshaw et al., 2008; Rawluk et al., 2014) and may be impractical on steep slopes and across deep valleys (Bremner, 2008). An alternative BMP is the provision of an OSWPs (Bisinger, 2014; Franklin et al., 2009; Ganskopp and Bohnert, 2009; Kaucner et al., 2013; Miller et al., 2011; Rawluk, 2013).

OSWPs have been suggested as effective tools for drawing cattle away from riparian areas to potentially reduce impacts on the riparian area and improve in stream water quality (Brueggen-Boman, 2012; Godwin and Miner, 1996; Miller et al., 2011; Olson et al., 2011). For example, a study in Piedmont of Georgia, USA, found that providing OSWPs at a distance of 91 m and 81 m from the stream resulted in an 63% overall reduction in the time cattle spent in or near streams during the cooler months, consequently instream water quality improved with

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a 64%–95% reduction in total suspended solids (TSS); 85–95% reduction in *E. coli* concentrations and a 57% reduction in total phosphorus (TP) (Franklin et al., 2009). Similarly, earlier studies conducted by McInnis and McIver (2001)McInnis and McIver (2001) and Sheffield et al. (1997) indicated reductions in nitrogen, phosphorus and suspended solid loads greater than 50% and a 77% reduction in stream bank erosion when providing cattle with an OSWP.

Twenty-one studies published between 1985 and 2003 were reviewed by Agouridis et al. (2005) to ascertain the effects of commonly implemented BMPs on water quality in the Southern humid climatic region of the United States. Only one study cited by the review focused primarily on the provision of OSWPs as an effective BMP to improve water quality (Sheffield et al., 1997, cited in Agouridis et al., 2005).

Quantifying the time cattle spend near water sources under different conditions is necessary to enable effective decisions regarding the provision of OSWPs as a BMP (Pandey, 2007). However, research quantifying and linking environmental benefits to the provision of OSWPs is generally limited (Brueggen-Boman, 2012; Rhodes et al., 2007).

The basis of the BMP is the hypothesis that if sites where OSWPs are available are compared to sites where only the riparian habitat is available, cattle will spend more time in the riparian area with no OSWP. Therefore, this systematic review and meta-analysis will focus on the effectiveness of OSWPs in reducing the time cattle spend in riparian areas and identify factors that may influence the use of OSWPs.

2. Materials and methods

Indexed scientific databases were searched in September 2016 to identify information relating to the placement of OSWPs to protect riparian health and improve water quality by reducing the amount of time cattle spent in streams. Databases searched included Scopus, CAB extracts (EBSCOhost), Science Direct, ProQuest Dissertations & Theses Global, Wiley Online and Agriculture Collection. Search criteria included search term phrases containing a combination of key words and Boolean operators such as “And” and “Or”. Keywords included in the search were “offstream; stream; watering points or troughs”; “cattle”; “supplements”; “water quality improvement”; “riparian”; “distribution”, “grazing”; “behaviour”; “best management practices” and “mineral licks” (Appendices A; Table A1). Results were included if they provided information on the use of OSWPs by cattle and/or made mention of OSWP placement with the aim to improve riparian health and water quality.

The initial search results for the period 1960 to March 2017 yielded 1135 papers. Papers were eliminated in an unbiased way through stages of elimination to produce a total of 37 papers included in this systematic review, seven of the 37 had sufficient data to conduct a meta-analysis. Fig. 1 outlines the process by which studies were selected in an unbiased way for a systematic review and meta-analysis.

A meta-analysis was undertaken to determine the overall effect of providing OSWPs to reduce time cattle spent in streams. Effect size calculation for Cohens (d) was computed using Campbell’s online effect size calculator (campbellcollaboration.org, 2016) using mean, standard error and frequency distributions. Where written numerical data were not sufficiently described within a paper, graphs were imported into a graph digitizer where possible to extract the necessary information to calculate effect sizes. The meta-analysis was conducted in Microsoft Excel using a random effects model according to guide provided by BMC Research (Neyeloff et al., 2012).

3. Review results

Thirty seven papers included in the review were analysed in full text for location, climate and factors that may impact on the effective use of OSWPs and grazing distribution. Over the last decade the majority of research was conducted in the United States (n = 24) followed by

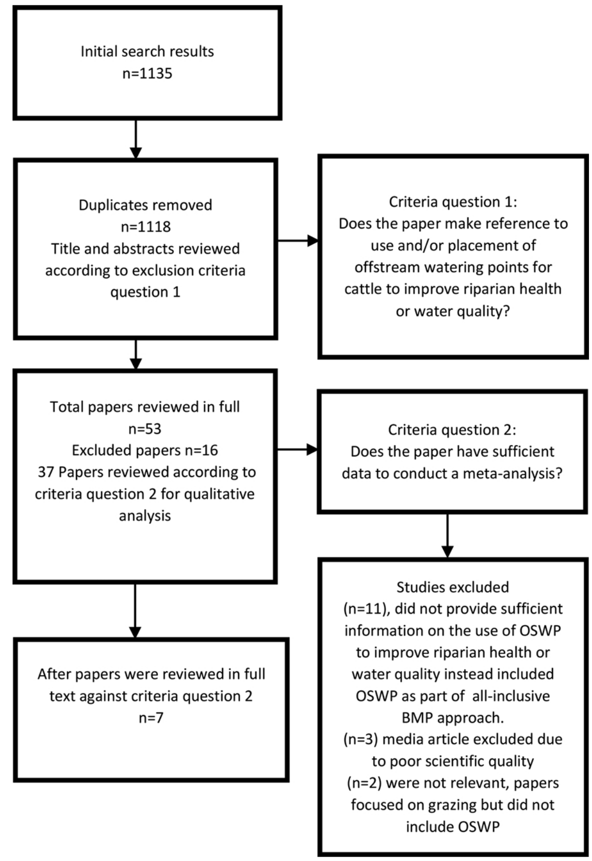

Fig. 1. Flow chart indicating study eligibility, selection and elimination criteria.

Canada (n = 5), Australia (n = 4), Brazil (n = 2) and New Zealand (n = 2) (Fig. 2, Appendices B Table B1). The following factors that may impact on OSWP use were identified: OSWP distance from stream; slope; climatic conditions including the Temperature Humidity Index (THI); shade availability; instream and offstream water quality and grazing management including stocking density; provision of supplements and mineral licks; paddock size and paddock shape; social behaviour. Fig. 3 illustrates the factors that may impact OSWP use by cattle and the links between them.

3.1. Distance to water

Of the reviewed papers, 17 identified that OSWP provision can impact on grazing distribution, seven identified that access to an OSWP may reduce the time cattle spend in riparian areas and three papers had inconsistent results (Appendices C, Table C1). According to six studies: Bailey et al., 2006; Bremner, 2008; Coimbra et al., 2012; Goulart et al., 2008; Howery et al., 1998; Wagner, 2011 the placement of an OSWP is a tool that in turn affecting the use of the OSWP, affecting the how cattle utilise the riparian zone.

As early as 1956 a study conducted by Goebel et al. observed that when cattle are further than 1 km from water sources, grazing and utilization patterns become more uniform and cattle use areas of the paddock which were previously underutilized (Pandey, 2007). However, a study conducted by Wagner (2011) indicated that a travel distance of 200 m to 300 m to a water source for cattle would achieve the same result.

Cattle’s grazing distance is limited by water availability but they display grazing preference around watering points (Hodder and Low, 1978; Low et al., 1981a, 1981b, 1981c). Ganskopp (1984) identified the preferred grazing distance for cattle from watering points to be 970 m while Harris (2001) identified either 0–100 m or 1100–1200 m.