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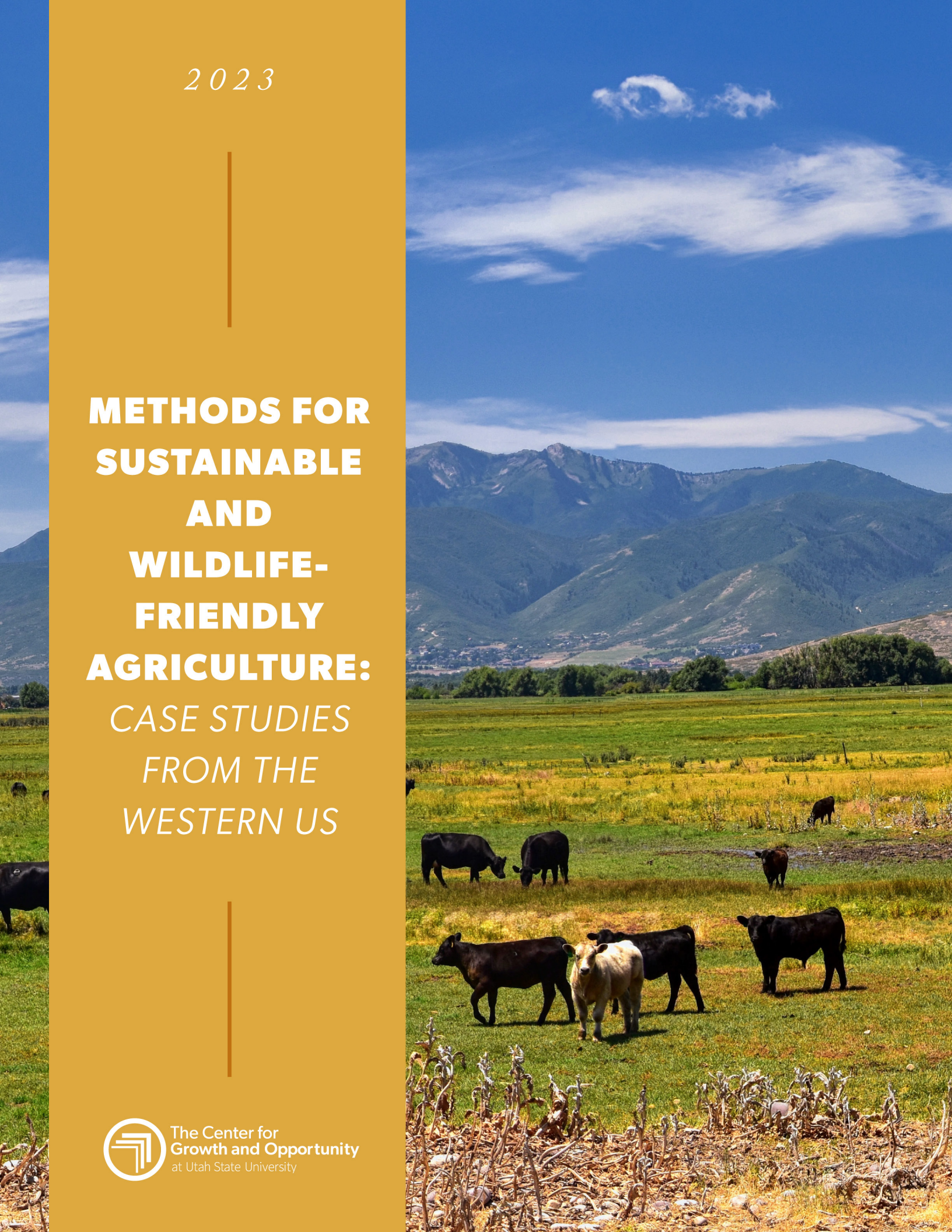
METHODS FOR SUSTAINABLE AND WILDLIFE-FRIENDLY AGRICULTURE:

CASE STUDIES FROM THE WESTERN US



The Center for Growth and Opportunity at Utah State University

Methods for Sustainable and Wildlife-Friendly Agriculture: Case Studies from the Western US

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Policy Paper

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Introduction

> Nearly every acre of range has other uses and values besides forage production—to protect watersheds, produce timber, give wildlife a home, and provide places for recreation.
>
> These are the "other" values of range. Each is important; on some ranges, indeed, the demands of one or more may dominate or even exclude grazing. If grazing is properly managed, however, the various uses are usually compatible with the use of forage by livestock.
>
> —C. A. Connaughton, "Grass and Water and Trees,"
> *Grass: The Yearbook of Agriculture, 1948*

Large working landscapes provide an opportunity in the western United States to increase conservation, biodiversity, and wildlife habitat. This paper tells the story of ranchers who are transitioning to a livestock management approach that focuses on the ecological integrity of the soil. Healthy soils, in turn, help enhance ranch revenues and can provide a multitude of ecosystem services. The approach is not new. Rather, it is a return to historical agricultural practices and natural processes.

Many methods of land management can be used to place an emphasis on soil and ecosystem health. They fall under umbrella terms such as conservation agriculture, regenerative agriculture, adaptive multi-paddock grazing, management-intensive grazing, and holistic grazing management. We use the term holistic grazing throughout this paper to imply livestock management focused on enhancing soil and plant health.

Holistic grazing is a systems approach of short-duration, high-intensity grazing that is intended to enhance soil health and, as a result, increase the forage available for livestock production. Potential cobenefits include increased water and carbon retention in the soil, greater resilience to drought, and protection of habitats and habitat connectivity. While holistic grazing is not the quintessential solution to conservation in the West, it can provide an economically sustainable method for producing food and fodder, enhancing ecological function, and providing ecosystem services.

The goal of this paper is to examine sustainable and scalable opportunities to increase conservation on western rangelands. We first describe the trend of land use change on the range and some potential unintended consequences. We then explain the benefits of intensive grazing management, also called holistic grazing, and share two case studies that demonstrate its implementation and outcomes. We describe a handful of policies that either assist or hinder the move toward holistic grazing. We then argue that sustainable conservation on large working lands requires the ranch's economic viability. Using a holistic grazing method of management is sustainable because it can provide ranchers with increased economic returns that result from the enhanced ecological function of the soil.

Why Holistic Grazing Management?

The character and ownership of large working lands across the West are changing: some lands are being combined into larger conglomerates, while others are threatened by development that fragments the landscape and reduces biodiversity and ecosystem services. This trend puts wildlife habitat and some of America's most productive working lands at risk. Holistic grazing can potentially help slow this trend by increasing the profitability of working ranches and protecting the valuable environmental resources they produce.

By necessity, profit is a driving force on working lands. Typical revenue streams, such as animal and crop sales, can be complemented by a variety of other activities. Visitors will often pay for overnight stays, access to hunting and angling, and guided interpretive trips. Ecosystem services, including clean flowing water and soil carbon sequestration, can provide a financial return if there is a functioning market for such services. Ecological and economic benefits can meet on the ground—literally. Healthy soils increase biodiversity, plant growth, and resilience to drought, which in turn increase livestock production, wildlife habitat, and profits.

The case studies in this paper demonstrate the innovative approaches that some ranchers and ranch managers have taken to increase revenue and environmental quality. While there are multiple opportunities for revenue streams from the land and resources, these ranchers have found common ground in what lies below the surface. Switching focus from commodity outputs, such as beef, to healthy soils creates a ripple effect of increasing ecological function that in turn increases feed and financial return. Livestock, wildlife, carbon, and profits are all parts of the benefit stream. Lessons from these practitioners show how we can enhance the integrity of our food systems, protect our wide-open spaces, and preserve biodiversity.

Lost Landscapes

Rangelands have played an integral role in American history and culture. At one time, millions of bison roamed the West, and the combination of grazing bison and fire helped to maintain the prairie. By feeding on the grasses and fertilizing them in turn, the bison strengthened the rich soils that would become the backbone of American farming. Bison also provided habitat for other species: the trails they cut through deep snow were used by deer and antelope, their wallows were used by amphibians and birds as a source of water after rains, and prairie dogs preferred to make their home near bison herds.[1]

Throughout the 19th century, increasing settlement by homesteaders and pioneers as well as commercial hunting decimated bison populations, and by the 1890s bison were practically extinct. Cattle, brought in by the settlers, quickly replaced bison as the primary grazers of the rangeland. Unfortunately, poor management and high food demand led to a true tragedy of the commons, and the open range of the West was significantly overgrazed. The overgrazing and often poorly managed ranching on mostly public lands led to a series of devastating blows to the cattle industry in the last decades of the 1800s. Most famously, the Great Die Up in the winter of 1886/87 refers

1 "How Bison Help Shape the Northern Great Plains," World Wildlife Fund, accessed October 3, 2022, https://www.worldwildlife.org/pages/how-bison-help-shape-the-northern-great-plains.

to the loss of millions of head of cattle when a severe winter followed a long drought. Over the next several decades, reforms to public land management helped reduce overgrazing and alleviate the tragedy of the commons.[2]

Today, better public land policy and range management practices have lessened overgrazing, but there is still work to be done. One-third of US rangeland is public and leased by private ranchers for livestock. Historically, most western economies relied on the range and forestlands for commodities to feed, house, and energize their communities. Public land regulations were set accordingly: most federal land was set aside for managed production.

Today, however, the West increasingly relies on the aesthetic value and natural amenities provided by public lands. Tourism and outdoor recreation are becoming more important each year. In 2020, half of all Americans participated in some form of outdoor recreation, much of which happened on western public lands.[3] As recreation demand increases, the amount of federal land that restricts production and use has declined.[4] The number of cattle on the public range has decreased by more than 50 percent since 1954.[5] The number of livestock allowed on federal lands declined due to concerns about ecological conditions and resource management needs, to reduce conflicts with other public land uses, and as a result of changes in adjacent land use.

People traditionally think of conservation as occurring on public lands, but private lands provide a vast amount of open space, wildlife habitat, soil and water conservation, and carbon sequestration, as well as the food we depend on.[6] Overall, private lands make up more than 60 percent of American land and naturally hold much conservation potential, including 75 percent of all wetlands, habitat for 95 percent of endangered species, and 30 percent of America's drinking water.[7] Two-thirds of rangeland is privately owned, totaling 409 million acres. These are the lands where the antelope play and fawns frolic. They provide food for grand herds of elk as they make their way between winter and summer ranges. They offer tourists and locals alike the pristine views so often associated with the West.

Unfortunately, these working rangelands, which provide significant environmental benefits, are under threat on several fronts. The trends that endanger them include development, agglomeration, and ranch profitability.[8]

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2 Laura Clark, "The 1887 Blizzard That Changed the American Frontier Forever," *Smithsonian Magazine*, January 9, 2015, https://www.smithsonianmag.com/smart-news/1887-blizzard-changed-american-frontier-forever-1-180953852/; "Ecological Impacts of Grazing: Historical Impacts of Grazing," Rangelands Gateway (by the Rangelands Partnership), accessed April 24, 2023, https://rangelandsgateway.org/topics/uses-range-pastureland/historical-impacts-grazing.

3 OIA (Outdoor Industry Association), "2021 Outdoor Participation Trends Report," OIA, June 22, 2021, https://outdoorindustry.org/resource/2021-outdoor-participation-trends-report/.

4 Holly L. Fretwell, *Who Is Minding the Federal Estate: Political Management of America's Public Lands* (Lanham, MD: Lexington Books, 2009), 70.

5 CRS (Congressional Research Service), "Statistics on Livestock Grazing on Federal Lands: FY2002 to FY2016," CRS, August 28, 2017, https://www.everycrsreport.com/reports/R44932.html.

6 "Land Use, Land Value & Tenure: Overview," Economic Research Service (US Department of Agriculture), last modified May 21, 2021, https://www.ers.usda.gov/topics/farm-economy/land-use-land-value-tenure/.

7 Request for Information to Inform Interagency Efforts to Develop the American Conservation and Stewardship Atlas, 87 Fed. Reg. 235 (January 4, 2022), cited October 3, 2022, https://www.federalregister.gov/documents/2022/01/04/2021-28548/request-for-information-to-inform-interagency-efforts-to-develop-the-american-conservation-and; "Private Land," Forest Service (US Department of Agriculture), accessed April 24, 2023, https://www.fs.usda.gov/managing-land/private-land; "Range Resources," Natural Resources Conservation Service (US Department of Agriculture), accessed May 21, 2023, https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/land/range-pasture/range-resources.

8 See, e.g., D. Richard Cameron, Jaymee Marty, and Robert F. Holland, "Whither the Rangeland? Protection and Conversion in

While many conservation debates focus on public land use, private lands are most at risk of development: 75 percent of all natural areas developed in the United States between 2001 and 2017 are privately owned.[9] Development is driven by population growth and trends in population migration. Since the 2020 coronavirus pandemic, there has been a trend of movement away from coastal cities and to the small metropolitan areas and rural areas of the intermountain West.[10] The growth of exurbia, the region beyond the suburbs where people move seeking a rural lifestyle, beauty, open space, and recreational opportunities, can put neighboring rangelands in danger.[11] This growth is encouraging the development of lands that had been open range for centuries.[12] Ironically, however, the very development that seekers of open space create can have a negative effect on the natural beauty they seek.

Population growth causes both increasing housing density and expanding development, meaning more homes and less open space and natural beauty in the local area. Winkler et al. contend that "the natural environment and the ways in which resources are used both shape and are shaped by social and economic conditions in the local area."[13] In other words, increasing development has significant effects on the environmental value of the surrounding area.

Increased migration also affects land and home values in regions rich in natural amenities and beauty. Housing prices have increased nationwide, but they have risen particularly fast in recreation-dependent places.[14] Real estate makes up the greatest portion of farm assets;[15] hence, changing property values have a significant influence on landowner decisions. Higher land values increase the pressure to lease, sell, or parcel out and subdivide large working landscapes.[16] Given that the expected return on the average ranch is less than 1.5 percent[17] and most agricultural households rely on outside sources of income to supplement their livelihoods, selling land that has increased in value can be financially attractive to many ranchers.[18]

California's Rangeland Ecosystems," *PLoS ONE* 9, no. 8 (2014): e103468, https://doi.org/10.1371/journal.pone.0103468; Kathleen Epstein, Julia H. Haggerty, and Hannah Gosnell, "With, Not for, Money: Ranch Management Trajectories of the Super-Rich in Greater Yellowstone," *Annals of the American Association of Geographers* 112, no. 2 (2022): 432–48.

9 Matt Lee-Ashley and CAP (Center for American Progress), "How Much Nature Should America Keep?" CAP, August 2019, https://www.americanprogress.org/article/much-nature-america-keep/.

10 Saleh Ahmed, Elizabeth Eklund, and Vanessa Crossgrove Fry, "Population Growth, Inequality, and the Digital Frontier in the Shadow of the Pandemic in the American West," WRDC Research Brief, Western Rural Development Center, September 2021, https://www.boisestate.edu/bluereview/population-growth-inequality-and-the-digital-frontier/.

11 Mark W. Brunson and Lynn Huntsinger, "Ranching as a Conservation Strategy: Can Old Ranchers Save the New West?" *Rangeland Ecology and Management* 61, no. 2 (March 2008): 137–47, https://doi.org/10.2111/07-063.1; Paul Robbins, Stephen Martin, and Susan Gilbertz, "Developing the Commons: The Contradictions of Growth in Exurban Montana," *Professional Geographer* 64, no. 3 (2012): 317–31, https://doi.org/10.1080/00330124.2011.601193; John Harner and Bradley Benz, "The Growth of Ranchettes in La Plata County, Colorado, 1988–2008," *Professional Geographer* 65, no. 2 (2013): 329–44, https://doi.org/10.1080/00330124.2012.681584.

12 Richelle Winkler, Donald R. Field, A. E. Luloff, and Richard S. Krannich, "'Old West' and 'New West': A Regional Perspective," in *People, Places and Landscapes: Social Change in High Amenity Rural Areas*, edited by Richard S. Krannich, A. E. Luloff, and Donald R. Field, 45–62, Landscape Series 14 (Dordrecht, Germany: Springer, 2011).

13 Winkler, Field, Luloff, and Krannich, "'Old West' and 'New West,'" 62.

14 Megan Lawson, "Housing in Recreation-Dependent Counties Is Less Affordable." Headwaters Economics, May 2020. https://headwaterseconomics.org/equity/housing-affordability-recreation-counties/; Winkler, Field, Luloff, and Krannich, "'Old West' and 'New West,'" 48.

15 "Farming and Farm Income," Economic Research Service (US Department of Agriculture), last modified March 14, 2023, https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/farming-and-farm-income/.

16 Saleh Ahmed and Douglas Jackson-Smith, "Impacts of Spatial Patterns of Rural and Exurban Residential Development on Agricultural Trends in the Intermountain West," *SAGE Open* 9, no. 3 (2019), https://doi.org/10.1177/2158244019871037.

17 Richard V. Machen, Jason E. Sawyer, Stan J. Bevers, and Clay P. Mathis, "Measuring Economic Sustainability at the Ranch Level." *Rangelands* 43, no. 6 (2021): 240–45, https://doi.org/10.1016/j.rala.2021.10.005.

18 "Farming and Farm Income," Economic Research Service.

Dividing large ranches fragments range habitat and wildlife migration pathways, changes infrastructure needs and drainage system requirements, and makes the landscape more susceptible to the introduction of noxious weeds and invasive species.[19] The reduction of open space also limits genetic interchange between wildlife populations, which lessens genetic diversity.[20] In other words, while many amenity ranchers and ranchette owners purchased their land with the goal of living on a pristine range filled with elk and deer, removing grazing livestock can reduce habitat, making wildlife less likely to appear.

Rather than increasing fragmentation through ranch division and the creation of ranchettes or hobby ranches, some land buyers are agglomerating properties. A study by Haggerty et al. suggests that large landowners are increasing their reach.[21] A study across 25 million acres in Montana between 2005 and 2018 shows a growing concentration of large ownership. Landowners with more than 640 acres increased their landholdings by 7 percent. Only four of the twelve counties surveyed, however, showed the trend in concentration. Corresponding interviews demonstrate that the reasons for compilation by landowners varied. The holdings were increased for potential energy development, enhanced conservation, and intensified agricultural production, to name a few reasons. Some concentrated landholdings may enhance conservation, while others put the ecosystem services provided by large rangelands at risk. Negotiating with a single landowner to maintain conservation benefits, however, likely comes at a lower cost than negotiating with multiple landowners.

Environmental benefits of rangeland include the preservation of open space, the provision of food and habitat for wildlife, increased water and carbon retention in the soil, and the rejuvenation of native grasses and other plant species. Wild and domesticated ungulates, such as deer, elk, and cattle, rely on healthy grasses and forage. When grazers are removed from the landscape, the grasses become matted into the soil, reducing new forage growth.[22] Forage growth depends on the ecological function of the soil below it.

19 Thomas Elmqvist, Wayne C. Zipperer, and Burak Güneralp, "Urbanization, Habitat Loss and Biodiversity Decline: Solution Pathways to Break the Cycle," in *The Routledge Handbook of Urbanization and Global Environmental Change*, edited by Karen C. Seto, William D. Solecki, and Corrie A. Griffith, 139–51 (London: Routledge, 2016); Jesse B. Abrams, Hannah Gosnell, Nicholas J. Gill, and Peter J. Klepeis 2012 "Re-creating the Rural, Reconstructing Nature: An International Literature Review of the Environmental Implications of Amenity Migration." *Conservation and Society* 10 no. 3 (2012): 270–84. https://www.jstor.org/stable/26393083.

20 Elmqvist, Zipperer, and Güneralp, "Urbanization, Habitat Loss and Biodiversity Decline."

21 Julia H. Haggerty, Kathleen Epstein, Hannah Gosnell, Jackson Rose, and Michael Stone, "Rural Land Concentration & Protected Areas: Recent Trends from Montana and Greater Yellowstone," *Society and Natural Resources* 35, no. 6 (2022): 692–700, https://doi.org/10.1080/08941920.2022.2038318.

22 "Careful Management Results in Better Pastures and Forage," Oregon State Extension Service, accessed March 20, 2023, https://extension.oregonstate.edu/crop-production/pastures-forages/careful-management-results-better-pastures-forage.

Dirt to Soil

Soil is much more than the dirt under our feet. Soil is alive: it contains an intricate web of microbes, fungi, insects, and plant roots. Organic matter provided by these organisms improves the carbon storage, water retention, and nutrients of the soil, leading to healthier plants and bigger crops.[23] The soil of rangelands has a complex relationship with the grazing animals that live on the range: it is in part created by them and sometimes degraded by them.[24]

Just as bison provided habitat for other species and maintained the prairies, as mentioned earlier, they also improved the soil. Herds of grazing animals increase vital nutrients in the soil through their natural hoof-powered tillage and through the nutrients released in manure. Historically, large herds of grass-eaters moved in mobs across the range in sporadic patterns as they were stalked by predators, helping build soils and deepen roots as they moved.[25]

As settlers moved West, the effects they had on animal populations on the range also affected the soil underneath. The development of high-yielding crops together with the advent of fertilizers and pesticides during the Green Revolution in the 1960s fed more people on less land and encouraged more industrialized monocrop agricultural practices. Growing monocrops (single plant communities) or focusing on just one or two crop varieties is now a standard production process on US farms and rangelands, as is raising livestock with no crop production.[26] Though specialization can improve the yield of the land and take advantage of economies of scale, there are potential environmental and economic consequences of these practices.[27]

The Green Revolution's focus on high-yield production moved farming away from mixed-crop livestock systems and toward industrial agriculture. Large acreages are now devoted to single crops that are less resilient to climatic changes and require greater mechanical and chemical inputs. Increased agrochemical use has had environmental effects both through runoff into waterways and by eliminating many of the microbiomes in the soils that would otherwise naturally create nitrogen and other plant nutrients.[28] Studies comparing paired farms demonstrate that regenerative prac-

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23 Nicole Masters, *For the Love of Soil: Strategies to Regenerate Our Food Production Systems* (New Zealand: Printable Reality, 2019); "Tallgrass Prairie and Carbon Sequestration," Tallgrass Ontario, accessed October 3, 2022, https://tallgrassontario.org/wp-site/carbon-sequestration/.

24 Kris Nichols, "Regenerative Agriculture Builds Resilience with Soil Biology, Part 2," presentation at 2019 Mitchell Soil Health Event, February 14, 2019, Mitchell, SD. YouTube video, 57:13, https://www.youtube.com/watch?v=yX7mS5X34wc&list=RDLVpjfbhsBDRiU&index=2&ab_channel=JenNelson; Matt A. Sanderson, David Archer, John Hendrickson, Scott Kronberg, Mark Liebig, Kris Nichols, Marty Schmer, Don Tanaka, and Jonathan Aguilar, "Diversification and Ecosystem Services for Conservation Agriculture: Outcomes from Pastures and Integrated Crop-Livestock Systems," *Renewable Agriculture and Food Systems* 28, no.2 (2013): 129–44, http://dx.doi.org/10.1017/S1742170512000312.

25 Purbita Saha, "How Cattle Ranchers Are Helping to Save Western Grasslands and Birds," *Audubon Magazine*, Spring 2017, https://www.audubon.org/magazine/spring-2017/how-cattle-ranchers-are-helping-save-western.

26 Samuel D. Fuhlendorf, David M. Engle, R. Dwayne Elmore, Ryan F. Limb, and Terrence G. Bidwell, "Conservation of Pattern and Process: Developing an Alternative Paradigm of Rangeland Management" *Rangeland Ecology and Management* 65, no. 6 (November 2012): 579–86, https://doi.org/10.2111/REM-D-11-00109.1; James M. MacDonald, Robert A. Hoppe, and Doris Newton, "Three Decades of Consolidation in U.S. Agriculture," Economic Information Bulletin Number 189, 37–39, Economic Research Service, US Department of Agriculture, March 2018, https://www.ers.usda.gov/webdocs/publications/88057/eib-189.pdf?v=9067.2.

27 MacDonald, Hoppe, and Newton, "Three Decades of Consolidation in U.S. Agriculture;" Ethan Gordon, Federico Davila, and Chris Riedy, "Transforming Landscapes and Mindscapes through Regenerative Agriculture," *Agriculture and Human Values* 39 (2022):809–26. https://doi.org/10.1007/s10460-021-10276-0; Emile A. Frison and IPES-Food, "From Uniformity to Diversity: A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems," International Panel of Experts on Sustainable Food Systems, June 2016, https://ipes-food.org/reports/.

28 Richard Teague and Urs Kreuter, "Managing Grazing to Restore Soil Health, Ecosystem Function, and Ecosystem Services," *Frontiers in Sustainable Food Systems* 4, September 29, 2020, https://doi.org/10.3389/fsufs.2020.534187; Hannah Gosnell, Susan

tices produce soils with more organic matter, minerals, and phytochemicals than does the use of synthetic fertilizers and herbicides.[29]

Furthermore, the removal of livestock from farms has eliminated the natural fertilizers livestock provide. Proper livestock management can enhance the fertility of soils and improve crop growth, whether the crops are for human consumption or for livestock forage. The methods of regenerative agriculture focus on natural processes to enhance the ecological function of the soil and, hence, increase output productivity. Regenerative grazing focuses on the use of livestock to improve soil health and plant diversity.

Different types of grazing provide different ecological benefits. The most commonly used forms of grazing in the US today are moderate and heavy continuous grazing.[30] Grazing systems that allow livestock to roam a full pasture in an area over a long period or season are known as continuous grazing. During the Green Revolution, such systems largely replaced the combined production of livestock and crops.[31] Continuous grazing tends to create overgrazed areas and bare ground where unfavorable plants can gain a foothold. Given the opportunity, cattle graze the most palatable plants first and spend more time in shady areas and near water, resulting in an uneven distribution of manure and disturbance.[32]

Alternatively, rotational grazing cycles livestock through divided pasture areas called paddocks. Livestock may be moved among a few paddocks every couple of weeks or among many paddocks every couple of days. The variability in the size and number of paddocks and frequency of movement, together with other variations across the range, limits robust comparisons of rotational grazing management outcomes.

Holistic grazing theorizes that rotational grazing is better for forage production and quality because it harvests only a portion of the plant, provides a rest period for plants to regrow, and more evenly spreads livestock fertilizer—urine and manure—across the paddock. Livestock forced to roam and eat all the forage in a small paddock leave a more stable species composition, with more evenly spread manure and less bare ground, when they are rotated appropriately.[33]

Soils microbiologist Kris Nichols believes that "we are the masters of our own disasters" when it comes to soil.[34] Her research indicates that the chemicals and fertilizers used in conventional farming harm the bacteria and fungi in soil that plants need in order to grow. Dowhower et al. have also shown that intensive agriculture and livestock grazing practices, including the use of inorganic fertilizers and biocides and continuous grazing, negatively impact the soil biota and reduce

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Charnley, and Paige Stanley, "Climate Change Mitigation as a Co-benefit of Regenerative Ranching: Insights from Australia and the United States," *Interface Focus* 10, no. 5 (2020), http://doi.org/10.1098/rsfs.2020.0027.

29 David R. Montgomery, Anne Biklé, Ray Archuleta, Paul Brown, and Jazmin Jordan, "Soil Health and Nutrient Density: Preliminary Comparison of Regenerative and Conventional Farming," *PeerJ* 10 (2022): e12848. https://doi.org/10.7717/peerj.12848.

30 Steven L. Dowhower, W. Richard Teague, Ken D. Casey, and Rhonda Daniel, "Soil Greenhouse Gas Emissions as Impacted by Soil Moisture and Temperature under Continuous and Holistic Planned Grazing in Native Tallgrass Prairie," *Agriculture, Ecosystems and Environment* 287 (January 1, 2020): 1, https://doi.org/10.1016/j.agee.2019.106647.

31 Teague and Kreuter, "Managing Grazing to Restore Soil Health, Ecosystem Function."

32 "Livestock Grazing Home Study Course: Continuous Grazing Systems," Penn State Extension, accessed April 25, 2023, https://extension.psu.edu/courses/livestock-grazing/grazing-management/methods-of-grazing-management/continuous-grazing-systems.

33 "Livestock Grazing Home Study Course: Rotational Grazing Systems," Penn State Extension, accessed April 25, 2023, https://extension.psu.edu/courses/livestock-grazing/grazing-management/methods-of-grazing-management/continuous-grazing-systems.

34 Nichols, "Regenerative Agriculture Builds Resilience."

biodiversity.[35] Degraded grasslands have deteriorated soil structure and increased bare ground, and they are more susceptible to erosion and desertification.[36]

Efficient nutrient uptake by native grasses and crops requires the assistance of friendly microbes delivered to the soil by livestock, allowing plants to thrive. Although synthetic nutrients can enhance growth in the short term, in the long run, they can stunt natural processes by destroying the soil bacteria and fungi habitats that assist in nutrient uptake.[37] Farmers and ranchers can regain the benefits of healthy soil by using different management practices, such as holistic grazing, that are adapted to the unique topography, climate, and soil type of their land.[38]

On rangelands, holistic grazing is used to improve soil health by mimicking the behavior of wild herds. This method requires ranchers to set up multiple paddocks and rotate the herd between them as needed. Removing only about half of the plant leaf matter and allowing plants time to recover between grazing sessions allows for more root development, increasing soil organic matter and thus soil health.[39] The number of paddocks and length of time grazing depend on the land, season, and climate and require the rancher to pay attention to the health of the range and adjust grazing as needed.

Short-duration grazing practices can stimulate plant growth and aerate and fertilize soils, producing healthier plants. In a symbiotic process, the actions of livestock motivate the actions of the soil biology, which in turn improves forage growth. This cycle reduces the need for chemicals and synthetic fertilizers, but it takes time for the natural organisms to regenerate from previous damage caused by overgrazing and chemical fertilizer use.[40] Once the soil is healthy, range managers can increase livestock numbers and reduce the use of inputs, such as soil additives, machinery, and fuel.[41] The reality of changing soil composition depends on the practices used, the speed with which they are adopted, and the soil baseline. Some range managers can double grazing capacity in a few years by changing management techniques.[42] For others, doubling capacity may take decades.

Soil-centric management that mimics the grazing patterns of wild herds can produce many other desirable ecosystem services, such as biodiversity, wildlife habitat, water retention, and soil carbon

35 Dowhower, Teague, Casey, and Daniel, "Soil Greenhouse Gas Emissions as Impacted by Soil Moisture and Temperature.

36 Li Wang, Yantai Gan, Martin Wiesmeier, Guiqin Zhao, Ruiyang Zhang, Guodong Han, Kadambot H. M. Siddique, and Fujiang Hou, "Grazing Exclusion—an Effective Approach for Naturally Restoring Degraded Grasslands in Northern China," *Land Degradation and Development* 29, no. 12 (December 2018): 4439–56. https://doi.org/10.1002/ldr.3191.

37 Gordon, Davila, and Riedy, "Transforming Landscapes and Mindscapes;" Masters, *For the Love of Soil*.

38 See, e.g., Ryan C. Byrnes, Danny J. Eastburn, Kenneth W. Tate, and Leslie M. Roche, "A Global Meta-Analysis of Grazing Impacts on Soil Health Indicators," *Journal of Environmental Quality* 47, no. 4 (July–August 2018): 758–65, https://doi.org/10.2134/jeq2017.08.0313; Gosnell, Charnley, and Stanley, "Climate Change Mitigation as a Co-benefit of Regenerative Ranching;" Masters, *For the Love of Soil*.

39 Samantha Mosier, Steven Apfelbaum, Peter Byck, Francisco Calderon, W. Richard Teague, Ry Thompson, and M. Francesca Cotrufo, "Adaptive Multi-paddock Grazing Enhances Soil Carbon and Nitrogen Stocks and Stabilization through Mineral Association in Southeastern U.S. Grazing Lands," *Journal of Environmental Management* 288 (June 15, 2021), https://doi.org/10.1016/j.jenvman.2021.112409; Savory Institute. n.d. "Holistic Management Case Studies, Profiles and Articles," accessed October 3, 2022, https://savory.global/wp-content/uploads/2017/02/Holistic-Management-Case-Studies-Profiles-Articles.pdf; Richard Teague and Matt Barnes, "Grazing Management That Regenerates Ecosystem Function and Grazing Land Livelihoods." *African Journal of Range and Forage Science* 34, no. 2 (2017): 77–86, http://dx.doi.org/10.2989/10220119.2017.1334706; Tong Wang, W. Richard Teague, and Seong C. Park, "Evaluation of Continuous and Multipaddock Grazing on Vegetation and Livestock Performance—a Modeling Approach," *Rangeland Ecology and Management* 69, no. 6 (November 2016): 457–64, https://doi.org/10.1016/j.rama.2016.07.003.

40 Masters, *For the Love of Soil*.

41 Todd Graham, pers. comm., August 10, 2022; see also Masters, *For the Love of Soil*.

42 See the UCross Ranch case study later in this paper.

sequestration.[43] Soils are carbon reserves: worldwide, soil sequesters around 2,344 billion tons of organic carbon. Agricultural practices such as tilling, however, have released an estimated 133 to 200 billion tons of carbon from global soils. That is the equivalent of 20 percent of all atmospheric carbon.[44] Intensive grazing practices that limit tillage can help retain carbon in the soil.

The amount of carbon retained in the soil depends on a number of factors including soil management, soil type, organic matter, moisture and climate, and topography. This means that soils in some regions can retain more carbon at a faster rate than soils in other regions. Grasslands can store large stocks of carbon, but they store carbon less readily in hot and dry areas. The additional carbon increases nutrient cycles and water retention, reducing the need for irrigation, enhancing plant growth, and potentially leaving more water in streams for fisheries and other uses.[45]

Regenerative agricultural practices are growing in popularity, but they constitute a small fraction of total production. The Economic Research Service reports that about 40 percent of cow-calf operations in the US use some form of rotational grazing, which includes the estimated 16 percent that use intensive rotational grazing.[46] In 2015, researchers estimated that about 12.5 percent of global crop production used some form of regenerative agriculture.[47] The Savory Institute estimates that more than 10,000 people have been trained in the practice of holistic grazing and that it is being applied to more than 40 million acres. This is less than 1 percent of the range used for livestock production.[48]

While these practices enhance conservation, that is not necessarily the driving force for adoption. The potential to improve profits while also improving the ecosystem is why many ranchers are changing their management practices. Both Barney Creek Livestock in southwestern Montana and UCross Ranch in Wyoming turned to holistic management to increase their bottom line. We outline their stories below, as well as that of the conservation-oriented Wall Creek Wildlife Management Area, which adopted similar practices to regain habitat for native elk populations.

43 Jong-Yoon Park, Srinivasulu Ale, W. Richard Teague, and Jaehak Jeong "Evaluating the Ranch and Watershed Scale Impacts of Using Traditional and Adaptive Multi-paddock Grazing on Runoff, Sediment and Nutrient Losses in North Texas, USA," *Agriculture, Ecosystems and Environment* 240 (March 2017): 32–44, https://doi.org/10.1016/j.agee.2017.02.004; Masters, *For the Love of Soil*, 45.

44 Masters, *For the Love of Soil*, 66.

45 Masters, *For the Love of Soil*, 63.

46 Christine Whitt and Steven Wallander, "Rotational Grazing Adoption by Cow-Calf Operations," Economic Information Bulletin Number 243, Economic Research Service, US Department of Agriculture, November 2022, https://www.ers.usda.gov/webdocs/publications/105077/eib-243.pdf?v=3929.9; see also IBC (Iowa Beef Center), "Iowa Cattle Grazing Survey: Part 1 Results." *Cows and Plows* (Iowa State University Extension), October 2007.

47 A. Kassam, T. Friedrich, and R. Derpsch, "Global Spread of Conservation Agriculture," *International Journal of Environmental Studies* 76, no. 1 (2019): 29–51, https://doi.org/10.1080/00207233.2018.1494927.

48 Savory Institute. n.d. "Holistic Management Case Studies, Profiles and Articles," accessed October 3, 2022, https://savory.global/wp-content/uploads/2017/02/Holistic-Management-Case-Studies-Profiles-Articles.pdf.

Barney Creek Livestock

Pete and Meagan Lannan are the fourth generation to work the Jordan Ranch. They founded Barney Creek Livestock, a new ranch enterprise, leasing a part of the original ranch from Pete's parents.

Located in Montana's Paradise Valley, the ranch is just 40 miles north of Yellowstone National Park. It provides a plethora of amenities desired by developers, tourists, and wildlife. Paradise Valley, as the name suggests, is spectacularly beautiful and checks off nearly every box in the high natural amenity areas of the West that are so at risk of development. It is close to Yellowstone National Park, the Yellowstone River runs through it, wildlife is abundant, and it is near the quaint town of Livingston and the Bozeman Yellowstone International Airport. It is a tourist attraction and a wealthy landowners' haven.

To sustain their new enterprise, the Lannans knew they had to make a profit. They looked to holistic grazing and selling their grass-fed beef direct to consumers to do this. The Lannans understand that the grass and forage available to livestock and wildlife above the ground is a reflection of what's happening underground in the soil, so they focus on managing the plants that manage the soils. Historically, a portion of the leased land had been used to grow hay for feed and sale. Rather than haying the leased pasture, which exports nutrients from the soils, they now put their livestock to work digesting the forage and recycling nutrients back to the ground.

Following standard holistic or regenerative grazing practices, the Barney Creek pasture is divided into about 50 paddocks that range from half an acre to just over three acres. The point is to force livestock to intensively graze a small area. Cattle are moved daily between the paddocks. Small paddocks and constant movement encourage a "mob" mentality: animals compete for forage. As a result, they eat fairly evenly across all plant species, including weeds like thistle that they are less likely to eat if given the choice. The goal is for the grass to look like an uneven haircut, with everything nibbled but not all the way to the ground. The grass and plant cover are trampled by the herd, creating a protective residue on the soil. The protective layer helps carbon drawdown, which feeds the bacteria and fungi that produce the nutrients for plants and other organisms. Livestock manure and urine fertilize the soil, improving soil health.

The range improvement was noticeable, indicated by the arrival of a variety of new species. The appearance of dung beetles, which are a sign of healthy pasture, was a celebratory moment for the Lannans. Dung beetles help move the manure and its nutrients underground into the soil. They also reduce fly larvae, decreasing the risk of fly-borne diseases to livestock. These diseases can financially impact ranches at a cost of $30 to $50 per head. Dung beetles can reduce these costs by reducing the fly population by 95 percent.[49]

Using holistic range management practices, the Lannans are getting more forage per acre at a lower cost. They produce enough forage on the ranch and adjacent leases to graze year-round. They purchase some hay as a supplement to feed during storms, but otherwise they are self-sustaining. They fed hay only 30 days in 2021, compared to an average of 135 days for US ranchers, saving them about $20,000.[50] The choice to not produce hay has also decreased equipment and fuel expenses.

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49 Spencer Smith, "How to Establish Dung Beetles in Pastures," *Eco Farming Daily*, November 2018, https://www.ecofarmingdaily.com/build-soil/soil-life/dung-beetles/establish-dung-beetles-pastures-want/.

50 Meagan Lannan, pers. comm., June 9, 2022.

Many landowners in Paradise Valley are absentee owners who have no intention of ranching on their own but are interested in maintaining healthy landscapes and wildlife habitats. The Lannans have negotiated grass leases with a few absentee owners and other neighbors, providing additional acres of forage for their livestock. Typically, landowners charge for grass and forage provided to a lessee for livestock. The Lannans, however, begin lease negotiations at a price of zero. There are mutual gains. Their cows are a workforce that add value to the land they graze by adding nutrients, replanting native seeds, and mitigating fire. The landowner benefits from better ecological function on the ground, and the Lannans get the forage. The Lannans bring their own infrastructure, including fiberglass fence posts, high-tensile wire, and flexible water pipes, and they pay for any electricity needed for irrigation.

John Tomlin is one owner who has leased about 100 acres to the Lannans since 2021. He has worked with other ranchers over the years, but he saw a tremendous difference in the quality of the forage after one year with the Lannans.[51] How the livestock is managed is the key to enhancing soil productivity, which increases forage growth to feed livestock and wildlife. The Lannans work by the often-cited slogan "It's not the cow, it's the how."

The Lannans help absentee landowners and other landowners regenerate wildlife forage using cattle. Without grazers that eat and fertilize the land, grasses turn dormant. This is a reality faced by many absentee owners who purchase large ranchlands and remove miles of fencing with a goal to provide space for wildlife, only to see both the grasses and the wildlife disappear.

The lands grazed by the Lannans are seeing more birds, bugs, and wildlife. In early June 2022, an Audubon bird count on the ranch found the ecosystem extremely healthy. Cattle from Barney Creek Livestock are now Audubon-certified as bird friendly. This is one more nature-friendly attribute the Lannans can share with their customers. Although there is no documented price premium associated with this single attribute, it is important at a time when grassland bird populations are declining. Total grassland bird populations have dropped more than 40 percent in North America since 1966.[52] The eastern meadowlark, for example, has declined 71 percent since the 1960s, largely in response to the loss of grasslands.[53]

Healthy rangelands in the valley also provide critical habitat for migrating elk, grizzly bears, wolves, and a multitude of animals that roam in and out of Yellowstone National Park. Paradise Valley is part of the Greater Yellowstone Ecosystem, where 80 percent of elk winter range is on private lands. Regenerating and sustaining these lands is critical for the future of this wildlife.

The Lannans' conservation efforts reach beyond the Barney Creek pastures by enhancing wildlife habitat on all the lands they graze. This habitat is used by native birds, deer, migrating elk, and many more organisms under the soil that are increasing plant growth, nitrogen production, and carbon sequestration while retaining soil moisture.

51 John Tomlin, pers. comm., June 9, 2022.

52 C.B. Wilsey, J. Grand, J. Wu, N Michel, J. Grogan-Brown, and B. Trusty, *North American Grasslands and Birds Report*, 1 (New York: National Audubon Society, 2019).

53 John M. Marzluff, *In Search of Meadowlarks: Birds, Farms, and Food in Harmony with the Land*, 3 (New Haven, CT: Yale University Press, 2020).

Wall Creek Wildlife Management Area

Even outside private ranching, holistic range management techniques help enhance wildlife habitat. The Wall Creek Wildlife Management Area (WMA) is located near Ennis, Montana, in the Madison Valley (about two hours west of Paradise Valley). Before the 1960s, Wall Creek was privately owned and continuously grazed. The Montana Department of Fish, Wildlife & Parks purchased a portion of the drainage in 1960 to protect the core of the elk winter range and alleviate wildlife damage on neighboring lands. In an effort to enhance elk winter forage, the agency removed the cattle.[54]

In spite of these management changes, the elk continually strayed away from Wall Creek and onto neighboring private ranchlands. The department tried to entice the elk to stay on the public land by fertilizing and haying the WMA and even hazing elk off the private lands, but nothing seemed to work. After 21 years, the department tried something different: putting cattle back on the land. Using a rest and rotation method, cattle were moved between three different small pastures created within the WMA.

Ranchers that lease pasture from the department move their cattle every four to six weeks. During the growing period from May through July, the cattle graze on one set of high-elevation pastures. They are moved down to a second set of pastures following grass-seed maturity in August and September. The third set of pastures is left to rest until the following year. Cattle are moved back to private land during the winter, leaving the publicly owned winter pasture for wildlife.

Much as rotational grazing management has done on the Lannans' ranch, integrating livestock back into the WMA has produced positive results. The elk prefer the WMA fields that are grazed with rest and rotation. Occasional livestock grazing has replaced the standing dead vegetation with more nutritional forage that elk prefer.[55]

UCross Ranch

Northeastern Wyoming is high prairie country, with grass-covered rolling hills and snowcapped peaks in the distance. Here the UCross Ranch has operated its 21,000 acres for profit and environmental benefit since 2005. Relying on private, state, and federal lands, the ranch is owned by the Apache Corporation and Ucross Foundation.

Before 2002, the ranch was struggling. Bare soils covered about 50 percent of the rangelands,[56] erosion and noxious weeds were a problem, and productivity was low. To increase productivity, the ranch changed its management approach. Rather than learn from scratch, UCross hired Ranch Advisory Partners (RAP), a range consulting group, to help regenerate the range.

Conventional ranch management theory suggested that the ranch should decrease livestock numbers. Following recommendations from RAP, however, UCross increased the number of livestock instead. Using a holistic approach, the ranch was able to nearly triple stocking rates by

54 Kurt L. Alt, Michael R. Frisina, and Frederick J. King, "Coordinated Management of Elk and Cattle, a Perspective—Wall Creek Wildlife Management Area," *Rangelands* 14, no. 1 (February 1992): 12–15.

55 Alt, Frisina, and King, "Coordinated Management of Elk and Cattle, a Perspective."

56 "Apache Foundation—Ucross Ranch: 2017 Landowner of the Year—Sheridan Region," Wyoming Game & Fish Department, accessed April 25, 2023, https://wgfd.wyo.gov/Get-Involved/Landowner-of-the-Year/2017/Apache-Foundation-Ucross-Ranch.

utilizing a short-duration rotation strategy.[57] These changes led to more forage, less bare ground, and increased cattle production.

Like Barney Creek Livestock and the WMA, UCross divided its pasture into small paddocks. Cattle are moved among the paddocks, increasing the length of time grasses can grow and build roots in each paddock without being grazed. The smaller paddocks push the cattle across all parts of the range, disturbing more vegetation. Shortening the grazing period gives disturbed plants time to recover until the next growing season and reduces erosion in riparian areas.

Eventually, the ranch was divided into 57 rangeland paddocks using high-tensile electric wire and temporary polywire fencing. The ranch managers developed stock water because much of the ranch had limited water availability. Investing in stock tanks and distributing them throughout the ranch where they could service multiple paddocks and where soils were high in quality but water was scarce helped disperse the pressures of cattle on the range. The tanks were encircled with fencing, and gates allowed access to just one paddock at a time.

To measure success, the Apache Corporation and RAP tracked the costs and benefits of the transition. Improvements cost the ranch $10.45 per acre (2005 dollars). The full investment in fencing and water was recouped within three and one-half years. Within five years, the additional return per animal day of grazing was $3.66 (2005 dollars). This was accomplished solely through changes in grazing management. No irrigation, fertilizing, or seeding took place.[58]

The natural actions of the intensely managed cattle encouraged plant growth, which was further enhanced as more water saturated the soil instead of running off the land. Initially, this growth included undesired species, such as cheatgrass and Japanese brome. Within a few years, the desired successional species, such as bunchgrasses, took over. Between 2002 and 2011, stock days grazed more than quadrupled while plant cover and diversity increased (see table 1).

Table 1. UCross Ranch Middle Alkire Pasture: Increased Grazing Increased Plant Diversity and Coverage

	2002	2005	2007	2011
Bare ground	50%	44%	25%	5%
Desirable live plant cover	n/a	4%	6%	10%
Plant species count	n/a	21	29	38
Stock days grazed	35,000	72,000	79,000	154,000

Sources: Todd Graham, "Beyond Resilience: Managing Toward a Higher Level of Ranch Performance, Ucross Ranch, Wyoming," *Resilience: A Voice of the New Agrarian* 40 (September 2014), https://static1.squarespace.com/static/5a55308018b27d45fac8ec43/t/5d1a89246d0d9e00013087ca/1562020141330/Ucross+Ranch+_Resilience.pdf; "The Proof Is in Performance," Ranch Advisory Partners, accessed April 25, 2023, https://www.ranchadvisory.com/impact; "Apache Foundation—Ucross Ranch: 2017 Landowner of the Year—Sheridan Region," Wyoming Game & Fish Department, accessed April 25, 2023, https://wgfd.wyo.gov/Get-Involved/Landowner-of-the-Year/2017/Apache-Foundation-Ucross-Ranch.

57 "Apache Foundation—Ucross Ranch: 2017 Landowner of the Year—Sheridan Region," Wyoming Game & Fish Department.

58 Todd Graham, "Beyond Resilience: Managing toward a Higher Level of Ranch Performance, Ucross Ranch, Wyoming," *Resilience: A Voice of the New Agrarian* 40 (September 2014), https://static1.squarespace.com/static/5a55308018b27d45fac8ec43/t/5d1a89246d0d9e00013087ca/1562020141330/Ucross+Ranch+_Resilience.pdf.

To be sure, wetter years prove more productive than drier years, and disturbance, including fire and insect damage (such as a severe grasshopper infestation in 2008 and 2009), can cause significant forage losses. To prepare for the unexpected, UCross has reserve grasses, and it has used them. The higher-performing ecosystem the ranch now manages reduces the negative risks of disturbances. The ecosystem is more resilient even during times of drought or insect infestation.

The changes in range management made the ranch more productive and more profitable. Bare ground decreased from 50 percent to less than 2 percent by 2019, while desirable live plant cover and the number of species increased (see table 1).[59] The ranch increased the number of grazing days on the same number of acres from 35,0000 to 200,000 between 2002 and 2019, an increase of more than 450 percent.[60] Ranch performance measures show benefits to both ecological and economic outcomes. According to ranch manager Nathan Lindsey, the management shift "has not only increased our livestock carrying capacity but also increased our conservation value and wildlife values helping us sustain and keep a viable operation."[61] The enhanced ecological function of the soil increases water retention, making formerly ephemeral streams flow year-round, increasing water availability for livestock and wildlife. Increased livestock numbers have resulted in higher earnings.

Revenue Opportunities

Ranching is often a financially precarious business, and most agricultural operations supplement revenues with off-farm income.[62] Ranch revenue sources typically include the sale of cows, calves, bulls, or crops. Many operations generate additional revenues through the production of value-added products and services. The production of goods such as organic grains and vegetables, honey, and specialty cheeses can be complementary to ranch activities. Guest services are becoming more popular, including accommodation rentals, property access, and guided tours. And ecosystem services such as healthy soils, water supply, and carbon retention can align management with conservation outcomes.

Regenerative grazing is one opportunity for ranchers to increase revenues and environmental outcomes. The resulting conservation from regenerative approaches can enhance other revenue opportunities, such as providing access to hunting, fishing, and birding; offering guided recreation and accommodation rentals; and participating in carbon markets. Markets exist for many of these services. Negotiating for the provision of some ecosystem services, however, such as wildlife habitat and soil carbon sequestration, can be difficult.

Carbon markets, for example, are expanding and seeking healthy soils that can act as a carbon sink. But effectively measuring carbon in the soil over time and space is difficult, which limits the number of soil carbon transactions that take place. Many ecosystem services are nonmarket amenities, such as open space and biodiversity, that may be desirable but are hard to charge for.

59 "Blending Science and Finance with Stewardship and Conservation," Ranch Advisory Partners, accessed April 25, 2023, https://www.ranchadvisory.com/what-and-how.

60 "The Proof Is in Performance," Ranch Advisory Partners, accessed April 25, 2023, https://www.ranchadvisory.com/impact.

61 "Our Approach: What We Do and How We Do It," Ranch Advisory Partners, accessed May 21, 2023, https://www.ranchadvisory.com/what-and-how.

62 "Farming and Farm Income," Economic Research Service.

Regenerative agriculture can help capitalize on these enhanced environmental outcomes. Soil carbon sequestration, soil water retention, increased forage growth, biodiversity, and enhanced wildlife habitat are all cobenefits of regenerative grazing methods. It makes sense to find ways to tie the value society places on environmental goods to the ranchers and landowners who provide them.

Hurdles to Scaling Holistic Grazing

Despite the successes of holistic grazing laid out in this paper, the method has not been adopted on a large scale. Changing range management from more conventional approaches requires potential costs and risks for ranchers. Public land barriers and scientific disagreement also pose significant challenges to the wider adoption of holistic grazing tools.

Improving Grazing on Private Lands

Change is difficult for any business, including ranching; it requires rethinking the way things are done and moving into the unknown. Many ranchers follow traditional methods learned from family and the community, and altering those techniques may offend friends and neighbors while also risking potential failure. Although most ranchers have a deep connection with the land and want to take care of it, the social pressure and sunk costs of traditional practices can make it difficult to change.

Aside from the social pressures, the initial investment required to adopt holistic grazing can be prohibitive. Fortunately, there are many sources of funding and financial assistance available to support private land conservation. Some government services will pay landowners to improve the environmental quality of their land. The Environmental Quality Incentives Program is one such program that pays farmers and ranchers to engage in prescribed grazing for conservation purposes, including improving the quality of plant communities and wildlife habitat.[63] Between 2005 and 2018, the US Department of Agriculture's Natural Resources Conservation Service provided more than $278 million to the program.[64] While the program does not explicitly use the term "holistic grazing," many of the practices it outlines run parallel to those outlined in this paper.

Other programs, such as the US Department of Agriculture's Conservation Stewardship Program, also provide funding for ranchers looking to improve their conservation practices. Both this program and the Environmental Quality Incentives Program require the development of a conservation plan before application. This plan is often produced in coordination with agency technical support.

The Conservation Reserve Program (CRP) is a similar government program run by the Farm Service Agency that pays farmers and ranchers to remove certain lands from production and increase environmental services such as cleaner air and water, healthier soil, and reduced erosion. Private landowners voluntarily enter into 10–15 year agreements and receive payments for the land

63 "Environmental Quality Incentives Program: EQIP," Natural Resources Conservation Service, US Department of Agriculture, accessed April 25, 2023, https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives.

64 Christine Whitt and Steven Wallander, "Rotational Grazing Adoption by Cow-Calf Operations," Economic Information Bulletin Number 243, Economic Research Service, US Department of Agriculture, November 2022, https://www.ers.usda.gov/webdocs/publications/105077/eib-243.pdf?v=3929.9.

taken out of production in addition to cost assistance for implementing conservation practices.[65] Generally, the CRP does not allow grazing on enrolled lands except under emergency drought conditions, though there are some exceptions.[66] As we've shown throughout this paper, the environmental services that the CRP seeks to create are also available through holistic grazing. The regenerative approach not only conserves resources but enhances ecological function.

As part of the broader trend of increased support for conservation on working lands, the Farm Service Agency may wish to consider including some form of holistic grazing as an option for CRP enrollment. Payments for holistically grazed lands could be lower than payments for lands removed from production and could be modeled after grazing allowed during drought years, which usually results in payments of 10–15 percent less.[67] Though using CRP lands for grazing may seem contrary to the goal of the program, capturing environmental services from agricultural land is the primary goal, and if grazing can improve that ability, it should be considered as an option.

The Inflation Reduction Act of 2022 will increase available federal funding for agricultural conservation programs. The act will direct about $20 billion to farmers and ranchers seeking financial and technical assistance to enhance conservation measures, including those discussed earlier. The law aims to increase climate-smart practices, such as increasing stored carbon in soils. An additional $300 million will be available to analyze the climate impact of Natural Resources Conservation Service conservation programs. As demonstrated below, better metrics for holistic grazing outcomes may help drive ranch management to focus more on soil and ecological function.

Private conservation funds are also available to ranchers seeking to adopt conservation practices. The Sage Grouse Initiative, a large-scale public-private partnership, offers funds to landowners to help them turn their working lands into sage grouse habitat. Sage grouse require large amounts of wide-open space and healthy grasslands to thrive. The initiative recognizes the importance of conservation-minded grazing in achieving its goals and supports landowners who seek to start holistic grazing on their property.[68] Other private conservation groups, including the Nature Conservancy, support landowners' holistic grazing efforts using tools such as conservation easements.[69]

There are also multiple avenues for ranchers to find educational support. Allan Savory, the founder of Holistic Management International and the Savory Institute, is perhaps the godfather of holistic grazing practices. The institute provides in-person and online training, operates independently owned learning centers around the world, and equips boots-on-the-ground educators and verifiers. Many outfits provide similar educational opportunities, including the Ranching for Profit School, Integrity Soils, and Western Sustainability Exchange. All have a goal of expanding the scale of regenerative agricultural production to increase both environmental outcomes and rancher profit.

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65 Megan E. Jenkins and Harrison Naftel, "Making Private Lands Count for Conservation: Policy Improvements toward 30x30," Policy Paper, Center for Growth and Opportunity at Utah State University, March 30, 2022, https://www.thecgo.org/research/making-private-lands-count-for-conservation/.

66 "Conservation Reserve Program," Farm Service Agency, US Department of Agriculture, accessed April 25, 2023, https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/PDF/CP1.pdf.

67 Megan Stubbs, "Conservation Reserve Program (CRP): Status and Issues," Congressional Research Service, August 29, 2014, https://nationalaglawcenter.org/wp-content/uploads/assets/crs/R42783.pdf.

68 "Get Involved," Working Lands for Wildlife, accessed April 25, 2023, https://www.wlfw.org/get-involved/.

69 Jenkins and Naftel, "Making Private Lands Count for Conservation;" "Food & Water Stories: Regenerative Grazing Lands," Nature Conservancy, last modified September 18, 2022, https://www.nature.org/en-us/what-we-do/our-priorities/provide-food-and-water-sustainably/food-and-water-stories/sustainable-grazing-lands/.

Multiple consulting groups also exist to help ranchers who don't want to make the change alone. As we described earlier, the Ucross Ranch was turned around by the consulting group Ranch Advisory Partners. Working on more than 40 ranches and millions of acres across the West, RAP manages, monitors, and advises using an adaptive approach to enhance ecological function.

While start-up funding can help motivate the transition into regenerative grazing practices, achieving sustainable and scalable solutions to enhance the ecological function across large landscapes requires economic viability. That is the beauty of holistic grazing. Focusing management on ecological function increases productivity and thereby improves profit potential.

Scientific Disagreement

Another reason why ranchers hesitate to change grazing practices is the disagreement between results like those laid out in this paper and scientifically published best practices. In 2013, Teague et al. noted that there are "differences in the perspectives of ranchers' observations and scientific research results."[70] Briske et al., for example, aggregated a group of range studies and concluded that the "recent reviews of published rangeland grazing studies suggest that multi-paddock rotational grazing improves neither vegetation nor animal production relative to single-paddock continuous stocking."[71] Other studies found little difference in financial return between different forms of grazing or little difference in ground cover and forage growth.[72]

On the other hand, as previously discussed, multiple studies and on-the-ground action show benefits from short-duration rotational grazing, including increasing ecological function in the soil, plant cover, and profit.[73] The Savory Institute, Integrity Soils, and the Ranching for Profit School are just a few of the schools founded on the principles that holistic management and short-duration rotational grazing will enhance ecological function and increase ranch profitability. The decades of success stories from their outreach help ground claims of the beneficial results that can be realized.

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70 Richard Teague, Fred Provenza, Urs Kreuter, Tim Steffens, and Matt Barnes, "Multi-paddock Grazing on Rangelands: Why the Perceptual Dichotomy between Research Results and Rancher Experience?" *Journal of Environmental Management* 128 (October 2013): 700, https://doi.org/10.1016/j.jenvman.2013.05.064.

71 David D. Briske, Justin D. Derner, J. R. Brown, Samuel D. Fuhlendorf, W. Richard Teague, Kris M. Havstad, R. L. Gillen, A. J. Ash, and W. D. Willms, "Rotational Grazing on Rangelands: Reconciliation of Perception and Experimental Evidence," *Rangeland Ecology and Management* 61, no. 1 (January 2008): 3–17, http://dx.doi.org/10.2111/06-159R.1.

72 David J. Augustine, Justin D. Derner, María E. Fernández-Giménez, Lauren M. Porensky, Hailey Wilmer, and David D. Briske, "Adaptive, Multipaddock Rotational Grazing Management: A Ranch-Scale Assessment of Effects on Vegetation and Livestock Performance in Semiarid Rangeland," *Rangeland Ecology and Management* 73, no. 6 (November 2020): 796–810, https://doi.org/10.1016/j.rama.2020.07.005; Zander S. Venter, Michael D. Cramer, and Heidi-Jayne Hawkins, "Rotational Grazing Management Has Little Effect on Remotely-Sensed Vegetation Characteristics across Farm Fence-Line Contrasts," *Agriculture, Ecosystems and Environment* 282 (2019):40–48. https://doi.org/10.1016/j.agee.2019.05.019.

73 See, e.g., Paulo César de Faccio Carvalho, Pedro Arthur de Albuquerque Nunes, Arthur Pontes-Prates, Leonardo Silvestri Szymczak, William de Souza Filho, Fernanda Gomes Moojen, and Gilles Lemaire, "Reconnecting Grazing Livestock to Crop Landscapes: Reversing Specialization Trends to Restore Landscape Multifunctionality," *Frontiers in Sustainable Food Systems* 5, October 21, 2021, https://doi.org/10.3389/fsufs.2021.750765; Rattan Lal, "Regenerative Agriculture for Food and Climate," *Journal of Soil and Water Conservation* 75, no. 5 (2020): 123A–124A, https://doi.org/10.2489/jswc.2020.0620A; Rachel Lawrence, R. D. B. Whalley, Nick Reid, and Romina Rader, "Short-Duration Rotational Grazing Leads to Improvements in Landscape Functionality and Increased Perennial Herbaceous Plant Cover," *Agriculture, Ecosystems and Environment* 281 (2019):134–44, https://doi.org/10.1016/j.agee.2019.04.031; Masters, *For the Love of Soil*.; Jong-Yoon Park, Srinivasulu Ale, W. Richard Teague, and Jaehak Jeong, "Evaluating the Ranch and Watershed Scale Impacts of Using Traditional and Adaptive Multi-paddock Grazing on Runoff, Sediment and Nutrient Losses in North Texas, USA," *Agriculture, Ecosystems and Environment* 240 (March 2017): 32–44, https://doi.org/10.1016/j.agee.2017.02.004.

Some of the disagreement among studies can be explained by the conclusions of Teague, Kumar, and others that traditional scientific methods based on field studies are incomplete because they do not allow for the variation in the environment, adaptation by range managers responding to changing conditions and undesirable outcomes, and the lengthy process of the holistic approach.[74] Soil type and aridity, for example, have a significant impact on the soil's carbon content.[75] The interrelationships between soil systems, organic biota, biodiversity, and human management make studies comparing the intensity of grazing management hard. The adaptive process of regenerative agriculture makes it difficult to track and aggregate data on specified factors that produce precise metrics for comparison. Indeed, these are wicked problems that influence not only the natural systems above and below the ground but also social and cultural perspectives.

Many of the academic studies completed for peer-reviewed publication rely on quantitatively measured and repeatable experiments, which are typically small-scale and short-term. Alternatively, social science studies focus more on the qualitative and quantitative experience of the rancher.[76] There is immense variability in on-the-ground ranch management experience. Holistic grazing focuses on moving livestock to follow forage as it grows throughout the season, which varies on the basis of constantly changing factors, such as the amount of precipitation, weather conditions, acreage managed, paddock size, rotation timing, and the number and type of livestock. Where the academic scientist is acting on a prescribed management process to measure repeatable outcomes, the ranch manager is constantly adapting to changing conditions. Every ranch is different, which makes comparison difficult. Furthermore, ranchers that successfully transition are more likely to continue using the holistic approach, while others may quit using it. Social science surveys are not good at distinguishing this effect.

New satellite imagery is helping to quantify management results on a larger scale. Remote sensing aggregates image data over space and time and provides a clearer picture of forage and range improvements, including changes in bare ground and vegetation composition. Spatial and temporal data can be overlaid with management practices to quantify rangeland results from various practices over time.[77] Researchers are developing methods to analyze and use satellite data about the range.[78] Remote sensing can help quantify vegetative changes on the range and the potential drivers of such changes. Matching on-the-ground management techniques with remote-sensing data can provide information to help increase the scalability of adaptive management.

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Barriers to Change on Federal Lands

Many ranchers in the West rely on public lands for grazing, and these lands come with their own regulations. About 200 million acres, or one-third of the US range, are federal lands leased for private livestock grazing.[79] Federal leases provide the additional range needed for many western ranches to stay in business, including about 17,000 permittees. Federal policy designates the number of livestock that can graze and the start and finish dates that livestock can be on the public range. When lessees meet all land health standards, some flexibility may be granted for holistic rest and rotation management if the change is permitted by environmental policy. Often the prescriptive nature of federal leases and strict adherence to livestock numbers permitted don't allow ranchers to realize the full benefits of the adaptive grazing approach on federal lands.

Forest Service grazing leases further restrict flexibility with a requirement that the lessee own both the livestock and the base property that is associated with the federal grazing allotment. Every Forest Service grazing lease coincides with an adjacent private range known as a "base property." The requirement to own both the livestock and the base property prevents the owner from leasing livestock, leasing the forage, or dividing ownership with partners or corporate entities. As a result, the transfer of a permit is possible only with the sale or redesignation of the base property.

In 2018, the Bureau of Land Management began an outcome-based grazing program to help test the results of increasing the flexibility of federal grazing policy. The agency selected 11 pilot ranches to test a more flexible management approach focused on meeting operational and ecological objectives rather than on following prescriptive grazing rules.[80] After several years of planning and environmental analysis, eight of the demonstration projects are in the implementation phase.

The Department of the Interior is expanding the program by incorporating additional flexibility for grazing authorizations. National Environmental Policy Act documentation is being developed for permit renewal and to allow more flexibility in grazing to respond to changing conditions at the ranch and landscape levels.[81] When National Environmental Policy Act analysis and documentation identify potential grazing management adjustments, these adjustments become part of the lease terms and conditions of the grazing authorization, giving lessees flexibility to adapt to variable conditions. Cooperative monitoring plans that describe the objectives and desired outcomes are required for all Bureau of Land Management outcome-based grazing projects.

Rangelands do not follow property lines, however, and improving the conservation value of rangeland owned by the federal government will require more than just altering public land management. The outcome-based grazing program will allow for more holistic grazing practices on both public and private rangelands and will improve both the economic and the environmental value of cattle operations using these lands.

79 CRS, "Grazing Fees: Overview and Issues," CRS, last modified March 4, 2019, https://sgp.fas.org/crs/misc/RS21232.pdf.

80 "Updates to Outcome-Based Grazing Program Shared in New Webinars," Partnering to Conserve Sagebrush Rangelands, April 1, 2022, https://www.partnersinthesage.com/blog/2022/3/30/updates-to-outcome-based-grazing-program-shared-in-new-webinars.

81 Adrienne Hoskins, Bureau of Land Management outcome-based grazing program director, pers. comm., October 5, 2022.

Conclusion

Holistic grazing appears to be very promising, and additional analysis will help decipher best practices that result in more productivity and profit for ranchers.[82] As previously mentioned, finding the tipping point for ranchers to transition into holistic grazing is more than a scientific understanding. There are socioeconomic costs and benefits and policy implications that need to be addressed. Working against conventional norms creates tension and discomfort. The transition requires ranchers to change their mental model and to be willing to let go of conventional inputs and rely on natural processes. Holistic grazing is a move to work with nature instead of fighting against it, and it requires a new understanding of ecological conditions.[83] The transition to holistic grazing also requires economic viability. If a shift in management is not profitable, it is not sustainable or scalable.

Finding ways to create more sustainable systems is one of the most important challenges facing society, and perhaps no system is more important than the agriculture that provides the world's food. Implementing more holistic grazing is just one step toward improving the sustainability of that system—a step that will also improve the profitability of ranching itself. There is no one way to manage the landscape, any more than there is a single method to raise a child. Focusing on soil health, in the ways outlined in this paper, can provide an economic return by improving the ecological function of the working ranch. The enhancement of ecosystem services, including increased water and carbon retention in soils and enhanced biodiversity and wildlife habitat, are additional benefits. Working lands are an integral part of America's ecosystems, and making sure they are profitable not only helps farmers and ranchers, it also protects the many benefits and environmental services they provide every day.

82 Gosnell, Charnley, and Stanley, "Climate Change Mitigation as a Co-benefit of Regenerative Ranching."

83 Hannah Gosnell, Nicholas Gill, and Michelle Voyer, "Transformational Adaptation on the Farm: Processes of Change and Persistence in Transitions to 'Climate-Smart' Regenerative Agriculture," *Global Environmental Change* 59 (November 2019): 101965, https://doi.org/10.1016/j.gloenvcha.2019.101965.