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Utilizing technology to better understand rangeland and cattle grazing dynamics

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Introduction

Grasslands of the northern Great Plains are a unique and important natural resource that provides valuable ecosystem services such as forage for livestock, habitat for wildlife, and cycling of water and nutrients. Range and pasture lands in Nebraska cover approximately 46% of the total land area (23 million acres). The Nebraska Sandhills region in the north central part of the state make up about half of this area and offer one of the largest intact native prairie rangeland areas in the Great Plains.

Cattle grazing in the Great Plains is influenced by several variables including extremes with drought and flooding, invasive species, and land-use changes. Managing and adjusting grazing management to address these challenges is important to sustaining and improving grasslands for specific vegetation or landscape management objectives to accomplish multiple ecosystem services. Advances in technology can aid producers in making data-driven decisions on rangelands. Precision agriculture technology has long been used in cropping systems and now there are technologies that bring the benefits of precision agriculture to rangelands. These proceedings will highlight a few new technologies that provide 1) local and regional-scale predictions of grassland production early in the growing season, 2) low cost GPS tracking and health monitoring for individual animals, and 3) determining diet composition of animals using fecal DNA sequencing.

Spatial and temporal variability on rangelands in the Great Plains

Between and within year variability in precipitation drives plant production in semi-arid grasslands of the Great Plains. This temporal variability in the amount and timing of precipitation is complicated by spatial variability across a landscape (e.g., topography, soils, and vegetation species composition) that is often present at both ranch and pasture scales. In the Nebraska Sandhills, topographic position (e.g., slopes or interdune swales) influences species composition, soil-moisture accumulation, and plant production (Stephenson et al. 2019). Swales and lowlands between dunes at even relatively small scales can increase plant production and influence the response of plant production to increasing precipitation. A 17-year study found that total plant production was 48% greater on interdune swales compared to surrounding upland dunes in close proximity (Fig 1; Stephenson et al. 2019). Compared to the dune slopes and ridges, the swales also were more responsive to increases in growing season precipitation with a greater rate of increase in plant production during years with greater precipitation than dunes (Fig 1). Accounting for these topographic differences can improve understanding, planning, and estimating appropriate stocking rates at the pasture level.

Smaller scale differences are important in making stocking rate decisions at the local level, but at larger spatial scales, long-term plant production data sets provide valuable information for modeling and predicting total plant production across larger regions like the Great Plains (Chen et al. 2019). Predictive tools that forecast plant production early in the growing season are now freely available online to help producers in making management decisions for critical drought trigger dates, annual pasture stocking rates, grazing rotations. Grass-Cast (http://grasscast.agsci.colostate.edu/) is an online platform that provides growing season forecasts on estimated increases or decreases for the long-term mean in total plant production. Grass-Cast uses observed and forecasted weather, evapotranspiration, a normalized difference vegetation index (or NDVI, a land greenness value collected using satellite sensor data), and known relationships between historical weather data and grassland production to generate forecasts for predicted total plant biomass during the growing season at the county level.

Technologies to understand cattle grazing behavior

GPS tracking has made large strides in helping researchers better understanding cattle grazing behavior over diverse landscapes. In the past, GPS tracking of individual animals was prohibitively expensive to use at a production scale (e.g., $1,000 to $2,000 per collar). However, newer technologies have been employed with success at a more reasonable expense (e.g. $200, Knight et al. 2018). With this technology, producers can more easily deploy a number of tracking collars to identify grazing use patterns and develop grazing strategies to either increase or decrease grazing pressure in strategic locations for specific management goals.

While still more important to research projects than with production agricuture, tracking technologies will continue to provide options to better understand grazing behavior and potentially improve monitoring of animal health and well-being. Ear-tags are now being marketed that can track the movements of an animal and estimate daily grazing times and movement patterns. Just like a FitBit® or an iWatch® can monitor a humans movements, number of steps, and other health measures, these ear tags can take estimates of the amount of time an animal spends grazing or resting and develop algorithms to assess the health of an individual animal. These technologies are continually being improved to identify individual sickness, heat detection, and parturition.

In addition to understanding when and where animals are grazing, understanding what they are consuming can provide insight into plant-animal interactions at different times of the growing season. Fecal DNA sequencing is a relatively new technology that reconstructs diets of grazing animals based on amounts of dietary plant protein content in the feces. This non-invasive technique provides a tool that can be used to guide grazing management based on when animals are selecting for or against certain key plaint species. While this technology is complicated and still being validated with cattle diets (Scasta et al. 2019), DNA sequencing can provide valuable information to determine what animals are consuming and how that may affect overall rangeland health. In the near future, GPS tracking of where livestock are grazing and DNA sequencing of what animals are consuming may provide real-time data to make management decisions from the larger pasture spatial scale to the individual plant or animal level.

Using new technologies to evaluate targeted cattle grazing

Livestock grazing is an important driver in the management of ecosystems. Large ungulates have long played an important role in rangeland ecosystems for the creation and management of heterogeneity and biodiversity and changes in plant species composition to alternative, stable ecological states (Hobbs 1996). Livestock grazing can be managed so that livestock can serve as “ecosystem engineers” in accomplishing specific vegetation goals that may not be mutually exclusive of beef production (Derner et al. 2009).

Targeted grazing is the term used to characterize the application of grazing animals at strategic times and intensities to accomplish defined vegetation management objectives (Launchbaugh et al. 2006). Targeted grazing has been successfully used to suppress invasive weed species, decrease biomass for potential wildfire management, and improve wildlife habitat. For targeted grazing to be successful, practitioners need to have a thorough understanding of how grazing influences both target and non-target plant species and stockmanship skills to apply grazing treatments appropriately to accomplish specific objectives.

Cheatgrass (*Bromus tectorum*) is a species of concern in the western Great Plains that targeted grazing has been suggested as a tool to help manage. While cheatgrass invasion negatively affects perennial grasslands, cheatgrass can be a useful early season forage and targeted grazing may be one of the best opportunities to decrease cheatgrass abundance on rangelands at large spatial scales. The overall goal of targeted grazing on cheatgrass is to utilize high quality cheatgrass biomass early in the growing season while reducing the amount of cheatgrass seed production and not causing harm to native grasses. However, there are several unknowns when applying this type of targeted grazing including 1) when cattle actively select for cheatgrass compared to other plants, 2) how early season grazing on cheatgrass may affect native cool-season grasses which are often growing intermixed with cheatgrass, and 3) how year-to-year variability affects grazing selection.

Current research in western Nebraska and eastern Wyoming by the USDA Agriculture Research Service and the University of Nebraska is using GPS tracking and fecal DNA sequencing to better understand opportunities and challenges associated with early season targeted cattle grazing on cheatgrass. Cattle in this study are grazed within 10 acre pastures that have been mapped to identify areas with large amounts of cheatgrass cover. Approximately 50% of the pastures have cheatgrass invasion and 50% are predominately native perennial grasses by area. Cattle are grazed from mid-April until later in June. GPS tracking is being used to identify when cattle are grazing in cheatgrass or native grass patches and fecal DNA sequencing provides insight into whether cattle are focusing their grazing on cheatgrass or native grasses at different times during the study. With this data, we are able to make better predictive models of when cattle are grazing (or not grazing) cheatgrass based on the physiological stage of the cheatgrass. The overall goal of this project is to further pinpoint the period when grazing is most effective based on the grazing behavior of cattle.

Conclusion

Technology will continue to improve our understanding and management of grazinglands and grazing animals. These technologies can aid producers in making grazing management decisions. However, technology will not replace the art and skill required by grazing managers to successfully apply grazing management treatments over large landscapes. On-the-ground evaluation and understanding is critical to meet the requirements of many rangeland management objectives. Thus, technology is a tool in the larger grazing management toolbox and when combined with practical experience and knowledge offers greater insight to accomplish defined grazing management goals.

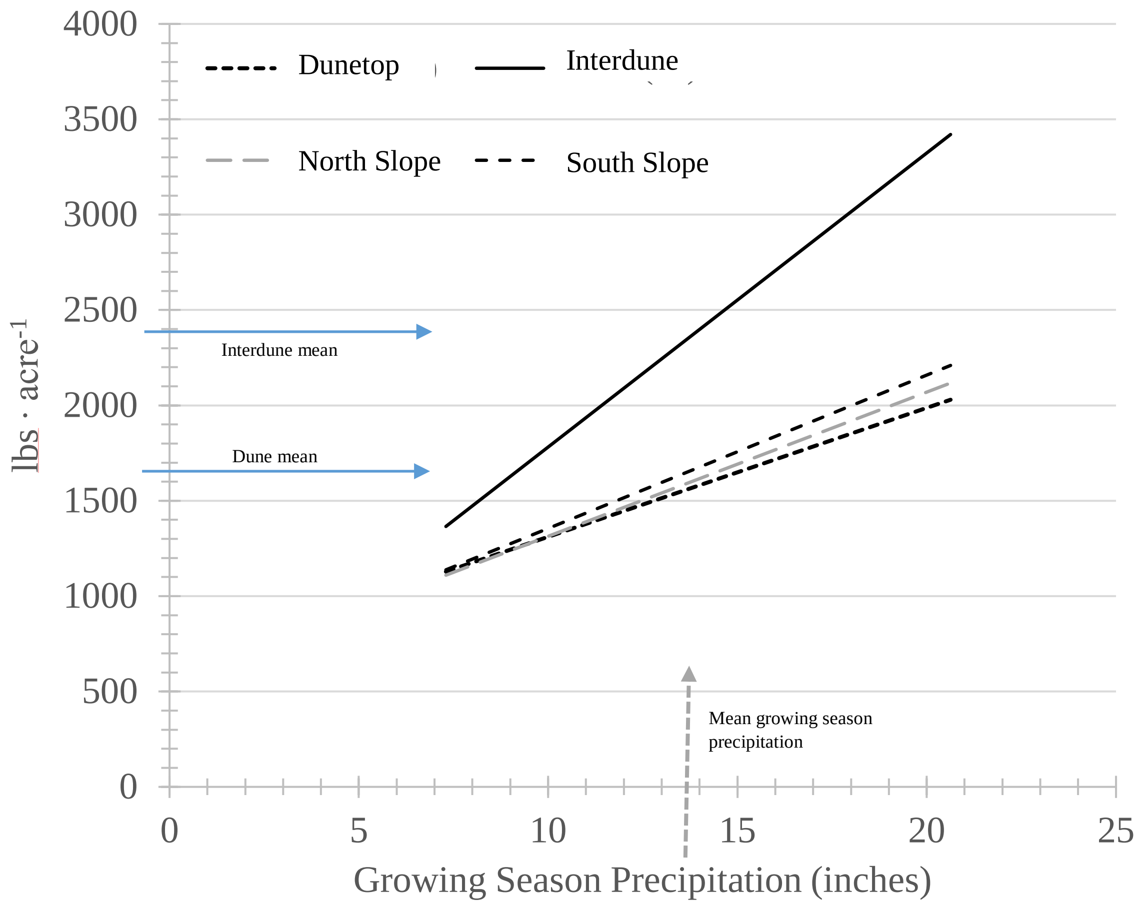

Figure 1. Relationship between total plant production (lbs · acre^{-1}) and growing season precipitation (April 1 to August 15) at different topographic positions the UNL Barta Brothers Ranch in the eastern Nebraska Sandhills. Plant production data collected from 2001 to 2017. Arrows on the y-axis indicate the mean plant production averaged over all years for the dune positions (1,630 lbs · acre^{-1}) and interdune positions (2,390 lbs · acre^{-1}). The arrow on the x-axis indicates the mean growing season precipitation (13.8 inches) between 2000 and 2017.

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