Utilizing managed grazing to sustain wetland ecosystem functions: A case study of the Willits Bypass wetland mitigation

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Research Objectives & Purpose

Provide support for the role managed grazing has in supporting wetland ecosystem functions by addressing the following research objectives:

1. Assess the benefit managed grazing can provide for wetland plant and wildlife communities at the Willits Bypass.
2. Use existing Mendocino County Resource Conservation District (MCRCD) data to determine the impact of excluding historical grazing on wetland plant communities.
3. Use historical Google Earth imagery and high-resolution aerial images (*i.e.,* unmanned aerial images, and NAIP imagery) to compare the composition of wetland plant communities between grazed and ungrazed area and ground-truth model with data collected from objective #1.
4. Assess site hydrodynamics, hydrology, soil carbon and nitrogen to develop longer-term models that assess the role of grazing on plant productivity, N-, and C-cycling.

Background

California is a biodiversity hotspot (Myers et al., 2000), but that biodiversity will be negatively impacted by changing climates and land uses (He et al., 2019; Holl et al., 2022). California wetlands support provisioning of ecosystem services related to carbon and nitrogen cycling (Kahara et al., 2022) while providing habitat for a vast diversity of California endemic species (Barbour et al., 2007). In addition, the cattle industry is California's top producing agricultural commodity and its continued productivity will be important to support a growing population and financial development (CDFA, 2018). As such, it will be prudent to develop strategies to manage working lands to support both biodiversity, nutrient cycling, and cattle production. Yet, grazing is often viewed as a novel disturbance that is incompatible with managing semi-natural systems (Caltrans, 2014; Dasmann, 1965; DiTomaso, 2000) even though California ecosystems evolved with millennia of disturbances (Anderson & Moratto, 1996; Eviner, 2016; Wigand, 2007). Numerous studies demonstrated that grazing can limit biological invasions and improve native plant diversity (Alofs & Fowler, 2013; Hayes & Holl, 2003; Michaels et al., 2021; Van Auken, 2009). Grazing can also aid the germination for a diverse suite of herbaceous grass and forb species in seed banks which are suppressed by encroaching shrub species (Bartolome et al., 2014; Menke, 1992).

Nutrient removal in wetlands requires a specific suite of conditions including fast growing plants and denitrifying bacteria (Zhang et al., 2021). Hydrology can also play a critical role as higher flow can flush out nitrogen and increase oxygen (Fisher & Acreman, 2004; Meng et al., 2014). Under the right hydrological conditions, controlled grazing can also be an important tool for managing wetland nutrient cycling (Bohlen & Gathumbi, 2007). Nitrogen inputs from cattle can serve as fertilizer and promote higher vegetation abundance and diversity (Sonnier et al., 2020), which in turn, could increase carbon capture and wildlife diversity. Manipulating pasture management intensity on sub-tropical wetlands demonstrate that managed grazing can result in higher plant biomass, increased plant nutrient content and improved forage palatability (Sonnier et al., 2020). However, excess nitrogen may be detrimental to sensitive wildlife such as amphibians (Burton et al., 2009; Knutson et al., 2004), and even human health if nitrates infiltrates water sources (Tariqi & Naughton, 2021). Furthermore, mechanical disturbance due to trampling may also limit benefits from oxidizing wetland peat stores leading to re-release of carbon (Bohlen & Gathumbi, 2007).

California plant communities evolved with numerous disturbances, including large grazing ungulates that are now extinct (Anderson & Moratto, 1996; Wigand, 2007). Loss of periodic disturbance in systems that historically developed with them can result in habitat conversion and reduced ecosystem functioning (Lehmann et al., 2011; Luong, 2022; Van Auken, 2009). In Willits, CA (Mendocino County), this loss of periodic disturbance is even more concerning as it facilitates invasion by *Phalaris aquatica*, which transforms the system by developing a deep litter layer, and *Rubus armenicacus*, which results in conversion to thicket covered shrublands (personal communication, K. Cooper, MRCD). Both these mechanisms reduce available habitat for managed state-listed species, *Pleuropogon hooverianus* (North coast semaphore grass) and *Limnanthes bakeri* (Baker's meadowfoam) (personal communication, K. Cooper, MRCD). Research within Californian and non-Californian inundated habitats indicate that reintroduction of managed grazing regimes can help revert some habitat change to support a more diverse species composition (Bartolome et al., 2014; Michaels et al., 2021; Scotland's Farm Advisory Service, 2018).

Traditional wetland vegetation field survey techniques are labor intensive and often impeded by dense vegetation and aquatic inundation (Madurapperuma, Kahara, et al., 2020). Aerial imagery and spatial modeling of wetlands can be useful in capturing vegetation change engendered through management practices such as grazing, water pumping, and dredging. Remote sensing data can also help reduce sampling limitations and be used to monitor ecosystem functions by assessing of spatial and temporal changes related to hydrology (Li et al., 2009), changing land uses (Pande-Chhetri et al., 2017) and carbon footprints (Crichton et al., 2015). Unmanned aerial systems (UASs) offer new methods to collect relatively low-cost accurate, low altitude, high resolution spatial and temporal data that can be used to distinguish, and quantify wetland herbaceous plant communities, vegetation guilds and plant succession (Boon et al., 2016; Husson et al., 2014; Ishihama et al., 2012; Zweig et al., 2015). For example, species composition was determinable by vegetation specialists even with relatively low pixel resolution, as long as spatial resolution remained high (Husson et al., 2014).

Promoting the conservation of diverse wetlands and ensuring continued support for cattle production, California's top agricultural commodity, are both important state goals. However, these goals are not always mutually exclusive and can have overlapping management practices. Our proposal aims to assess the multi-use utility of constructed wetlands as habitats to support both cattle production and plant and wildlife biodiversity. We will combine 1) an observational field study at Willits Bypass (Willits, Mendocino County, California); 2) analyze existing data from the Mendocino Resource Conservation District on grazing exclusion on historically grazed wetlands; 3) pair vegetation data with aerial imagery to create tools to assess grazing-induced vegetation change; and 4) model long-term grazing-induced changes to hydrology, nutrient cycling (nitrogen, carbon), and plant productivity.