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# Detecting the Influence of Best Management Practices on Vegetation Near Ephemeral Streams With Landsat Data

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## Abstract

Various best management practices (BMPs) have been implemented on rangelands with the goals of controlling nonpoint source pollution, reducing the impact of livestock in ecologically important riparian areas, and improving grazing distribution. Providing off-stream water sources to livestock in pastures, cross-fencing, and rotational grazing are common rangeland BMPs that have demonstrated success in drawing livestock grazing pressure away from streams. We evaluated the effects of rangeland BMP implementation with six commercial-scale pastures in the northern mixed-grass prairie. Four pastures received a BMP suite consisting of off-stream water, cross-fencing, and deferred-rotation grazing, and two pastures did not receive BMPs. We hypothesized that the BMPs increased the quantity of riparian vegetation cover relative to the conditions in these pastures during the pre-BMP period and to the two pastures that did not receive BMPs. We used a series of 30-m Landsat normalized difference vegetation index (NDVI) images to track the spatial and temporal changes (1984–2010,  $n=24$ ) in vegetation cover, to which NDVI has been well correlated. Validation indicated that the remotely sensed signal from in-channel vegetation was representative of ground conditions. The BMP suite was associated with a 15% increase in the in-channel NDVI (0–30 m from stream centerline) and 18% increase in the riparian NDVI (30–180 m from stream center line). Conversely, the in-channel and riparian NDVI of non-BMP pastures declined 30% and 18% over the study period. The majority of change occurred within 2 yr of BMP implementation. The patterns of in-channel NDVI among pastures suggested that BMP implementation likely altered grazing distribution by decreasing the preferential use of riparian and in-channel areas. We demonstrated that satellite imagery time series are useful in retrospectively evaluating the efficacy of conservation practices, providing critical information to guide adaptive management and decision makers.

**Key Words:** best management practice (BMP), livestock grazing, northern mixed-grass prairie, off-stream water, rangeland, riparian areas

## INTRODUCTION

Various best management practices (BMPs) have been implemented on rangelands with the goals of controlling nonpoint source pollution and reducing the livestock-induced degradation and overuse of riparian areas (Agouridis et al. 2005), common across the western United States (Fleischner 1994; Chambers et al. 2004). These BMPs are designed either to reduce or to eliminate the disproportionate amount of time livestock spend in riparian areas because of the abundance of forage, water, and shade (Senft et al. 1985; Fleischner 1994). Continuous season-long grazing has been widely cited as degrading to riparian areas, even in lightly stocked pastures (Ehrhart and Hansen 1997; Agouridis et al. 2005; George et al. 2011). Overuse of riparian areas compromises their ability to store water, recharge aquifers, filter chemical and organic waste, trap sediments, build banks, produce abundant biomass,

and provide critical wildlife habitat (Ehrhart and Hansen 1997). Furthermore, riparian degradation reduces erosional resistance provided by vegetation, thus increasing consequent erosion (Trimble and Mendel 1995).

Although eliminating direct livestock access to streams with riparian exclosures has been advocated by some, this method removes an important source of livestock forage (Stillings et al. 2003), especially in semiarid and arid regions (Ehrhart and Hansen 1997). Moreover, doing so is often impractical, costly, and undesirable to livestock producers (Godwin and Miner 1996). In response to these shortcomings, a variety of rangeland BMPs have been implemented for riparian improvement including: off-stream water sources, alternate shade sources, controlled grazing, supplemental feeding, and herding (Agouridis et al. 2005; George et al. 2011). The Natural Resources Conservation Service (NRCS) commonly cost-shares BMP implementation programs, which have been readily accepted by livestock producers (Ehrhart and Hansen 1997). One frequently investigated BMP involves providing off-stream water sources to livestock in pastures. Researchers have often reported the effectiveness of off-stream water practices (OSWP), cross-fencing, and deferred-rotation grazing in reducing livestock use of riparian areas (Godwin and Miner 1996; Sheffield et al. 1997; Agouridis et al. 2005; George et al. 2011). Sheffield et al. (1997) reported that OSWP implemen-

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