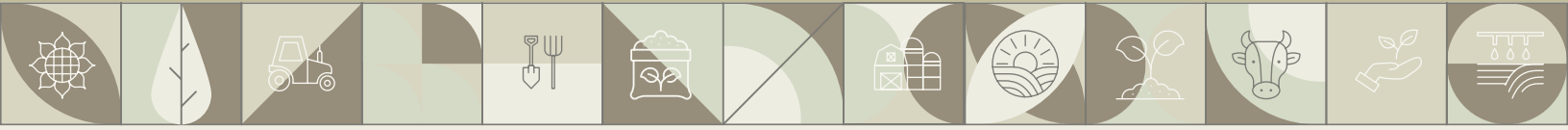


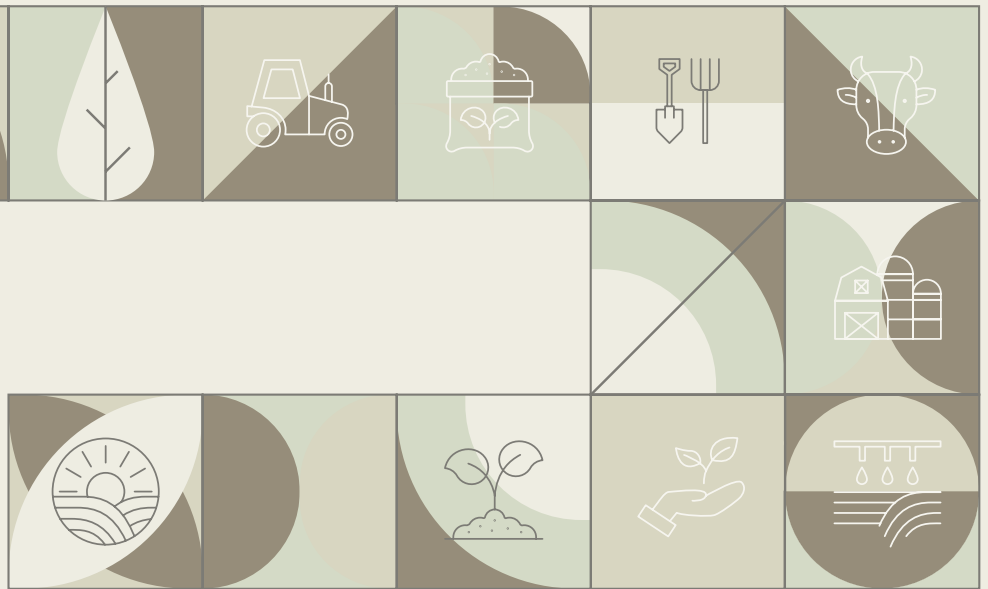
43rd Annual Faculty Lecture



RANGELAND COMPLEXITY

A systems approach to grazing management

- Grazing Livestock Management
- Soil and Rangeland Resources
- Wildlife Conservation
- Ranch Financial Sustainability

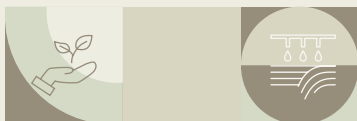


Dr. Benjamin Turner

Associate Professor, Laura and Robert Underbrink Endowed Chair in Agribusiness,
Agriculture and Natural Resource Management



About Dr. Benjamin Turner



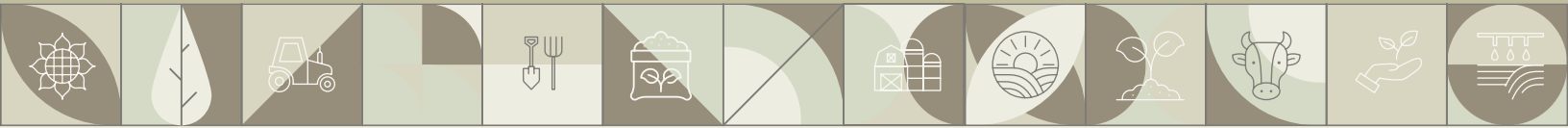
About Dr. Benjamin Turner

Dr. Benjamin Turner is associate professor of natural resource management in the Department of Agriculture, Agribusiness, and Environmental Science and The Laura and Robert Underbrink Endowed Chair in Agribusiness in the King Ranch Institute for Ranch Management (KRIRM). He teaches agribusiness, ranch management, systems thinking and modeling courses for undergraduate and graduate students, and since 2018, the John B. Armstrong Lectureship in Systems Thinking for KRIRM. His research program, which has contributed to over \$5 million in successful external grants, focuses on systems analysis of agroecosystems (both cultivated and rangeland settings), decision making in natural resource management contexts, and development of teaching and learning and decision support tools. Dr. Turner has received the Junior Research Award and the Senior Research Award from the College of Agriculture and Natural Resources, the Texas Section Society for Range Management's Popular Writing Award, and two of his student mentees have received TAMUK's Distinguished Student Awards during commencement. He is a member of the System Dynamics Society and the Society for Range Management, where he currently serves on the Texas Section-SRM Board of Directors.

Research Abstract

Rangeland ecosystems possess self-organizing feedback relationships that modify resource structure and performance in myriad ways, that coupled to socio-economic signals drive management decisions. These systems can be characterized as dynamically complex systems which self-organize in ways to produce emergent properties that are historically path dependent yet are capable of endogenously generating surprise behaviors. In dynamic settings such as these, complexity tends to overwhelm decision makers' abilities which contribute to poor performance. Scientific training has also tended to "silo" problems into specific domains that don't always reflect real-world conditions. The net result are managers that develop decision-making heuristics or "short cuts" that satisfy rather than optimize system performance. To illustrate the scientific contributions capable of arising from the systems approach and to fill some of the gaps described above, this lecture will center around the development and application of a rangeland ecosystem model which integrates ecosystem processes, grazing livestock pressure, and human decision-making pertaining to management of stocking rates in cow-calf systems representative of South Texas. Results will highlight model use for ranch context-specific grazing insights generation, and more broadly, operational means to test the resiliency of managed rangeland systems which accounts for short- and long-term interaction and feedback effects.





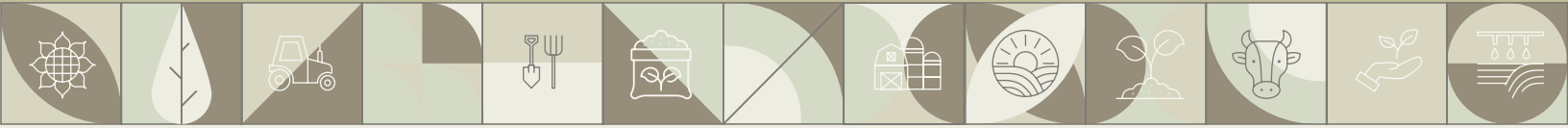
Purpose

The purpose of this work is to probe a new line of inquiry into complex rangeland ecosystems using a systems approach to natural resource problem solving. Rangeland ecosystems possess self-organizing relationships grounded in feedback connections that modify resource stocks and capacity in myriad pathways, which cascade to influence capital and management decisions via socio-economic feedbacks. These systems can be characterized as dynamically complex: systems which self-organize in ways to produce emergent properties that are history (path) dependent yet are capable of endogenously generating surprise behaviors (Ford 2010). These ecological characteristics thwart management efforts in a variety of ways. First, the underlying complexing of dynamic systems often overwhelms human decision-making abilities, leading to poor management performance across many domains (e.g., fish population sustainability, climate change mitigation; Sterman 2014, Meadows et al. 2017, Rooney-Varga et al. 2020), including agricultural and natural resource ones (e.g., public lands issues, commodity market inventories, agricultural-wildlife conservation trade-offs; Wayland et al. 2018, Turner et al. 2020, Crozier et al. 2023).

Second, the traditional scientific disciplines in which we are trained often runs at odds with the underlying feedback complexity which constitutes ecological structure. For example, academic training is often segmented into scientific silos representing various disciplines: soil, plant, animal, and wildlife sciences, hydrology, chemistry, physics, or economics (which are further segmented into their own sub-disciplines).

Third, and partly as an outgrowth of the previous two factors, is the development and use of heuristics in decision-making (Tversky and Kahneman 1974, Kahneman 2011). Heuristics are decision-making rules or “short-cuts” that human mental models develop subtly and subconsciously based on personal experiences and circumstances and are colored by our expertise or previous training. Heuristics can be both highly effective and also misleading. Because they require little cognitive effort and often yield desirable short-term outcomes, they are very effective. They can become misleading, however, in complex systems of dynamic nature which produce counterintuitive and delayed feedback. Given that one of the preferences for heuristics is their low cognitive burden, we fail to allocate enough cognitive effort to more fully analyze appreciate the long-term outcomes of our decisions. All of the above features permeate cross-cutting interactive management problems in rangeland ecosystem: Grazing livestock (Maestre et al. 2022), invasive species (e.g., woody plants; Londe et al. 2022), wildlife conservation (Grant et al. 1997), and ranch financial sustainability (Machen et al. 2021) (conceptualized in Figure 1).





therefore, rangeland management, conservation policy, and scientific inquiry would benefit from greater understanding of how ecological processes interact with and cross-cut socio-economic and decision-making processes. Approaches and methods have been developed in the integrative field of systems analysis (a.k.a. systems thinking, system dynamics modeling, many others). Such approaches have been successfully applied in other fields which are arguably less complex than rangeland ecosystems (e.g., industry dynamics, urban dynamics; Forrester 2007)

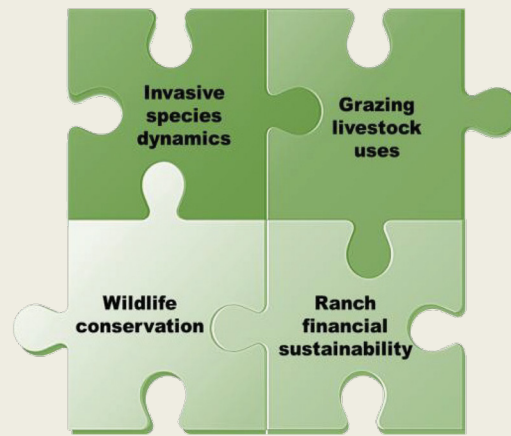
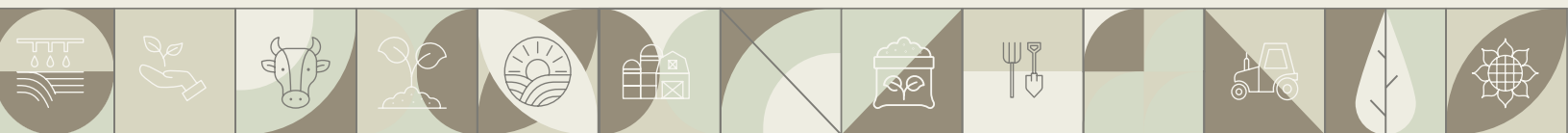


Figure 1. Conceptualization of the high-level, cross-cutting interactive problems in rangeland ecosystems requiring holistic management approaches to managing their trade-offs: invasive species, wildlife conservation, grazing livestock uses, and ranch financial sustainability.

Description of Inquiry

Previous systems models have been developed to explore ecological states-and-transition potential (D’Odorico et al. 2012), wildlife population conservation (DeMaso et al. 2011), ranch management decisions (Turner et al. 2013, Tinsley et al. 2019, Taylor et al. 2022), economic and policy dilemmas (Fuhlendorf et al. 1996, Crozier et al. 2023). Of particular interest are models of grazing livestock-forage nutrition-rangeland health interactions (Walker et al. 1989, Blackburn and Kothmann 1991, Diaz-Solis et al. 2003, 2006, 2009, Teague et al. 2008, 2009, 2015). Some of the latter referenced models were originally developed using data from south Texas but have primarily been adapted and applied in more temperate ecosystems with assumptions about invasive species dynamics and livestock management systems that are not always widely applicable. For example, the majority of rangelands are degraded in at least one dimension (soil/site stability, hydrological function, or biotic integrity) (Herrick et al. 2010). This is especially true in southern plains ecosystems in Texas which have significant woody plant encroachment (Scholtz et al. 2021). Most



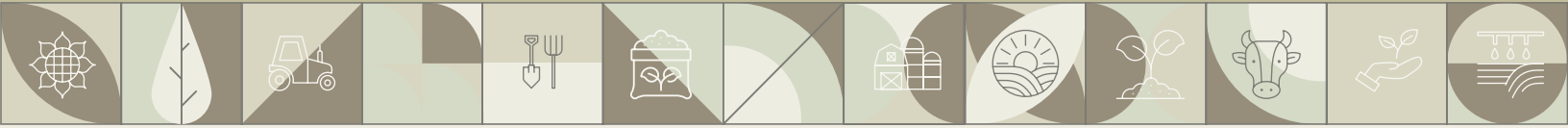


grazing management models however assume that initial rangeland ecological conditions are in healthy and productive state (cited above). Another example pertains to stocking rates. Stocking rate is defined as the consumptive animal demand over a given unit of land for a specified unit of time, typically standardized as an animal unit-days (AUD), animal unit-months (AUM), or animal unit-year (AUY), where an animal unit is the equivalent consumption of a mature cow weighing 1,000 pounds. In most modeling applications, stocker animals (non-breeding stock that are bought and sold seasonally) are used in order to avoid the modeling considerations of breeding herd inventories (whereby animals are not liquidated or added instantaneously) and their subsequent effect on stocking rate over time (i.e., the stocking rate is simply manipulated via turning grazing on and off via the movement of stocker animals into or out of the system at will). Most grazing livestock business models on rangelands are based on breeding animal herds that produce offspring for market (cow-calf systems consisting of spring calving herds, fall calving herds, or ranches with both spring and fall calving herds). Mimicking these systems in scientific modeling work requires specification of management culling and retention decisions (Turner et al. 2013, Tinsely et al. 2018, Taylor et al. 2021) and therefore remains an important contribution in rangeland systems analysis. To illustrate the scientific contributions capable of arising from the systems approach described in the previous section and to fill some of the gaps described immediately above, the inquiry for this lecture will center around the development and application of a rangeland ecosystem model which integrates ecosystem processes, grazing livestock pressure, and human decision-making pertaining to the management of stocking rates in cow-calf systems representative of south Texas. To facilitate this, weather, soil, plant community, and livestock production data will be gathered from TAMUK King Ranch Institute for Ranch Management (KRIRM)'s H.R. Smith Ranch, a 7,000-acre working cow-calf ranch representative of the southern plains. The ranch property and resources are quite diverse, given the number of soil-ecological sites and rolling topography, the mix of herbaceous and woody plant species composition, and the 150 head of cows which are split between both spring and fall calving herds. The primary challenge to KRIRM is how to improve livestock and wildlife sustainability in economically feasible ways given the ranches initial conditions. Upon receipt of the ranch in 2023, the ecological conditions were severely degraded.

Once constructed to the initial ecological conditions, the model will test for varying management treatments. For example:

- Intensity and grazing management efforts (manipulation of pasture sizes and rest/recovery days via inclusions of infrastructure improvements and decisions rules for retaining, culling, and rotating animals)
- Intensity of brush management treatment (manipulation of brush treatment rate, season, and method)
- Response variables will include but not be limited to: ecological condition (an index of long-term herbaceous forage growth potential), percentage of brush cover, and livestock inventories. To the extent costs of management investments are estimable, inferences will be made to return on investment (ROI) of varying management strategies



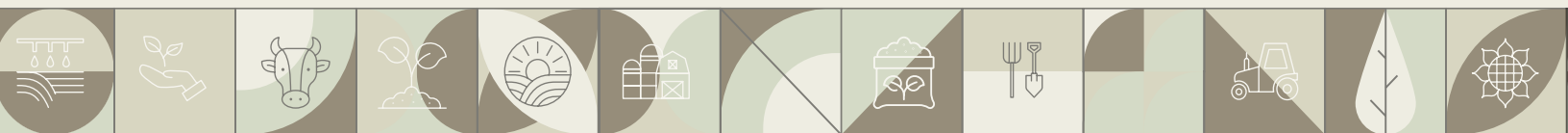


Provisional conclusions

Because in previous modeling work our field has relied on the representation of stocker systems to manipulate stocking rate across rangeland situations that are assumed to be in good initial ecological conditions, model-based insights about possible long-term grazing management strategies are unintentionally skewed towards strategies that may be more management intensive and require less brush or invasive species control than what is ecologically possible on most rangeland settings. The results from this inquiry will provide more context-specific recommendations applicable to south Texas ranches about long-term ranch improvement efforts which respects and accounts for the short- and long-term interaction effects between grazing and brush management.

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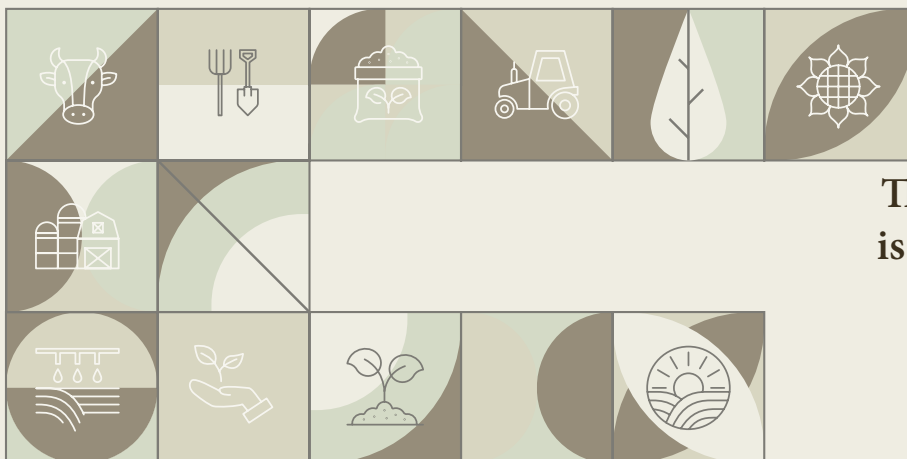


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