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Community-Engaged Research Builds a Nature-Culture of Hope on North American Great Plains Rangelands

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Abstract: In the North American Great Plains, multigenerational ranches and grassland biodiversity are threatened by dynamic and uncertain climatic, economic, and land use processes. Working apart, agricultural and conservation communities face doubtful prospects of reaching their individual goals of sustainability. Rangeland research could serve a convening platform, but experimental studies seldom involve local manager communities. The Collaborative Adaptive Rangeland Management (CARM) project, however, has undertaken a ten-year, ranch-level, participatory research effort to explore how community-engaged research can increase our understanding of conservation and ranching goals. Using ethnographic data and the nature-culture concept—which recognizes the inseparability of ecological relationships that are shaped by both biological and social processes—we examine the CARM team's process of revising their management objectives (2016–2018). In CARM's early days, the team established locally-relevant multifunctional goals and objectives. As team members' understanding of the ecosystem improved, they revised objectives using more spatially, temporally and ecologically specific information. During the revision process, they challenged conventional ecological theories and grappled with barriers to success outside of their control. The emerging CARM nature-culture, based on a sense of place and grounded in hope, provides insights into effective community-engaged research to enhance rangeland livelihood and conservation outcomes.

Keywords: collaborative adaptive management; goals and objectives; natural resource management; grassland bird conservation; sense of place

1. Introduction

This paper explores how community-engaged research efforts can increase mutual understanding of conservation and ranching production goals in working rangelands. Rangelands are uncultivated and/or extensively managed grazing lands that support culturally and biologically diverse social-ecological systems worldwide; they cover approximately 40–60% of the Earth's terrestrial surface (Reid et al. 2008). Working rangelands of the US Western Great Plains include some of the last remaining intact shortgrass steppe in North America. This semi-arid ecosystem, at the driest and warmest edge of the Great Plains (Lauenroth and Burke 2008), provides crucial habitat for wildlife. This includes a suite of rapidly declining grassland bird species, about which the conservation community is increasingly concerned (Brennan and Kuvlesky 2005; North American Bird Conservation Initiative US Committee 2009). Multigenerational ranching communities also have an interdependent relationship with these working lands, a large portion of which are controlled by federal and provisional/state land management agencies (Figure 1). In many rangelands, conservation-production trade-offs drive conservation and agricultural groups into conflict (Sayre 2002; Sheridan 2007; White 2012; and Walker and Hurley 2004). Yet, evolutionary history makes the shortgrass steppe a potential common ground, because the ecosystem evolved with large herbivore grazing and depends on this ecological process to sustain biodiversity (Hart and Ashby 1998; Milchunas et al. 1988; Augustine and Derner 2012; Lauenroth and Burke 2008; and Porensky et al. 2017). Additionally, conservation interests and ranching communities share similar challenges to reaching their distinct goals, including highly variable weather and climate, and regional land-use conversion from grasslands to urban, cultivated, and industrial uses (Figure 1); (Haggerty et al. 2018; Gosnell and Abrams 2011; Gosnell et al. 2006; and Hamilton et al. 2016). In this study, we seek to describe goal setting in the Collaborative Adaptive Rangeland Management (CARM) project by a team of ranchers, conservationists, public agency employees, and researchers tasked with managing a ranch-scale research project.

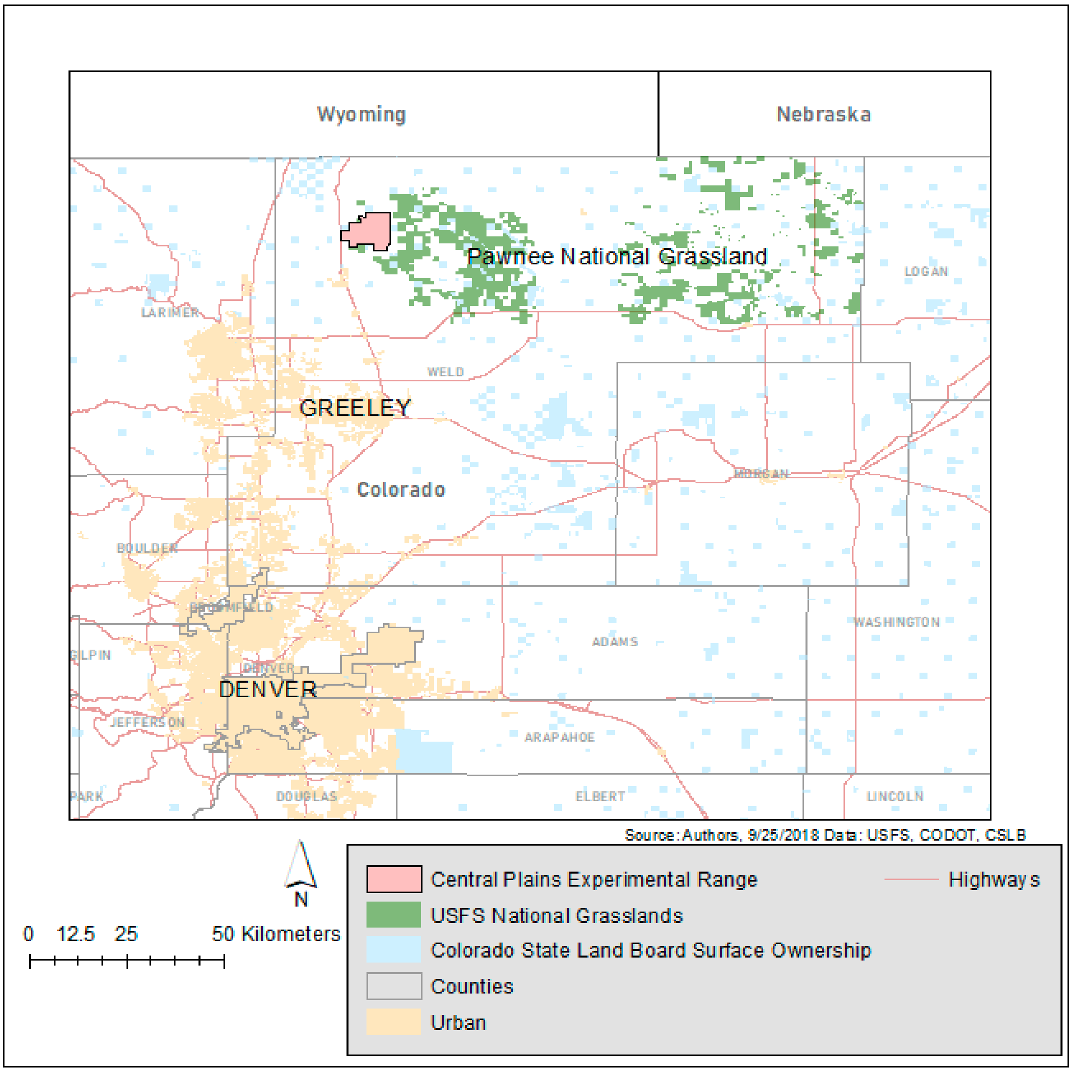

Figure 1. The Collaborative Adaptive Rangeland Management (CARM) project takes place at the Central Plains Experimental Range in Nunn, Colorado. This is a United States Department of Agriculture (USDA) Agricultural Research Service (ARS) research location. The site is located in the far Western, and therefore, the driest and warmest edge of the US Great Plains in the shortgrass steppe ecosystem, near the US Forest Service Pawnee National Grassland.

1.1. Social and Ecological Context of the Shortgrass Steppe of Eastern Colorado

The CARM project is embedded in a complex conservation context that shapes how conservation and ranching stakeholders engage in shared management responsibility. The working landscapes of shortgrass steppe in the Western Great Plains face high levels of weather and grassland production variability (Figure 1) (Sala et al. 1988; and Derner et al. 2009). The resilience of these systems was shaped by fire, grazing by native large and small mammals, and highly variable precipitation over evolutionary time scales (Milchunas et al. 1988, 1989; Augustine and Derner 2012; and Knapp and Smith 2001). Thus, the shortgrass steppe is relatively tolerant of grazing and resilient to these ecological disturbances (Porensky et al. 2017; and Milchunas and Lauenroth 1993). Today, the shortgrass steppe is largely managed by ranching families, including those with public land grazing permits, and by federal and state public land management agencies. Conservation in the region requires limiting conversion of rangelands to cultivated cropland or urban/exurban development, and restoring and reconnecting heterogeneous native prairie areas to benefit a suite of Great Plains grassland bird species (Fuhlendorf et al. 2012; Knopf 1994; and Parton et al. 2003). Some target bird species require habitats shaped by prairie dogs or fire (mountain plover, *Charadrius montanus*), or short-structured areas formed by large herbivore grazing (McCown's longspur, *Rhynchophanes mccownii*). Other species rely on tall-structured or shrub dominated areas (lark bunting, *Calamospiza melanocorys*; grasshopper sparrow, *Ammodramus savannarum*; Brewer's sparrow, *Spizella brewer*) (Derner et al. 2009; Augustine and Derner 2012; Samson and Knopf 1996; Augustine and Derner 2015; Knopf 1994; and Skagen et al. 2018). Despite recognition of the importance of restoring "pattern and process" to improve conservation outcomes (Fuhlendorf et al. 2012; Fuhlendorf and Engle 2001), conventional grazing practices often produce homogenous vegetation structure (Briske 2011). Forage production and vegetation diversity determine beef production outcomes for these ranching operations and are highly influenced by variable rainfall.

A working hypothesis in rangeland science predicts that loss of extensively managed private family ranches can result in conversion to land uses that remove ecological processes, in particular grazing by large herbivores, from the ecosystem (Brunson and Huntsinger 2008; Gosnell et al. 2006; and Charnley et al. 2014). This can occur due to conversion to cropland, exurban development, or alternatives to working rangelands, such as government-funded programs that restore grassland, but generally preclude ecological disturbance by grazing and fire (e.g., Conservation Reserve Program in the USA) (Brunson and Huntsinger 2008; Wallace et al. 2006; Charnley et al. 2014; and Knight 2007). A decline in rangeland resources can also shift the social capital of remaining ranching families, which may lead to a decline in rural community cohesion, and loss of rural aesthetic and financial resources (Tickamyer et al. 2017). Decision-making by family ranchers is viewed as an important driver of wildlife conservation outcomes for several reasons. First, private ranch land provides extensive areas of native rangeland and wildlife habitat, which family ranches have been shown to manage sustainably for generations (Brunson and Huntsinger 2008), particularly with moderate stocking rates in this grazing-adapted ecosystem (Hart and Ashby 1998; and Milchunas et al. 2008). Second, private land often connects tracts of public land, "stitching" habitat together across public-private boundaries that might otherwise fragment continuous habitat in the region (Charnley et al. 2014; Wallace et al. 2006). Third, ranchers and the ranching industry have traditionally been active in local, regional and national conservation and industry political processes, and are regarded as key stakeholders in the Western US context (Robbins 2006). Rangeland-based livestock production systems are an important economic sector in the Great Plains. Ranchers remain the foundation of early stages of beef and lamb production systems, raising calves, yearlings, and lambs on open rangeland until they are weaned for feeding or finished on grass.

Public land ranchers own and operate small to mid-sized cow-calf, yearling, or combined operations (running between ~25–300 head on the Pawnee National Grassland), and depend on the forage provided by native or restored rangelands for at least part of the growing season (May–October). Weaned calves or yearlings are marketed through video auction, private treaty or the local livestock auction, and conventionally go to a feed yard for finishing before slaughter. Cattle are typically of a Continental breed (Black and Red Angus, and Angus/Hereford crosses are most popular). Stocking rates vary with rainfall, though an average moderate stocking rate for the grazing season is typically ~0.6 animal unit months (AUM)·ha^{-1} (Augustine et al. 2017). These ranches rely on multi-generational local ecological knowledge and rural community networks to adapt to market and environmental changes over long-term planning horizons (Wilmer and Fernández-Giménez 2015). Increased demand for amenity ranch property and shifting economic prospects in rural areas can make ranch expansion and succession difficult or impossible (Munden-Dixon et al. 2018; Wilmer and Fernández-Giménez 2015; and Haggerty et al. 2018). Furthermore, shifting land ownership and community structure in ranching communities is predicted to reshape social capital across the region as operators adapt to changing climates (Briske et al. 2015; and Joyce et al. 2013). Additional ranch income in the region is often derived from off-ranch work, dryland small-grain farming, and from wind energy or oil and gas revenue.

Our study also takes place within the context of a diverse scientific community with a complex history. Rangeland research efforts in the region historically operated as social enclosures, keeping scientists in and manager communities out, so manager-researcher interactions were limited. Research began in 1939 at the Central Plains Experimental Range (CPER, operated by the USDA-Agricultural Research Service since 1953). Early efforts emphasizing small-scale, productivist work (Shoop et al. 1989). More recent, ranch-scale multifunctional investigations have addressed agro-ecological interactions. Despite an increasingly multifunctional perspective, knowledge end-users were kept at an arm's length. Stakeholders were rarely directly included in the research process, or in the evaluation and application of research findings. Increased criticism of this science model and the resultant "science-management divide," which pitted research evidence against manager experience in grazing management, erupted in a debate in the late 2000s (Briske et al. 2008; Teague et al. 2013; Roche et al. 2015; and Brunson and Burritt 2009). The Collaborative Adaptive Rangeland Management (CARM) project, described below, sought to mend this divide and pilot a different model of collaborative research, with direct and continued engagement of representatives from the ranching, conservation and government agency land manager communities, together with biophysical and social scientists in a long-term participatory research project.

1.2. The Collaborative Adaptive Rangeland Management Study

Formed in 2012, the CARM researcher and stakeholder team manages an experimental yearling cattle ranch on the Central Plains Experimental Range (a Long-Term Agro-ecosystem Research site in Nunn, CO, see: Spiegal et al. 2018) via collaborative adaptive management (CAM) (Hopkinson et al. 2017; Beratan 2014; and Susskind et al. 2012). Conceptually, the project incorporates collaborative decision-making and evidenced-based practices, in this case, within a broader experimental design (Armitage et al. 2009). The CARM project explicitly strives to offer useable findings for real-world management contexts outside of the experimental range, including interdisciplinary, multi-use management scenarios on nearby federal lands, and community-based, collaborative conservation efforts spanning multiple land ownership boundaries.

In 2012, the CARM researchers identified a group of 11 stakeholders, comprised of conservation, public agency, and ranching community representatives, and invited them to manage, together, a herd of yearling cattle grazing on ten (CARM) pastures, each 130 ha, at the CPER (Figure 2). The conservation organization representatives have expertise in wildlife and rangeland management and research. Public agency representatives are employees of state and federal agencies that manage publicly owned rangelands in the region, or advise rangeland managers in grazing decision-making. Rancher members are cow-calf, yearling, or cow-calf plus yearling ranchers and also members of the local grazing association, comprised of a community of local ranching families, and which holds a local Pawnee National Grassland grazing permit.

Since 2012, this group has worked with rangeland, social, wildlife, economic, and animal scientists to establish goals and objectives and make decisions for the spatio-temporal distribution of cattle grazing and prescribed burning. Together these researchers and stakeholders comprise the "CARM team," though researchers do not vote. A comparison treatment, the Traditional Rangeland Management (TRM) treatment, is implemented simultaneously on a second set of ten 130 ha pastures paired in soils, topography, and vegetation composition characteristics to the CARM pastures. This treatment is not actively adaptively managed, but reflects the grazing management common across the region, specifically on the nearby Pawnee National Grassland, via season-long, continuous grazing at the same stocking rate as the CARM treatment (Bement 1969), and thus provides comparison data for CARM decision making.

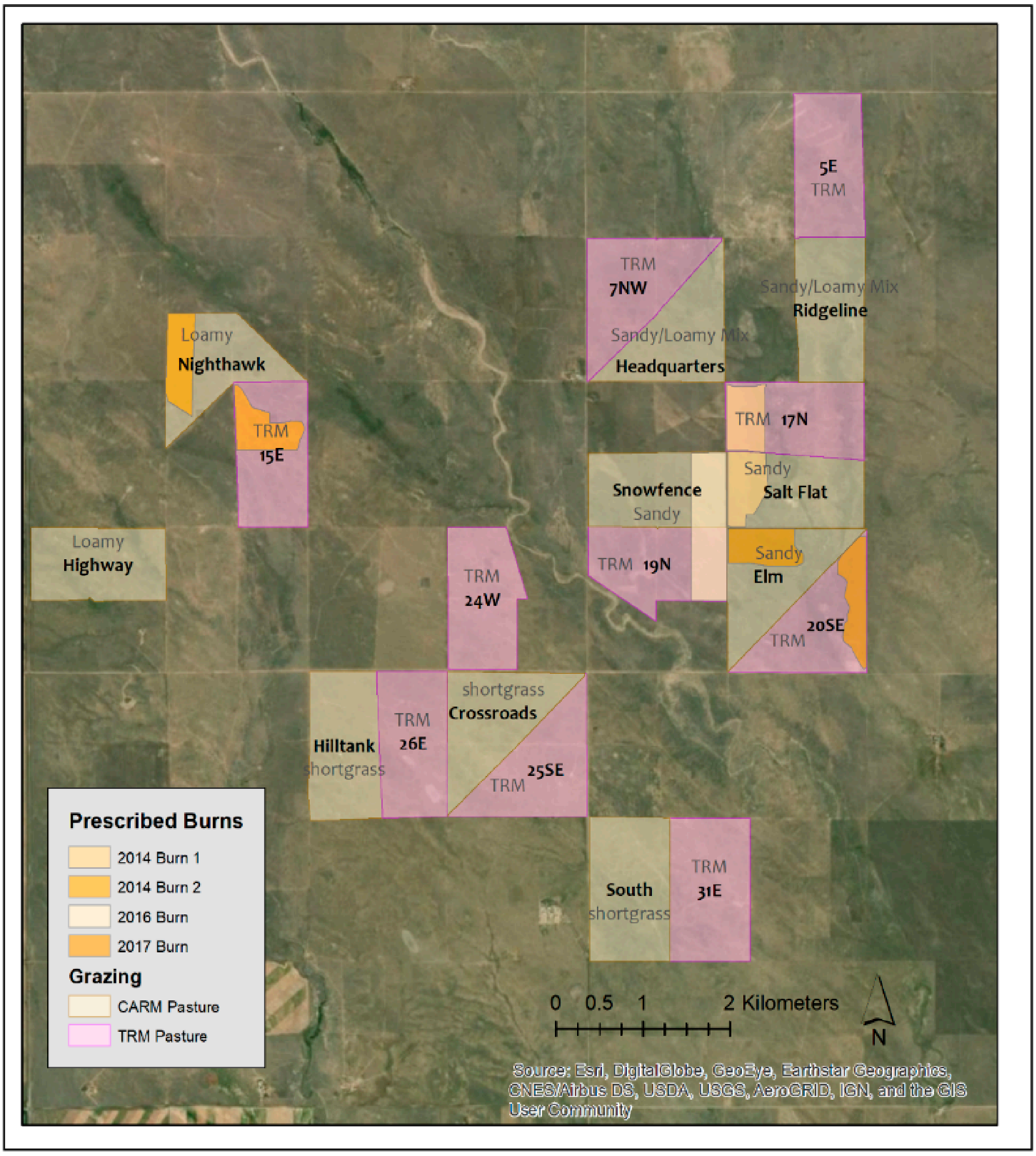

Figure 2. The CARM project includes ten, 130 ha named pastures managed by a team of local ranchers, conservation organization representatives, public agency employees, and interdisciplinary researchers. This team makes decisions about number and spatio-temporal distribution of a herd of yearling cattle for wildlife, vegetation, profitable ranching and social learning outcomes on these pastures, and may also implement controlled burning. CARM pastures are paired with ten, 130 ha “Traditional Rangeland Management” (TRM) pastures on the basis of soil, ecological sites, topography, and plant communities. TRM pastures follow a locally relevant season-long (mid-May through early-October) continuous grazing system at the same stocking rate as the CARM herd.

The CARM group assembles at the CPER for decision-making meetings at least three times each year (typically January, April, and late October), and communicates virtually periodically between these meetings. They interpret monitoring data collected on CARM and TRM pastures by the researchers indicating progress toward objectives including: Plant species composition and production; temperature, precipitation, and soil moisture; cattle behavior, fecal quality, and average daily weight gains; and grassland bird nesting and abundance monitoring data. Researchers coordinate the meetings, which include field tours, presentations, data interpretation activities, and small group discussions to involve local and professional knowledge from the stakeholders. Researchers facilitate voting on proposed management actions. The group strives for full consensus, but its collectively determined operational rules require a 75% super majority of stakeholders to implement a proposed action.

CARM stakeholders make decisions about cattle grazing to control the density, sequence, and duration of pasture grazing and rest on CARM pastures. The spatio-temperal distribution of TRM cattle is constant. The CARM group also has control over the number of cattle and the use of prescribed burns. Any stocking rate shifts or burns implemented on CARM pastures are also implemented on TRM pastures to isolate spatio-temporal distribution of cattle as the main factor differing between the two treatments. Stakeholders may not change the type of cattle, the number of pastures, or the season of grazing for logistical reasons. In 2014, the CARM group decided to group all the yearlings into one herd and rotate them among pastures, striving to rest two pastures each year (for drought reserve and to benefit cool-season grasses) and to graze each pasture at a different time each year. Between 2014, when grazing treatments began, and 2018, the stakeholder group incrementally increased stocking rates from 214 head to 280 head. They also refined decision-making thresholds for moving the herd among pastures to deal with reduced cattle average daily gain in the CARM pastures, which was attributed to stock density (see Table 1 and pasture grazing records in Supplement A Tables A1 and A2). The group also implemented prescribed burns in 2014, 2016, and 2017 to enhance grassland bird habitat and forage quality (Figure 2). For more information on these decision-making processes, see (Wilmer et al. 2018).

Table 1. Management objectives for the CARM group in 2012 and following revisions in 2018. Additional rationale and metrics are included in Supplement C.

Vegetation Objective	
2012	"Increase percentage of cool-season grasses and non-shortgrass native plants, by weight and number of plants."
Revised (2018)	(A) "Attain and/or maintain abundances of cool-season perennial graminoids within 30% of 2015 targets". This is specific for each plot based on its identity as a sandy, loamy or "shortgrass target" sites, and uses a three-year running average to assess trend (see Figure 2). (B) "Maintain or increase plant compositional diversity both within and across pastures." This will be assessed using a three-year running average to assess trend.
McCown's Longspur Objective	
2012	"Maintain populations of McCown's longspur, Western Meadow Lark and Horned Lark." In the proposed revised objectives, the team established an individual objective for the longspur because of the exceptional rate of population decline for that species.
Revised (2018)	"Create or maintain high-quality breeding habitat for McCown's longspurs on 20–40% of the total landscape. Prioritize management for McCown's longspur habitat on loamy ecological sites with flat or gently rolling uplands (shortgrass target areas) (See Figure 2)."

1.3. Goal and Objective Setting and Revision

In 2012, prior to baseline ecological data collection in 2013 and grazing treatment implementation in 2014, the CARM team met for the first time. With the help of a social scientist with knowledge of goal setting literature, they drafted an overarching management goal: "To pass the land on to future generations, economically and ecologically" (Figure 3). They established management objectives relating to wildlife (grassland birds), rangeland vegetation, and profitable ranching outcomes, and in 2016 added social learning objectives (Figure 3). Initial goals and objectives were influenced by the context of a severe drought in 2012, specifically in the desire for more non-shortgrass plant species, and were notably vague, lacking quantitative targets, metrics, or specific spatial and temporal scales for objectives. The vague nature of the goals was attributed by researchers to the groups' need for additional baseline data (which was collected in 2013) and knowledge of the area's variability before specific quantifiable objectives could be set. As the project continued, the group eventually agreed to work together toward all objectives even though some team members were more knowledgeable about or interested in outcomes of one subset of objectives (Wilmer et al. 2018).

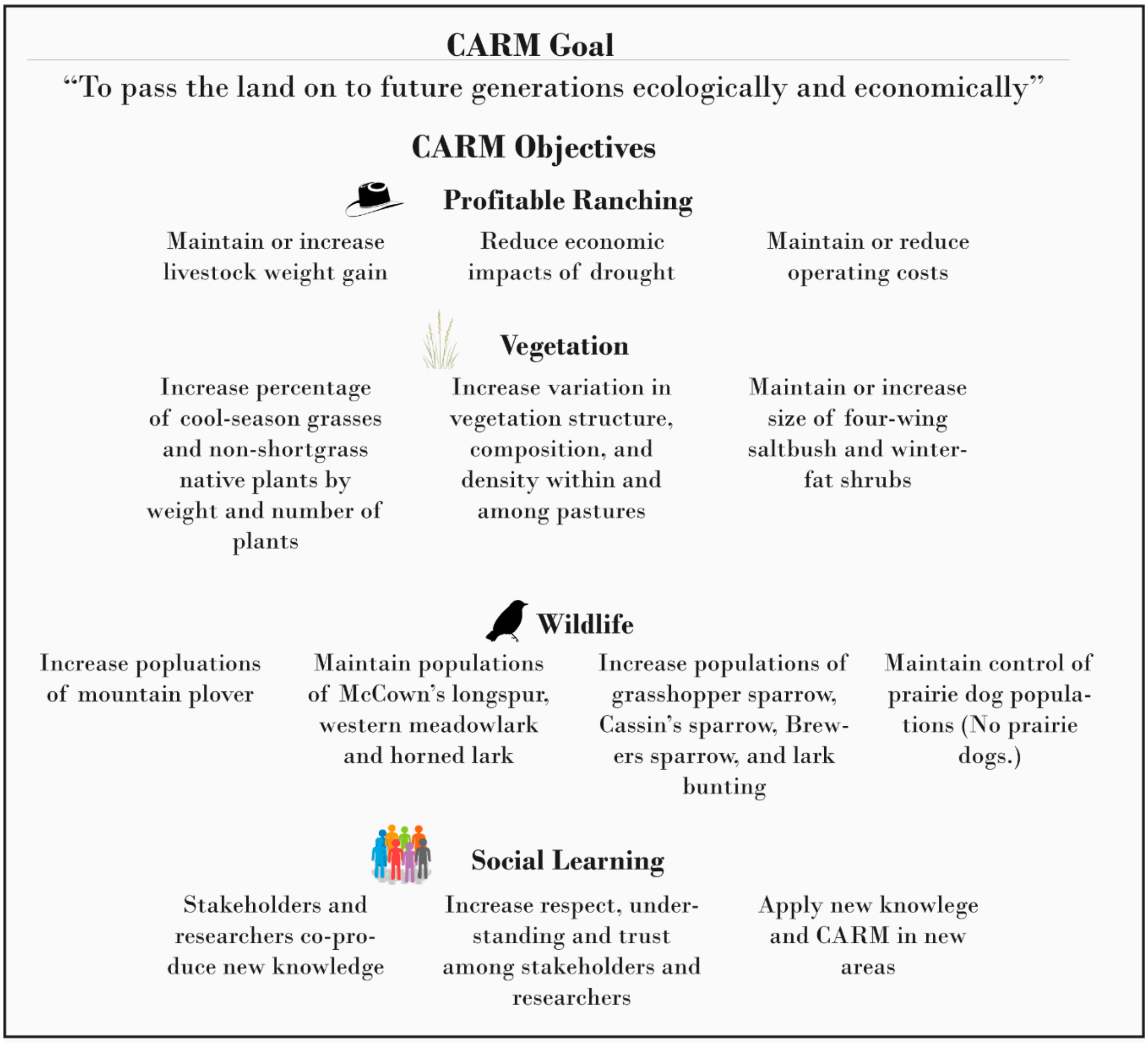

Figure 3. The CARM project goals and profitable ranching, vegetation, and wildlife management objectives were established in 2012. Social learning objectives were added in 2016.

In 2017, the CARM team began revising the original 2012 management objectives. Stakeholder participant comments at meetings in 2016 noted that roughly drawn, vague objectives aiming to improve ecological outcomes everywhere, every year, were creating decision-making challenges for the team. In response to these comments, researchers initiated the process of revising vegetation and wildlife objectives in CARM. The aim of this revision process was to evaluate and apply lessons learned, in the spirit of the adaptive management literature (Allen and Gunderson 2011). Researchers cited literature that suggests data and experience-informed revision of original management objectives (double loop learning) improves management adaptation to uncertain and complex contexts (Argyris 1977; Fernández-Giménezz et al. 2008). The team recognized that they were re-writing objectives when original objectives have not been met, and acknowledged that goal revision processes could be used to justify weakening environmental protection or improvement goals. While the group did not revise its overall goal, a series of team and subgroup meetings produced revised management objectives (Table 1), accompanied by specific targets and metrics (Supplement C). We examine these outcomes further in the findings section.

2. Natureculture Conceptual Lens

Investigating the process of developing rangeland management goals and objectives, as a focus of social research, requires a conceptual framing of human-nature relationships that moves beyond anthropo or eco-centric traditions (Glaser et al. 2008). As Lorimer (2012) argues, a growing emphasis on "multinatural" or "more than human" approaches to social sciences, by returning to questions of ontology, requires interdisciplinary inquiry of conservation and ecology in the Anthropocene era. The latter "represents the public death of the modern understanding of Nature removed from society" (Lorimer 2012, p. 1). Natural resource scholars increasingly recognize that complex links between humans and our environment preclude separate conceptualizations of "Nature" and "Culture" in the modernist sense (Latour 2012; Glaser et al. 2008). They have joined geographers and anthropologists in rejecting human-nature dualisms, seeking instead new tools to interrogate social reality and create opportunities to conserve multispecies thriving in an interconnected world (Huntsinger and Oviedo 2014; Roesch-McNally et al. 2018; Glaser et al. 2008, and Hruska et al. 2017). For example, the natureculture concept (Fuentes and Wolfe 2002; Haraway 2003; and Malone and Ovenden 2016) creates space for novel examinations of relationships between and among species and their environments.

The nature-culture concept recognizes the inseparability in ecological relationships that are formed through biophysical and social processes (Fuentes and Wolfe 2002; and Malone and Ovenden 2016), a tangled bond of nature with culture, and of biology and evolution with history (Haraway 2003, 2004). In selecting this framework, we seek a lens that offers an alternative to the human/nature, rational/emotional dualisms that have, for so long, limited the relationships between social and natural sciences. The human/nature divide has constrained rangeland systems research with ontological and epistemological incongruities, for example in recent debates about grazing management in the range science literature that pitted manager experience against positivist experimental evidence (see: Briske et al. 2008, 2011). Nature-culture thinking tackles the nature/culture divide explicitly via a consideration of (a) beyond-human agency; (b) manager responsibility to the natural world; and (c) consideration of relational ontologies, or "more-than-human" assemblages of interacting and co-existing species; (Haraway 2003; and Latour 2004). We engage with vital materialist ontology to explore "hybrid" or "cyborg" mixtures of human and non-human components and discuss social "response-ability", or manager's ability to adapt and relate to "flourishing" human-wildlife worlds (Haraway 2008; and Lorimer 2012).

Nature-culture provides a lens for interpreting how goals and objectives are constructed in the context of rangelands, where modernist agronomic approaches to land management fail (Sayre 2017) and productivist management goals have given way to multifunctional goals, or a combination of production, consumption, and protection priorities (Wilson 2007; and Holmes 2006). Nature-culture thinking allows social and biophysical scientists to consider the responsibility species have toward one another, and the role of multiple types of knowledge in shaping inter-species relations (De la Bellacasa 2010; Haraway 2008). In rangeland management, interspecies relations extend to the consideration of an entire agro-ecosystem, spanning various groups of managers, domestic livestock and managed wildlife populations, vegetation, and soil communities, and prevailing weather and climatic conditions, all at multiple spatio-temporal scales. Experience, emotion, and moral reasoning shape the culture of these multispecies relations, as they help individuals and social groups navigate biophysical processes and the decision-making of non-human agents (Plumwood 2006; Roesch-McNally et al. 2018; Ellis 2013; and Nightingale 2011). Given the need to interpret human-ecosystem relations as they relate to goals, we employ two key concepts to inform geographic and emotional specificity in the discussion of rangeland nature-cultures: A sense of place and hope.

Sense of place involves the meanings, emotions, and beliefs that tie individuals and communities to landscapes and multispecies networks (Chapin and Knapp 2015; Williams and Stewart 1998; and Masterson et al. 2017). Daily decision making for land managers—both ranchers and conservationists—depends upon working knowledge of geology, biology, ecology, climatology, and the dynamic and multi-scaled social, economic, and political context. This decision-making is situated in families, local social networks, religious practices, and in cultural traditions and history Knapp and Fernández-Giménez 2009). Management is living knowledge of place. For example, Marshall (2010) investigated the relationship between place attachment and resilience to climate variability for Australian ranchers, and showed that the most resilient, place-attached ranchers were also willing to use seasonal forecasts, and were employable, strategic, and financially secure. A sense of place may also serve as an important driver of stewardship and conservation ethic (Chapin and Knapp 2015).

Hope is "the will and the way" to achieve a different future (Snyder 1995). A goal-directed cognition, hope indicates important, socially acceptable goals that are under one's control and have some probability of attainment (Averill et al. 2012). Hope provides a foundation of human learning and coping (Snyder 1995), and is distinct from optimism, which is a positive outcome expectancy that does not necessarily enable navigation of roadblocks to goal attainment (Scheier and Carver 1985; and Rand 2017). In natural resource management, hope influences how managers establish goals and adapt these to achieve a sense of progress (Snyder 1995).

Ranchers often identify as conservationists and business people and prioritize goals for long term sustainability and lifestyle (Wilmer and Fernández-Giménez 2015; and Smith and Martin 1972). Rancher decisions involve trade-offs between profitability and sustainability, often during stressful drought or variable market conditions (Kachergis et al. 2014). Such decisions can be intellectually and morally daunting, as well as emotionally exhausting. The goal of passing a ranch to the next generation is a common aspiration and indicator of ranch-system resilience to these challenges. For conservationists, in contrast, optimism is fleeting for the decline of grassland bird species in the Great Plains to be reversed, as bird surveys continue to indicate rapid population declines across many species (North American Bird Conservation Initiative US Committee 2009; Samson and Knopf 1996). Hobbs (2013) suggests that conservation practitioners and researchers experience a process of grief in addressing species loss. Finding hope to reverse biodiversity loss may be important to reenergizing conservation science and practice (Jackson 2006).

Below we apply natureculture thinking as an analytical lens for rangeland management. We describe in more detail how objectives for conservation and ranching were constructed and revised (after five years of management) by participants in the CARM study. We then discuss how this process reveals the development and practice of nature-culture in CARM, including a sense of place through the development of more place-specific knowledge, and hope, by finding a will and a way toward positive outcomes.

3. Methodology

We employed a constructivist grounded theory approach to our qualitative analysis because it provided a rigorous method for examining our largely qualitative data set and for building on current theory through iterative data collection and interpretation of social experience and meaning-making (Charmaz 2006). Our use of the nature-culture conceptual lens, however, required a direct engagement with the interrelated socially and biologically constructed reality of the CARM experience (Lorimer 2012). The CARM project involves ongoing interpretation of weather and seasonal climatic forecasts and biophysical monitoring data by stakeholders and researchers together, including: Grassland bird abundance and nesting behavior; vegetation structure, production, and composition; cattle behavior, dietary quality and weight gain; and eco-hydrological monitoring from the grazing experiment and from other research at CPER and beyond. Key monitoring results of annual and weekly indicators were posted on the project website (https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/rangeland-resources-systems-research/docs/range/adaptive-grazing-management/research/). Progress toward management objectives was summarized by researchers at each quarterly meeting. While more in-depth examination of these ecological data will be published elsewhere, initial findings and interpretations were foundational to the social processes documented in this study. Our examination of interacting and interconnected biophysical and social data allowed us to engage more directly with questions of ontology in CARM and to counter-balance the anthropocentric aspects of our qualitative approach.

Qualitative Data Collection and Analysis

We focus on the revision processes of two key project objectives, both of which were first developed in 2012, in order to narrow our examination of the broad and data-rich CARM case and because the process of revising project objectives was staggered over several years. The vegetation objective aimed to increase plant species diversity and the production of cool-season mid-grasses (Table 1). This objective captured important aspects of both biodiversity conservation and grassland production for the CARM group. The second objective focused on wildlife, specifically the most threatened grassland songbird species on the project, the McCown's longspur, which is a short-structured grassland obligate. Additional vegetation and wildlife objectives were developed, but have not yet undergone in-depth revisions. Profitable ranching objectives are slated for revision in 2018–2019.

Each CARM team meeting was audio recorded and subject to in-depth note taking. For this study, we collected field notes and transcripts of meetings between January 2017 (when the revision process for goals and objectives began) and April 2018, and organized these in a computer spreadsheet. This included notes from whole team meetings, researcher-only reflective meetings, and personal field notes submitted throughout the project by researchers to an online form. We separated qualitative data relating to: (1) Reflective or summary discussion, (2) meetings and text regarding the vegetation objective, and (3) meetings and text regarding the wildlife objective. This included the original and revised goals and objectives language (Table 1) from the official CARM planning document: The "Grazing Management Plan".

We first identified major events and data products (e.g., Supplement A Tables A1 and A2, Supplement B) used in the revision process, and related these to literature, in order to select the nature-culture theoretical framework with which to evaluate the CARM experience. The first and second authors coded the transcripts via note taking within the spreadsheet to indicate both an interpretative summary of events and analytical notes in cells next to pertinent qualitative data. We compiled initial observations in a research memo and suggested two possible themes related to how CARM participants navigated and negotiated the objectives revision process. We identified these explanatory concepts as sense of place and hope. We explored these concepts with the other researchers and a subset of two stakeholders. At this time, project ecologists also provided insight into relevant biophysical data related to the objectives. We returned to the literature to refine our understanding of concepts of sense of place and hope, and their use in natural resource management, and the first author re-read the data and coded for specific examples and counter-examples of the hope and sense of place themes. We enhanced the trustworthiness of the data analysis by providing an audit trail of data synthesis, including direct quotes to inform reader interpretation, and by engaging in peer and member checking of key themes (Lincoln and Guba 1985, 1986). CARM participants gave informed consent to participate in social research regarding their decision-making via Colorado State University IRB Protocol 12-3381H. Qualitative data are provided in Supplement C.

4. Findings

4.1. Developing a Sense of Place

Through the early years of CARM and during the objectives revision process the team demonstrated growing attention to spatial, temporal, and theoretical specificities, including naming previously numbered CARM pastures (Figure 2). The team's revision of the vegetation production and diversity objective illustrated this process. The revised vegetation objectives included different production targets on three distinct soil/site types across the landscape (Figure 2). This increased specificity was based on extensive discussions of the ecological concepts and processes that relate site characteristics to management aspirations. The team also incorporated more specific temporal dimensions into the revised objectives. They assessed previous research, indicating that stocking-rate driven changes in vegetation composition take multiple decades at the site (Porensky et al. 2017), and discussed whether objectives to increase vegetation diversity and production of forage grasses were achievable in the planned ten-year time span of the project. In this exchange during a subgroup meeting, a researcher (1) asked a public land management agency representative to consider time scales for vegetation objectives and received a candid response:

> Researcher (R1) prompting stakeholders to decide the time scale for the revised objectives: " ... You just mentioned time scale. What about time scale and making sure that's in here?"
>
> Agency representative (AR1) draws upon her professional knowledge of the ecosystem: "50 years."
>
> (All-Laughing)
>
> AR1: "Seems most realistic out there."

By indicating that change would take decades in this slow-changing ecosystem, this agency representative brought in her local professional knowledge to help ensure that the CARM objectives were realistic. Eventually, the team extended temporal targets for the project as long as possible, at the logistically and funding-constrained ten-year time span of the project, which encompassed a realistic management horizon for ranching families and agencies (Table 1; Supplement C). The team spent multiple meetings selecting appropriate targets that accounted for the range of precipitation variability at the site. The team ultimately set targets for cool-season grass production in relation to 2015, a year within memory that had exceptional production. Rationale for the cool-season-mid grass objectives included the importance of increasing seasonal forage production during shoulder times (starting and ending of the grazing season in this warm-season grass dominated ecosystem), providing wildlife habitat, and increasing the capacity for enhanced forage production in wet years.

The CARM team also examined conventional theoretical frameworks used in rangeland vegetation management relative to their growing spatial and temporal ecological knowledge. US federal public agencies have adopted resilience-based theories of vegetation dynamics illustrated with state-and-transition models (STMs), or conceptual diagrams that indicate hypothesized management-driven plant community change at specific sites (Westoby et al. 1989), as illustrated in Figure 4. Public agency stakeholders asked the team to revise species composition targets using existing STMs. However, STMs for the study site indicate assemblages of species and alternate states not currently present or observed previously at CPER. Further, some team members disagreed with the use of vegetation targets that were based on the STM's "reference state" or "Historical Climax Plant Community". Team members argued that the reference state did not properly describe the group's desired conditions and failed to incorporate natural ecological disturbance regimes, climatic changes, or wildlife habitat needs. This was illustrated by an exchange during one meeting at which an agency representative and conservation group representative discussed the use and limitations of Ecological Site Descriptions (ESDs, which contain site-specific STMs) in the revised objectives:

> Conservation group representative 1 (CGR1) clarified how the new vegetation objective differed from the original 2012 objective: "This [revised vegetation objective] is moving beyond cool-season grasses, and trying to have a clear objective, and it's also then introducing the ESD [Ecological Site Description] as a reference point."
>
> Researcher 1: "Yes, [we are trying to develop] more specific objectives, including lessons learned with 4 plus years of data. You understand there's a loamy, sandy and mixed [ecological site]. To take it one step further."
>
> Agency representative (AR1) clarified that the proposed revision included a reference plant community derived from the Ecological Site Description: "It's introducing the reference state as a reference point."
>
> CGR1 expressed concern about the use of the reference plant community: "I don't feel like that expresses, this one doesn't express a value we would like."
>
> CGR2, agreed with AR1: "We would like to get, to get as close as we can to the reference condition."
>
> AR2, trying to understand why the reference plant community is needed in the revision: "Is this that cool-season grasses link to [cattle] weight gain?"
>
> Researcher 2 (responding to AR2): "These states include cool-season grasses and more diverse plant composition."
>
> CGR1 (responding to CGR2): "That, I have a problem with that."
>
> CGR2: "You don't want a more diverse plant community?"
>
> CGR1: "I've been trained to be very skeptical of the reference states [in Ecological Site Descriptions]. And I have experience in this area and I've seen agency people without mentioning names push for reference states which are their opinion of Ecological Site Descriptions."

The team voted to adopt revised vegetation objectives that did not include STMs as references but had more place-aware targets for production of cool-season forage species and plant biodiversity as two separate objectives. Groups of pastures managed under different targets are indicated on Figure 2.

A growing sense of place indicated by spatial, temporal and theoretical specificities, also informed the revision process for the wildlife objective. Team members assessed the site characteristics (vegetation composition, topography, and soil type) where the short-structure obligate bird, McCown's longspur, had historically been found and discussed, where pastures were potential management targets (Supplement B). Debate centered on whether objectives should reflect ideal future conditions and result in the creation of as many pastures as possible for a species in steep decline, or strive for more pragmatic conditions that would prioritize management on two or three pastures where outcomes were most likely to be achieved, considering other objectives. One agency representative noted:

> "The question is: are we creating this habitat in every pasture every year? On these three pastures? Or are we creating [habitat] on one of these three pastures every year?"

Stakeholders and researchers engaged with existing conservation theory, particularly heterogeneity-based management (Toombs et al. 2010; and Fuhlendorf et al. 2012) in relation to place-based knowledge of the CPER site. In several meetings, the team discussed the limitations of applying the general heterogeneity-based framework (see Figure 5) to the objectives without considering specific pasture characteristics, the broader land-use context, and relevant temporal scales. The exchange below among researchers and stakeholders illustrates how the group grappled with data, suggesting that long-term, heavy grazing may be needed to shift species composition, lower vegetation height, and create habitat for McCown's longspur.

Researcher 1: "So how many years do we have to hit [heavy graze] it? If one year [does not create the habitat]. Do you think five years of hitting it?"

Conservation group representative: "These outliers? That are potential [longspur pastures]?"

Researcher 1: "Yeah, heavy graze Nighthawk [pasture] for McCown's."

Researcher 2: "I think 30–50 years of heavy, sustained grazing, every year."

Agency representative: "I don't know what you're basing that off of."

(Laughter)

Researcher 2: "That table I showed you earlier today."

Agency representative: "So you're saying, somehow, they're, depicting species, so it has nothing to do with height. And they're depicting the buffalo grass and blue grama."

Researcher 2: "It has everything to do with height, but they know that species predicts height."

This ecologist ("Researcher 2" above) discussed this in more depth later in the meeting:

"If you want to generalize that [vegetation] height is really important, and in many cases more important than the species composition. But once you get to know these rangelands you start to realize that how you manage over the long term, for particular compositional shifts, greatly affects height. You know? Managing with long-term sustained heavy grazing is the way you get into a blue grama [shortgrass] dominated state that will consistently give you more short vegetation. The more midgrasses [e.g., western wheat grass] you have the more that height's going to fluctuate with rainfall."

This challenged the view of some in the group that heterogeneity (and biodiversity) could be maximized by increasing plant diversity and cool-season plant production, and by "not grazing the same pasture the same way every year." A conservation group representative expressed these challenges in reconciling theory with place-based knowledge in this way:

"I'm struggling between landscape scale objectives and pasture scale objectives. There are sometimes conflicts between the two. I'm not sure we have a decision framework for those two. Something in my ecological brain doesn't like having a fixed plan for a fixed place. Maybe it is a time scale, or place. My knowledge of the ecosystem doesn't like that."

This "struggle" to apply to a ranch or pasture-scale theoretical framework for conservation that emphasizes landscape and regional scale patch dynamics appeared repeatedly throughout the qualitative data. Following the emerging "heterogeneity" school of rangeland management, original objectives indicated the team would strive to increase heterogeneity at every scale, at all times (Toombs et al. 2010). The strategy to achieve this was to rotationally graze eight pastures with a single herd of cattle, resting two different pastures each year, and the pasture sequence of grazing would not be similar from one year to the next. The team discussed lessons from CARM and long-term data from CPER indicating that the McCown's longspur avoided pastures that had been rested the previous year, and preferred pastures with very short vegetation that had been shaped by multiple decades of heavy, season-long grazing. Data suggesting that the species of greatest conservation concern in the project required "a fixed plan for a fixed place" necessitated increased awareness and attention to pasture and ranch-scale spatial specificities.

The final proposed objectives included spatially and species-specific targets for grassland birds, as one conservation group representative articulated in discussion:

"I think we could do two things. Should we have a McCown's longspur objective? I'm saying I would be for that. And the second is, I would rather it be a local objective, not a CPER wide [objective]."

During the first five years of CARM, stakeholders made several requests to increase the number of tours, pasture photos and maps to help interpret CARM outcomes. To enhance geographical knowledge, the team added annual field tours and increased geospatial data and map-based communications. In 2018, a stakeholder described the value of field time during quarterly CARM meetings to enhance their pasture-specific knowledge and understanding of ranch-scale context and changes. They lamented that their knowledge of place had been limited by a lack of time on-the-ground early in the project, as the 2012 objectives were written before the researchers conducted a baseline assessment (in 2013). Multigenerational rancher stakeholders, who had more local knowledge, boosted the group's sense of place by sharing their experiences and observations with relative newcomers to the area.

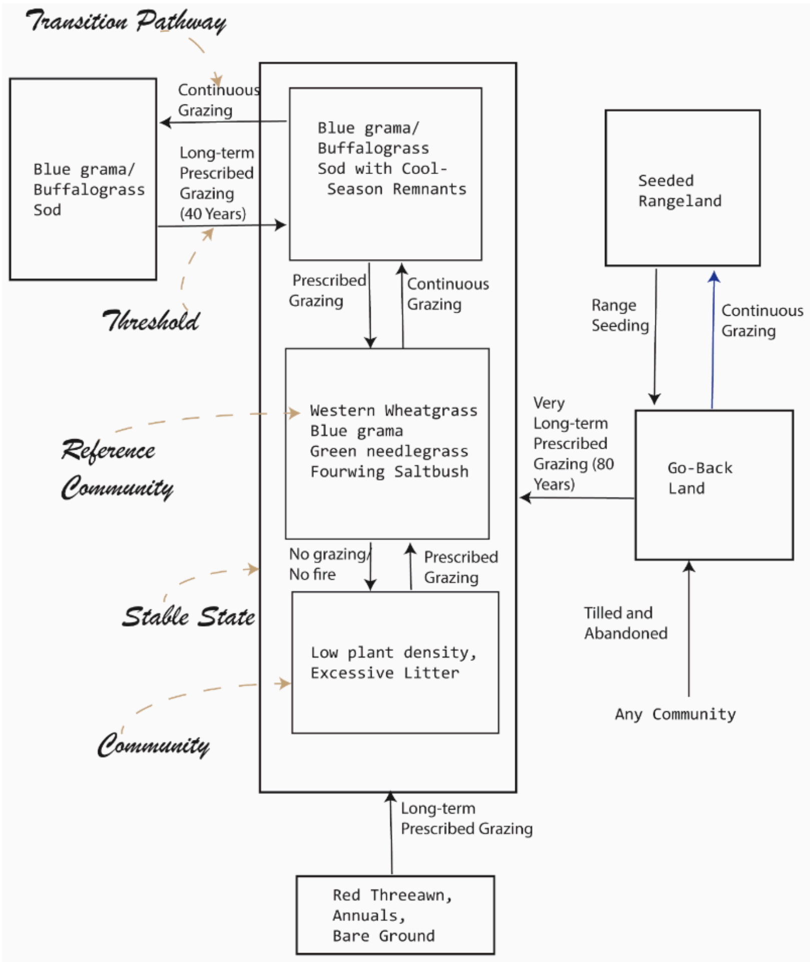

Figure 4. Ecological Site Descriptions (ESDs) are part of a land potential and vegetation classification and mapping system used by US federal land management agencies and private land-owners. ESDs include an estimate of rangeland production and vegetation potential based on specific climate, topography and soil characteristics. They often include State and Transition Models (STMs) such as the above-modified representation of the STM for the Loamy Plains ecological site that includes the study site, CPER, (downloaded December 2017). STMs are conceptual diagrams that indicate hypothesized management-driven plant community change (Westoby et al. 1989). Stable vegetation "states" may include multiple plant communities, including reference or "historic climax" plant communities (Stringham et al. 2003; and Briske et al. 2017). Transition pathways among communities are indicated for managers, and often emphasize grazing management (Twidwell et al. 2013). Transitions among states, or thresholds, are theoretically not reversible, though STMs, including this one, often include reversible dynamics among states (which have also been empirically demonstrated in this region, see Porensky et al. 2017).

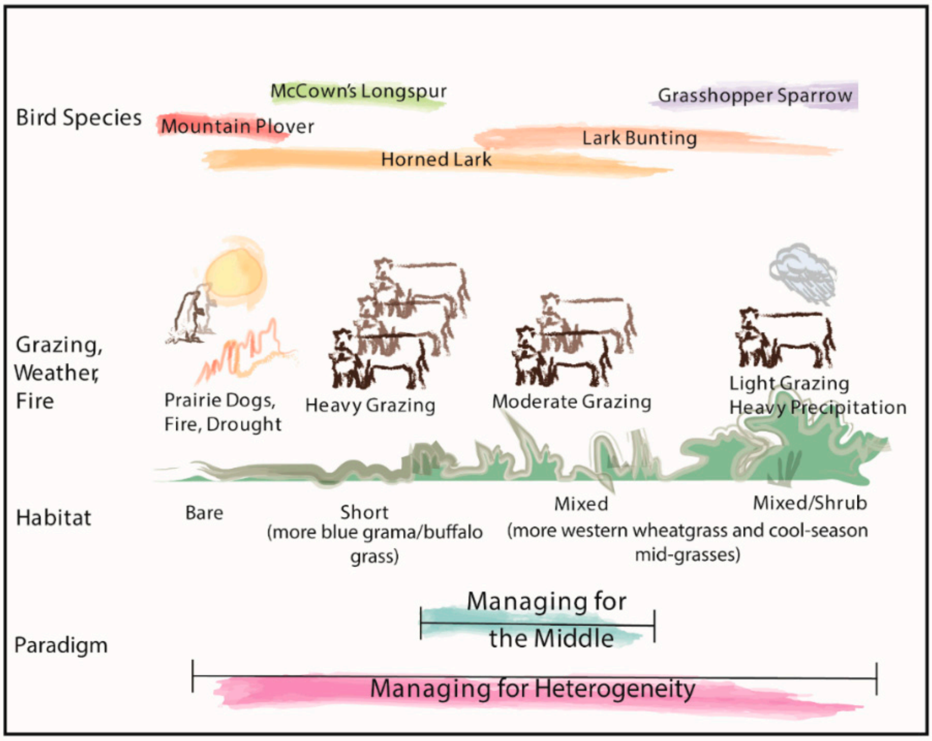

Figure 5. Graphical representation of heterogeneity-based rangeland management paradigm hypothesis. This predicts that a spectrum of vegetation structure from bare ground to tall created through the interaction of ecological disturbances (fire, weather, large herbivore and small-mammal herbivory), provides habitat for a broad suite of grassland species. Heterogeneity-based management contrasts with a "managing for the middle" approach promoted for years in rangeland management to optimize beef production (Bement 1969). Modified from Knopf (1994).

4.2. Hope: A Will and a Way

> "Look at the grassland birds that are declining in population. McCown's, lark bunting, mountain plover and grasshopper sparrow. You don't have to be a very good economist to see that these negatives are bad numbers. This didn't make it to the Endangered Species list, but it could. What are we going to be doing on this project to counter that?"

During the objectives revision process, the researcher quoted the above synthesized information regarding the rate of grassland bird decline and prompted the CARM team to discuss what opportunities they had to make an impact on conservation, and to prevent the birds of interest from becoming subject to additional conservation regulations that might impede ranching operations. The team discussed limitations of weather, animal behavior, and external human activity related to grassland conversation to agriculture and development both in the Great Plains and in the Mexican wintering grounds of the migratory grassland species. At several points during the process, the team recognized that desired outcomes would be difficult or perhaps impossible to achieve because of the uncontrollable effect of these combined drivers. A rancher reflected on the long-term trends in grassland bird populations and questioned:

> "Do we change our grazing management? Or do we not change our grazing management because there are no birds to come back?"

The team nonetheless moved forward to design aspirational goals, demonstrating a concept we coded as "responsibility to possibility" or the sense of responsibility and hope that framed their revision efforts. One conservation group representative stated:

> "These birds are facing a long-term decline, it would take a long time to bring birds back. If we manage better, we could stabilize them if not increase them in places."

The team developed the hypothesis "if you graze it, they may come," (echoing a line from a popular movie) during the CARM meetings. This indicated the belief that they could improve prospects for the species by creating habitat, in the hope that habitat would lead to increased McCown's longspur populations. A conservation group representative said:

> "I've always been struck by this, the populations. When most of these birds go away, that's so totally out of our control, in some ways. Having a habitat objective makes a lot of sense to me. I'm not opposed to saying something about the populations. But we can't necessarily say that populations are improving or declining because of anything we've done. Whereas we can, if we are really focused on making sure we have a certain amount, whatever that amount is, of the right habitat, we can."

In implementing the "if you graze it, they may come" idea, the team discussed how they could act for positive change, even if external factors (weather, farming and grazing practices, and exurban development) drive the species into further decline. One stakeholder, a public agency representative, reflected later that the CARM stakeholders hoped this positive change would gain recognition by managers outside the research project. They said: "the idea is that you set an example, and you hope that grows. You hope that whatever you can do, even on a small scale, people will recognize that, and it will spread."

The importance of finding hope for better outcomes in CARM was particularly pronounced for researchers, who spent the most time with the data and were acutely aware of the consequences and limitations of CARM progress. In this capacity, they felt a strong responsibility to project outcomes and for how the objectives were written. A short exchange during a subgroup meeting between a researcher and two stakeholders illustrates this point:

> Researcher (AR1): "Why not manage all of [these pastures for longspur]? It's the rarest species in the whole landscape."
>
> Conservation group representative 1 (CGR1): "Yeah. Well, why not all of them, but we better make sure we're focusing on those two [pastures] where most of the nests are."
>
> CGR2: "Why not all of them? Because that's contradictory to some of our other goals. That's why not all of them."
>
> Later, the same researcher reflected on this experience in this way:
>
> "As a scientist I see the data first, I experience it when I'm doing point counts. But I wait, and after two years we show the decline at the meeting, and by then there is not much we can do, and I am so frustrated."

In a group reflective session, the researchers noted that they were motivated to be involved in CARM because it offered a chance to make a positive impact in real conservation and production outcomes, both at the scale of the project and regionally, and to combine ecological and production-focused research efforts. One researcher reflected on the CARM experience:

> "It is hard to take off the scientist control hat. We were brought up to have full control of experimentation. We usually take out variability, test clearly identified treatments in a hopefully replicated design. […] This is a more holistic approach with impact, where we can understand implications of trade-offs and synergies, to have that impact. But it is hard to sit in the back of the room and watch the train come off the tracks and have to be quiet … "
>
> Another scientist echoed this sentiment, adding:

> "I care about conservation and producers. That's why I'm in this job. What excites me is it [CARM] is forcing us to be humble as scientists, and listen more, which is really important. I'm learning more about other people's knowledges, and how they think about the world."

Based on these reflections, the research team proposed guidelines for their involvement in CARM decision-making that allowed them to provide professional advice without becoming voting members (Supplement D). The team also discussed the need to work with an experienced facilitator to ensure that individual scientists could provide this advice outside of a facilitator role. Revising the scientists' roles allowed them to explore explicitly their own professional, personal, and emotional sense of responsibility to management objectives.

This reflection prompted new insights, including that for researchers and other stakeholders, a key aspect of hope in CARM involved responsibility, or "the will" to act for a better future. A subset of team members described the view that the group should take responsibility to act in any way possible to improve outcomes for the longspur. One team member expressed concern that a spatial target for bird conservation was too small. He said, "Why don't we have a more aspiration goal of what we'd like to see?" Another said:

> "Some people wait until they know birds are in decline, or that grazing is impacting birds, and then they act. I assume that we should do something before we know for sure that they are declining. I assume we should act until we have good evidence that they are fine."

They went on to describe what they saw as an "apathy of scale" in conservation, or the attitude that "someone else will deal with it" or that "conservation is beyond our control" because it is constrained by land use change or climate and weather. Proposed longspur objectives were presented at a full-team meeting in April 2018 with a rationale that identified the longspur as the species of "greatest conservation need in Colorado" and recognized barriers to success: "climatic trends, extreme weather events and changes in habitat outside the breeding grounds."

5. Discussion

The themes of sense of place and hope illustrate a nature-culture developing among the CARM team as members come to know place—a specific landscape full of interacting wildlife, vegetation, livestock and human communities. The process reveals how the team found a will (taking responsibility for) and a way (via more place-specific objectives) to envision a path forward. This became an emotionally challenging and socially complex experience, for both stakeholders and scientists, as team members re-evaluated their roles in the project, the application of well-established theories for management, and their experiences as participants. Rather than opting just to maintain habitat or vegetation composition where possible, the team expressed hope by writing aspirational, but pragmatic objectives for improved management at CPER.

5.1. Advancing Goal Setting for Conservation and Ranching Outcomes

This analysis of the CARM team's experiences illuminates how nature-culture develops to shape management objectives, a finding that has potential to advance collaborative conservation and management elsewhere. The team's engagement with current theories in rangeland management, including State and Transition Models (STMs) and heterogeneity-based management, suggests that community-engaged research can build upon our understanding of current ecological theories and decision-support resources (Joshi et al. 2017; and Knapp et al. 2011). We find that the process of discussing and modifying these theories in relation to place-specific information helped the team develop a sense of place, which in turn enabled them to craft more relevant, achievable objectives. In practice, CARM participants from diverse backgrounds relied on STM or heterogeneity-based theories to envision desirable future rangeland conditions. Those using the STM framework sought to achieve a reference plant community, while those from the heterogeneity school sought to create landscape scale heterogeneity.

Those seeking to define vegetation objectives based on "reference states" desired plant communities that exhibited their full "potential" relative to a specific combination of climate, topographic and soil characteristics. The reference plant community was described as a diverse mix of productive, native forage species with multiple growth forms and structures. A "reference state" objective seeks conservation of soil and plant diversity. The paradigm of reference-state based goals dates back to early ecological theory and management of rangelands (Sayre 2017; Clements 1928; Dyksterhuis 1949; and Briske et al. 2018) and is interpreted as the desire for presumed pre-European conditions. This approach often implies that a removal or reduction of disturbance (grazing, fire) improves rangeland "condition" (Clements 1928; Twidwell et al. 2013). We recognize that the STM literature and many users and teachers of STM concepts have gone to lengths to clarify that managers should set site-specific objectives and that the "reference state" is not the de facto vegetation objective for every site; however, earlier Clementsian ecology did presume a desired condition, defined as an "historic climax plant community". Our data show that managers' practice of these concepts is still shaped by the idea that conservation is generally achieved by minimizing disturbance and managing for a conceptualization of "reference" conditions. The reference state paradigm supports the discourse that managers can "do well by doing good" for the rangeland plant community, and posits tight feedbacks between rangeland plant species composition and ranching outcomes from cattle grazing. In particular, shifting rangeland plant communities towards the so-called "reference state" is generally hypothesized to lead to improved long-term ranch sustainability or profitability.

In contrast, stakeholders approaching objective setting from the heterogeneity paradigm sought conservation outcomes for wildlife which they believed would benefit from increasing variability in vegetation height and density across the landscape (Toombs et al. 2010; and Fuhlendorf et al. 2012). These characteristics are typically created through the management of ecological processes such as fire and grazing by large herbivores. While biodiversity conservation is the main objective of this paradigm, recent literature (and a hypothesis in CARM) explores the potential for heterogeneity-based management to maintain or improve beef production outcomes, via creation of forage reserves across the landscape that enhance drought resilience for ranchers, or via patch burn grazing to manage the distribution of high-quality forage quality (Fuhlendorf and Engle 2004; and Derner and Augustine 2016).

The CARM team's collaborative attempts to simultaneously employ both paradigms in one place revealed mismatches between the two theoretical frameworks at various temporal and spatial scales. In the vegetation objectives revision, those that sought a diverse "reference state" in all pastures faced opposition from those who sought heterogeneous rangeland composition and structure among pastures to support grassland bird habitat, particularly for shortgrass species. The fact that managers in CARM set out to use local STM reference conditions as baselines for their vegetation objectives, but ultimately created their own, place-based vegetation objectives that accounted for bird habitat requirements, indicates the importance of flexible, locally-relevant engagement with ecological theory coupled with explicit consideration of multiple management goals. Likewise, the challenges that the CARM group faced in engaging heterogeneity-based objectives, particularly for McCowns' longspur, suggest that non-spatial, theoretical management paradigms will be difficult for managers to adopt until such paradigms are related to and grounded in place-based knowledge built over long timespans. From an ethnographic perspective, this illustrates the complex and difficult process of how the CARM group interpreted and applied knowledge of what was possible for conservation improvements at the site.

Our evaluation of the CARM project also provides insight into the challenges conservation groups and ranchers face from external drivers such as climate, economic and ecological change. Ongoing research on the feedbacks between rangeland management strategies and ecological outcomes across scales highlight these barriers. For example, long-term data from the Great Plains and globally have identified the role of climate change and weather in rangeland plant community composition change (Hoover et al. 2014; Augustine et al. 2017; and Fernández-Giménez and Allen-Diaz 1999). Management baselines are shifting due to warming, changing seasonal patterns, and increased carbon dioxide

(Derner et al. 2018); thus, backward-looking management goals, such as the desire for pre-European conditions, are increasingly unrealistic (Perryman et al. 2018; Jorgenson et al. 2018). Economic research indicates the importance of variable weather, as well as fluctuating livestock markets, in limiting ranch profitability (Hamilton et al. 2016). This is a humbling prospect for ranching families, conservationists and researchers dedicated to intensifying agricultural production and improving conservation outcomes in the region. In the context of grassland bird conservation, urban development on migratory birds' wintering grounds in Mexico may nullify any conservation efforts in the Western Great Plains near the CARM study site (Pool et al. 2014). In sum, management research and recommendations have potentially over-emphasized the power of particular grazing management strategies to produce different ecological outcomes in complex, stochastic rangeland management systems, even in the relatively slow-changing, semi-arid Western Great Plains (Wilmer et al. 2018).

5.2. Fostering Hope and Sense of Place in Range Decision-Making

Our experience with CARM suggests that there is an increasing need to foster hope in public land managers for their ability to achieve conservation outcomes under high levels of uncertainty and with a lack of control over adjacent lands. What the CARM experience teaches us is that managers with hope and a sense of place are willing to try to achieve objectives that serve both conservation and production goals despite the variability and unpredictability of the ecosystem and management outcomes. CARM illustrates how community engagement in research can foster this responsibility to multispecies thriving by connecting manager communities to the landscape, and to one another. Managers from diverse backgrounds can effectively collaborate to develop and refine aspirational management objectives that work around the limitations of broader climate, biological and social drivers. Fostering knowledge of place and "a will and a way" to improve conservation outcomes may play a key role in overcoming these limitations to enhanced stewardship. Outside of the research context rangeland management for multiple goals often requires collaboration by diverse interests, and local manager knowledge can contribute to hopeful goal setting. Scholars of pastoralism have shown that herders worldwide, like US rangeland managers and the CARM stakeholder group, consciously and deliberately work within the bounds of "Nature". For example, pastoralists use their knowledge of topography, animal behavior, social networks, climate and ecological processes to adapt to large swings in precipitation and extreme events through flexible approaches that match forage supply and quality with demand, maintaining animal well-being, and negotiating access to both natural and human resources (LaRocque 2014; Huntsinger et al. 2010; Fernández-Giménez and Estaque 2012; Reid et al. 2014; and Davis 2016).

Developing a sense of place and practicing multispecies responsibility within a grazing research project like CARM requires manager-inclusive research methods and a commitment to connecting communities and ecosystems. Outside of the research context, public agencies, and conservation groups facilitating collaborative rangeland management can seek to build connections to place by maximizing stakeholder time together on the landscape and access to decision-making responsibility. The CARM team will always be less connected to CPER and the shortgrass ecosystem than if they were living and working on the site together. Those who do not have a connection to ranching are particularly distanced from the physical and emotional labor, financial risk, and lifestyle reward of the industry, as are absentee land owners and many of the decision-makers in other collaborative management contexts. Our analysis suggests that connecting local stakeholder groups to the scientific process and to extensive rangeland landscapes through management responsibility enables them to begin to develop and practice a new rangeland nature-culture. Development of nature-culture emerged from a growing collective sense of place and hopeful choices that re-imagined better conservation outcomes on the landscape.

Place-based knowledge, as practiced by pastoralists and ranchers, shapes their identities, families, communities, and their ecological environments (Knapp and Fernández-Giménez 2009; Fernández-Giménez 2015; and Dong et al. 2016). Research interpreting rancher local knowledge is limited (Knapp and Fernández-Giménez 2009), yet research on local ecological knowledge in natural resources management generally suggests such place-based knowledge shapes and is shaped by emotional, religious, spiritual, social connections to and management of specific places (Masterson et al. 2017; Plumwood 2006; Fernández-Giménez 2015; and Fernández-Giménez and Estaque 2012; Robinson et al. 2000; Aswani et al. 2018). Ranchers' local knowledge may also exist at scales that are different from those of research-derived knowledge and practice (Cote and Nightingale 2012). Knowledge built from prolonged management experience can be both deep—reflecting knowledge of ecological relationships and change over decades—and wide, spanning landscape scale social and ecological contexts (Kassam 2008). Evaluations of rangeland species composition across ranches with varying grazing strategies but culturally ubiquitous ranch goals for long-term viability showed that varied strategies could produce very similar results (Wilmer et al. 2018). Perhaps local knowledge of experienced managers, particularly ranchers who operate with a hopeful outlook, can provide insights for the broader management community seeking to develop effective collaborative conservation efforts (Knapp and Fernández-Giménez 2009; Tuhiwai Smith 2013; Chapin and Knapp 2015; and Fernández-Giménez et al. 2006).

6. Conclusions

This investigation into the process of revising goals and objectives offers insights into effective adaptive management and planning at ranch, community and regional scales (Domínguez-Tejo and Metternicht 2018). The CARM experience suggests that a discussion of nature-culture thinking is an important next step for collaborative conservation and management planning, which may depend on a sense of place, and the responsibility decision-makers feel to multiple species. Developing individual and community sense of place requires extended experiential time on the landscape together, and learning from local managers, such as ranchers, especially early in the process and especially for recent arrivals to the local area (Fernández-Giménezz et al. 2008). It also requires time for interpretation of theoretical and local geographical knowledge, and for knowledge of regional climate and social contexts beyond the area of interest. While biophysical science lacks the reflexive tradition of qualitative research (Opie 1992), explicit discussions of the roles of researchers as facilitators versus investigators may expedite goal setting and enhance researchers' awareness of their own subjective interpretation of management objectives (Hall et al. 2018). The contribution of an experienced facilitator should not be undervalued in this process.

Community-engaged research and collaborative conservation efforts will also benefit from opportunities to develop and practice hope—the thought process of effective goal setting and attainment (Rand 2017)—and shared moral and cultural aspirations for responsibility to multispecies thriving. Adapting Snyder's (1995) recommendations, hope may be nurtured through celebrations of past success, story-telling, reflection on achievements and setbacks, and efforts to cultivate interdisciplinary conversations about moral and ethical aspects of goal setting and responsibility. These processes should explicitly consider team members from all backgrounds, including researchers and facilitators in non-voting roles. Our experience in CARM suggests that effective collaborative research and management requires more than just attention to the process and scientific methods. It also relies on effective collaborative goal and objective development, the equally important processes by which managers identify and define their own capacity and motivation to participate in responsible nature-culture.

Supplementary Materials: The following are available online at http://www.mdpi.com/2076-0760/8/1/22/s1, Supplement A: Historical management treatments of the CARM herd, Supplement B: McCown's longspur factsheet, Supplement C: Qualitative data for CARM objectives revision process.

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