8-2024

Working Together for Working Lands: Knowledge Braiding and Adaptive Capacity at the Confluence of Rangelands, Climate Adaptation, and Watershed Stewardship

William Wesley Munger
Utah State University

WORKING TOGETHER FOR WORKING LANDS: KNOWLEDGE BRAIDING AND ADAPTIVE CAPACITY AT THE CONFLUENCE OF RANGELANDS, CLIMATE ADAPTATION, AND WATERSHED STEWARDSHIP

by

William Wesley Munger

A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Environment and Society

Approved:

Claudia Radel, Ph.D. Major Professor	Mark Brunson, Ph.D. Committee Member
Sarah Klain, Ph.D. Committee Member	Eric Thacker, Ph.D. Committee Member
Roslyn McCann, Ph.D. Committee Member	D. Richard Cutler, Ph.D. Vice Provost of Graduate Studies

UTAH STATE UNIVERSITY
Logan, Utah

2024

ABSTRACT

Working Together for Working Lands: Knowledge Braiding and Adaptive Capacity at the Confluence of Rangelands, Climate Adaptation, and Watershed Stewardship

by

William Wesley Munger, Doctor of Philosophy

Utah State University, 2024

Major Professor: Dr. Claudia Radel
Department: Environment and Society

Working lands are a mosaic that hold critical opportunities for biodiversity, rural community wellbeing, and climate change adaptation. This landscape mosaic is made up of public lands, tribal lands, and private ranches, farms, and forests. The current era of ecological restoration and climate adaptation requires engaging in working lands conservation because the most promising strategies require working across multiple ownership boundaries. This dissertation argues that supporting working lands conservation, climate adaptation, and ecological restoration is a joint venture. Building adaptive capacity for climate change involves both social and ecological components. Adaptive capacity consists of building social collaborative capacity and ecological health and integrity. The key to successful working lands conservation is understanding the deep interconnections between nature and people, that local relationships matter, and that flexibility and adaptability are essential. This dissertation explores how collaborative transdisciplinary science and the braiding together of plural knowledge systems can help improve social and ecological outcomes of conservation, restoration, and climate adaptation projects at the intersection of watershed and range management. The dissertation is based on two case studies: the Watershared conservation incentive program in Bolivia and the Wuda Ogwa ecological restoration project led by the Northwestern Band of the Shoshone Nation. In the case of Watershared, I used mixed methods including survey data, interviews and participant observation. In the first chapter, I show how cattle ranching contributes to local livelihoods and how participating in the Watershared program is associated with changes in range management practices. In the second chapter, I show how a relational approach to care-based stewardship is engendered by conservation program field staff attuned to local agency, care, and knowledge. In the third chapter, I reflect on lessons learned from transdisciplinary co-produced research conducted in partnership with the Wuda Ogwa project. Both case studies provide insight on how to work together on working landscapes by braiding together plural knowledges, designing relevant incentive structures that support intergenerational stewardship, and building the collaborative capacity to adapt to a changing climate.

(231 pages)

PUBLIC ABSTRACT

Working Together for Working Lands: Knowledge Braiding and Adaptive Capacity at the Confluence of Rangelands, Climate Adaptation, and Watershed Stewardship

William Wesley Munger

Working lands are a mosaic that hold critical opportunities for biodiversity, rural community wellbeing, and climate change adaptation. This landscape mosaic is made up of public lands, tribal lands, and private ranches, farms, and forests. The current era of ecological restoration and climate adaptation requires engaging in working lands conservation because the most promising strategies require working across multiple ownership boundaries. This dissertation argues that supporting working lands conservation, climate adaptation, and ecological restoration is a joint venture. Building adaptive capacity for climate change involves both social and ecological components. Adaptive capacity consists of building social collaborative capacity and ecological health and integrity. The key to successful working lands conservation is understanding the deep interconnections between nature and people, that local relationships matter, and that flexibility and adaptability are essential. This dissertation explores how collaborative transdisciplinary science and the braiding together of plural knowledge systems can help improve social and ecological outcomes of conservation, restoration, and climate adaptation projects at the intersection of watershed and range management. The dissertation is based on two case studies: the Watershared conservation incentive program in Bolivia and the Wuda Ogwa ecological restoration project led by the Northwestern Band of the Shoshone Nation. In the case of Watershared, I used mixed methods including survey data, interviews and participant observation. In the first chapter, I show how cattle ranching contributes to local livelihoods and how participating in the Watershared program is associated with changes in range management practices. In the second chapter, I show how a relational approach to care-based stewardship is engendered by conservation program field staff attuned to local agency, care, and knowledge. In the third chapter, I reflect on lessons learned from transdisciplinary co-produced research conducted in partnership with the Wuda Ogwa ecological restoration project. Both case studies provide insight on how to work together on working landscapes by braiding together plural knowledges, designing relevant incentive structures that support intergenerational stewardship, and building the collaborative capacity to adapt to a changing climate.

ACKNOWLEDGMENTS

I give deep gratitude to all the family, friends, and mentors who supported this journey. Particular thanks to Claudia, who is a guiding light of kindness, care, and intellectual rigor.

To all the committee members, Mark, Eric, Ros, and Sarah, thank you for the many challenging conversations and drafts. I could not have done this without the ENVS department staff, thank you Becky and Kay.

Special thanks to the USU Climate Adaptation Science program: Nancy, Thad, Sofia, Lindsay, and Cohort 3 as well as the Southwest Climate Adaptation Science Center: Anita, Michelle, Allison, Greg, and the Natural Resource Workforce Development fellows: Juli, Kelly, Ben, Junna, Sara, and Anne. Gracias to the Pathways Fellowship: Jan, Beth, Ben, Alex, Matt, Dylan, Christian, Valentia, Gerhard, and Mark.

Un abrazo grande al equipo de Fundación Natura Bolivia y nuestra banda del campo, nunca olvidaré tu apoyo. Gracias a Zhao, Jonathan, Brooke, Laura, Ricardo, Meagan, Edwin, Tito, Dionicio, Hugo, Maximo, Panfilo, Gever, Nigel, y Maria Teresa, Alfredo, Paula y Brigitt.

An extra special thanks to all the elders, leaders, and staff at the Northwestern Band of the Shoshone Nation: Brad, Rios, Maria, Gwen, Patty, George, James, and Chase. To Darren and Mel, thank you for the hunts, horses, and kinship. It was on honor to contribute a small part to the huge collective work of all the Wuda Ogwa partners: BIOWEST: Darren, Bob, Travis, Ryan, Drew. Trout Unlimited: Jim, Cathy, Tyler. Wildlife Conservation Society: Sarah. HAL: Brian. Sageland Collaborative: Rose and

Sarah. Stewards and students: Aidan, Nizhonii, Carson, Chloe, and all the NASMP students. Thanks to Eric for all the mentoring, support, and tunes around the campfire.

Thank you to all my ranching and range mentors: Burt, Dustin, Ken, James, Che, Merc, Alan, Tom, Kip, the Logan Canyon Grazing Association, Jay, Casey, and Shelly. Especially the Dugout Ranch and Canyonlands Research Center: Matt, Kristen, Heidi, Mike, Sasha, Cody, Casey, Preston, Trevor, Sue, Maria, and Kari. Shout out to the USU Range Team, all the staff and community in the Quinney College of Natural Resources, the Lab gang: Sarah, Bryn, & Cole, BNR 2nd floor citizens: Horacio, Iddy, Juan, Peter, Tim, Gary, and all the construction workers.

Special thanks to the lifetime mentors: Jack, Hailey, Emily, Darren, Barb, John, Mimi, Chris, Kristian, Alex, and Sara.

Much love to the cavvietta of range critters: Lucha, Yung Ephraim, Delta Dawn and Alice.

Endless love and gratitude to my family: Ron, Beth, and Noel. In memory of Maryellen Munger: artist, grandmother, and source of boundless creativity.

Graduate funding was provided by National Science Foundation Grant 1660481 (PI Zhao Ma) and the Wildlife Conservation Society's Climate Adaptation Fund.

Will Munger

CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Working lands are a mosaic that hold critical opportunities for biodiversity, rural community wellbeing, and climate change adaptation (Kremen and Merenlender, 2018; Steele and Hatfield, 2018). This landscape mosaic is made up of public land, tribal land, and private ranches, farms, and forests (Burger et al., 2019). While the first era of conservation prioritized protected areas, parks, and wilderness, the current era of ecological restoration and climate adaptation requires engaging in working lands conservation because the most promising strategies require working across multiple boundaries (Almaraz et al., 2023; Dertien and Baldwin, 2022; Tait and Brunson, 2021). In the western United States, land ownership patterns from settler colonization created a mosaic of private lands that have important qualities like water, good soils, and wildlife habitat (Sayre, 2017; Young, 1985). While the US government owns 47% of all land in the West, an estimated 74% percent of the high-quality landscape mosaic in the continental U.S. West is currently in private ownership (Allison, 2023). Additionally, 75% of remaining wetlands, 80% of remaining grasslands, and two-thirds of endangered species in the U.S. West are found on private land. The concept of working lands emerged in the early 1990s and while it has grown in popularity, it still faces challenges in mobilizing funding and organizing durable collaborations (Riley et al., 2019). Working lands might be a compelling area of opportunity, but what are the strategies and practices that create pathways to achieving the complicated objectives of supporting ecological health and biodiversity, rural community wellbeing, and climate change adaptation?

Working together on working landscapes requires building collaborations able to co-produce science, braid together plural knowledge, and build incentive structures that support intergenerational stewardship. These collaborations are strengthened by attention to relational values that emphasize humility, agility, persistence, and a shared understanding of place-based context (Chambers et al., 2022; Wainaina et al., 2023). There is no silver bullet for working together, but there are emergent strategies, paths that invite us to think about change as a constant state of being and how to align and direct it towards that which affirms and creates healthy human and ecological relations (Brown, 2017). This dissertation explores two emergent strategies that may better support working together on working lands: conservation incentive programs and knowledge braiding.

Twentieth century conservation in a patchwork of landscape boundaries used three main strategies: governmental regulation, resource exchange under a private property regime, and cooperative efforts to manage resources collectively (Ostrom, 1990). Another idea, ecosystem services, arose in the late 1970s and became a major part of global conservation policy discourse during the 2003 Millennium Ecosystem Assessment (Gómez-Baggethun et al., 2010). Ecosystem services arose not as an explicit conservation strategy, but as a way to recognize the direct and indirect benefits that ecosystems provide to humans. Working lands, such as rangelands, crop lands, and forests produce agricultural goods as well as provide a suite of ecosystem services that sustain human livelihoods. These ecosystem services are conceptualized as provisioning, regulating, cultural and supporting services (Assessment, 2005).

One conservation strategy to emerge from this line of thinking is known as Payment for Ecosystem Services (PES). Recognizing and incentivizing the ecosystem services provided by working lands now includes the services of carbon storage, biodiversity, water, open space, and cultural values (Mahowald, 2020). Because agriculture on working landscapes, particularly livestock production, is often targeted as a driver of the climate and biodiversity crises, conservation incentives programs emerging and evolving from PES ideas attempt to incentivize management and behavior changes that support conservation goals as well as agricultural livelihoods. There is now a growing body of research that evaluates the interaction of grazing and PES on working landscapes (Calle, 2020; Chapman et al., 2020). This dissertation contributes to this research with two articles that explore a hybrid PES program in Bolivia. The results point towards emergent strategies that can support the capacity to find adaptive pathways that benefit humans and the more-than-human world. The intersection of rangeland stewardship, climate change adaptation, and watershed management is a critical area needing research and collaborative experimentation. Understanding how humans and landscape mosaics interact together in ways that address biodiversity, watershed health, climate, and rural community well-being is one of the central challenges of our time.

There is widespread global interest in incentivizing ecosystem service provision, climate adaptation, and ecological restoration. Neoliberal conservation has continued to be promoted worldwide despite failing to live up to its own goals (Fletcher, 2023). Critical scholars coming from environmental justice, climate justice, and Indigenous perspectives point out that there are robust more-than-market values and paradigms of human-nature relations that offer critical insights into dealing with planetary crises. How are these big ideas interrelated and how can transdisciplinary research help advance our understanding of how to transform social ecological systems towards sustainable pathways? A growing scholarship is arguing that a broader perspective that engages plural knowledge and understandings of social-ecological systems and processes is needed for building working landscapes that support biodiversity and climate resilience (Bennett et al., 2022). A key consideration is that ecological knowledge is changing and land managers are being asked to value a wider range of ecosystem processes like fire, biodiversity, watershed function, and climate change. Another key consideration is that Indigenous and local knowledge has been marginalized yet now scientists are recognizing the importance of plural knowledge in climate adaptation and ecological restoration (David-Chavez et al., 2023; Whyte et al., 2023).

This dissertation argues that supporting working lands conservation, climate adaptation, and ecological restoration is a joint venture. It requires agile, humble, and persistent collaborations capable of co-producing actionable plural knowledge and values. Building adaptive capacity for climate change involves both social and ecological components. Adaptive capacity consists of building social collaborative capacity and ecological health and integrity.[1] The key to successful working lands conservation is understanding the deep interconnections between nature and people, that local relationships matter, and that flexibility and adaptability are essential. This dissertation explores how collaborative transdisciplinary science and the braiding together of plural knowledge systems can help improve social and ecological outcomes of conservation,

[1] Ecosystem health is defined as "the state or condition of an ecosystem in which its dynamic attributes are expressed within the normal ranges of activity relative to its ecological state of development" (Andel and Aronson, 2012). Ecosystem integrity is "the state or condition of an ecosystem that displays the biodiversity characteristic of the reference, such as species composition and community structure, and is fully capable of sustaining normal ecosystem functioning" (SER, 2002).

restoration, and climate adaptation projects at the intersection of watershed and range management. Collaborative transdisciplinary science benefits from a process in which different ways of knowing are braided together equitably to enable the reciprocal exchange of understanding for mutual learning and application (Alexander et al., 2021, 2019; Cebrián-Piqueras et al., 2020; Johnson et al., 2020; Norström et al., 2020).

The term "knowledge braiding" comes from *Braiding Sweetgrass* and refers to a framework that emphasizes reciprocal relationships between humans and ecologies as well as Indigenous knowledges and Western Scientific knowledge (Kimmerer, 2015). There are several theories that engage this concept including epistemological pluralism in co-produced science(Miller et al., 2008) and Two Eyed Seeing in education and ecology (A. J. Reid et al., 2021).

Within the field of conservation, restoration, and climate adaptation, there is an expanding field of scholarship addressing the need to bring together diverse stakeholders and diverse knowledge systems including Western Scientific knowledge, Indigenous knowledges, and local knowledges (Tengö et al., 2017). This is a particular challenge in the context of power differences and histories of colonialism, marginalization, and inequity within research and science (Smith, 2012). Rangeland historians have documented how the field's practical and theoretical knowledge are inseparable from colonial land expropriation and a capitalist imperative to manage rangelands for short term profit at the expense of land and community sustainability (Sayre, 2017). Another set of scholars have contributed to our understanding of addressing power differentials in collaborative research and education settings with particular attention to coloniality in how science and education are conducted (Litts et al., 2020; Medin and Bang, 2014;

Patel, 2016). There is a need to understand how research and applied social-ecological projects in the sphere of climate adaptation, watershed restoration, and range conservation can braid together Indigenous knowledge, local knowledge, and Western scientific knowledge (Henri et al., 2021).

This dissertation is based on three articles that explore interventions in rangeland headwater socio-ecological systems. Rangeland headwaters are grazing-based social-ecological systems located where watersheds originate. The three articles are connected to two separate projects from different sides of the globe: Fundación Natura Bolivia's Watershared Program and the Northwestern Band of the Shoshone Nation's Wuda Ogwa ecological restoration project. The distinct social-ecological systems represented in these case studies are facing increasing climate change risks including drought, precipitation variability, and increasing temperatures (Pörtner et al., 2022). These headwater ecosystems are also identified as playing critical functions to buffer climate risks like drought and increasing precipitation variability (McCoy, 2021). The contribution of this dissertation is to explore how the practical application of knowledge braiding can support more socially just and ecologically sound watershed restoration, rangeland management, and climate adaptation projects. The overarching research question framing this dissertation proposal is: what are the processes and practices that enable equitable collaboration and knowledge braiding that addresses rangeland vulnerabilities and builds adaptive capacity to climate change?

Literature Review

Climate adaptation and rangelands

Rangelands constitute approximately 50% of the world's land area globally and support a number of ecosystem services including forage for livestock that supports rural livelihoods (Briske et al., 2015). Grazing represents the most extensive use of land worldwide (Maestre et al., 2022). Climate change threatens the health and sustainability of rangelands and the human community whose livelihoods and cultures are interwoven with them (Havstad et al., 2018). Scholars working at the intersection of rangelands and social science highlight the need to engage with and be responsive to the needs of rangeland communities who have been historically marginalized and underserved by rangeland science (Brunson et al., 2021). This proposal seeks to engage these joint challenges by studying the implementation of two conservation initiatives that try to address the unique social and ecological vulnerabilities of two different communities who are working to steward landscapes that are affected by grazing and climate change.

The larger question is how to build local climate adaptation capacities that address vulnerabilities in an era where there is a push to transform range management practices and better manage the ecological footprint of agricultural production in rangeland systems (Teague and Kreuter, 2020). At the same time, it is critical to avoid vulnerability discourses that reinscribe colonial notions of vulnerability that ignore the agency of marginalized communities who are working to steward degraded ecosystems (Vinyeta, 2022).

Rangeland communities that include smallholder ranchers and farmers are potentially vulnerable to climate change impacts like drought, increasing climate variation, and loss of forage productivity (Burnham and Ma, 2015). These biophysical vulnerabilities are mediated by human conditions such as socio-political institutions and economic structures (Radel et al., 2018; Turner et al., 2003). Adaptive capacity is defined at multiple scales: individual, household, community, and systems levels. Adaptive capacity is broadly defined as the ability of a human or natural system to adjust to climate change (including climate variability and extremes) by moderating potential damages, taking advantage of opportunities, or coping with the consequences (EPA 2022). The Environmental Protection Agency's broad definition is similar to a systems definition that examines the ability or potential of a system to respond successfully to climate variability and change. This includes adjustments in both behavior and in resources and technologies (Adger et al., 2007). Analysis of adaptive capacity at the individual and household scale often focuses on social vulnerability assessments and livelihoods analysis (Nelson et al., 2010). This approach frames social adaptive capacity as a function of entitlements, resources, and capital (Keskitalo et al., 2011). There is a recent push to better understand the underlying socio-ecological governance systems and processes that create capacity and/or vulnerability and maladaptation (Vallury et al., 2022). This research responds to the call to also explore the motivations and objectives of actors that underpin adaptive action and understand the effectiveness of such actions in reducing vulnerability (Elrick-Barr et al., 2014).

Rangeland research on adaptive grazing management strategies for drought focus on increasing resiliency of rangeland ecosystems and reducing risk for ranching enterprises affected by drought. Practically, there are four general strategies that ranchers can use to deal with drought: 1) predict it using weather and climate forecasting tools, 2) track it, 3) employ conservative stocking rates, and 4) utilize inherent spatial variability (Derner and Augustine, 2016). Connecting broader climate risk assessment tools such as the Rangeland Analysis Platform with the local knowledge of land managers is a strategy being used by Rangeland Extension researchers working on adapting to drought in the United States (Thacker, 2022). Braiding together regional scale climate risk assessment tools with socially and locally specific vulnerabilities is a needed area of more research and extension (Dinan et al., 2021). Variations in biophysical and socio-economic adaptive capacities means that there is a need to better understand how rangeland communities' perceptions of their vulnerability are shaped by situational and social differences, including access to community and household resources and variations in livelihood activities (Green et al., 2020).

Rangeland headwaters are theorized here as coupled social-ecological systems (SES) and understanding the feedback loops between the systems is critical for adaptive management in an era of climate change (Brand and Jax, 2007; Hruska et al., 2017). Climate-related challenges such as extended drought and interannual variability make adaptively managing these rangeland headwaters a particularly challenging task. The coupling of social and ecological systems is conceptually important because human land-use decisions affect multiscale processes such as the water cycle and biogeochemical cycling. In this dissertation, the working definition of resilience in rangeland SESs to climate change focuses on the use of "resilience thinking " (Walker and Salt, 2012). This definition encompasses science and management aimed at reducing SES vulnerability to shocks by 1) focusing on transformative processes rather than stable states, 2) maintaining diversity and redundancy of system components, 3) improving information flow to detect thresholds before they are crossed, and 4) building social networks among scientists and stakeholders who can collaboratively influence change in response to local conditions and processes. Resilience can take on different meanings in social or ecological systems. Geographers and political ecologists have warned against overly broad definitions that ignore power asymmetries, offer apolitical solutions, and are conceptually vague (Mikulewicz, 2019).

Stakeholder engagement is widely used and recommended in range and water management (Allen et al., 2017). There is a call for applied scientific research on whether and how, and under what conditions, stakeholder engagement actually leads to improvements in social, economic, and environmental outcomes in working landscapes (Eaton et al., 2022). In each of the dissertation articles, the processes and practices that enable meaningful stakeholder participation will look different. This research contributes to understanding on how to move the needle towards more equitable collaboration. Equitable means addressing historic and ongoing inequities and injustices while also critically understanding power structures that shape how stakeholder knowledge is valued, measured, respected, and applied.

Political ecology, coloniality, and collaboration in natural resource science

Political ecology (PE) frameworks are theoretical foundations for describing both coloniality in contemporary natural resource issues as well as decolonial approaches to collaboration and environmental knowledge production. Political ecology contributes frameworks from anthropology, geography, and related disciplines to focus analyses on how and why structural forces, such as colonial and capitalist economic processes and power relations, drive environmental change in an increasingly interconnected world (Roberts, 2020). Within PE there is an established scholarly exploration of how environmental knowledge claims are "generated, packaged, promoted, accepted, and rejected by the different actors involved in cases of environmental management, conservation, and development" (Goldman et al., 2010). PE focuses attention on the struggles surrounding environmental knowledge by examining how such struggles shape conceptions of the environment, and whose interests are served in the process. A key idea is that knowledge, even 'scientific' knowledge, always comes from somewhere. It is the product of particular perspectives and partial visions (Haraway, 1988). To "know nature" is to grasp how multiple agents not only produce knowledge about the environment but struggle to authorize, legitimize, and deploy it. Attention is needed at the surfaces of engagement where multiple knowledge systems interact to nurture a plurality of social and ecological stewardships in an era of intersecting crises (Escobar, 2016).

Natural resource scholars have emphasized the importance of multi-stakeholder collaboratives for over a century (Sayre, 2017). Which stakeholders and knowledge systems were considered legitimate was and is affected by power structures like colonialism, capitalism, and race and gender hierarchies (Vinyeta, 2022; Vinyeta et al., 2015). The historical arc of watershed governance in the western United States demonstrates both a well-known history of conflict but also collaboration. Today, as climate change forces a reworking of watershed management and governance frameworks like the Colorado River Compact, tribal governments and Indigenous water protectors are demanding a seat at the negotiating table. In the Intermountain West, there are open questions as to how future collaborative science and management will include Indigenous people and tribal governments who have a stake in the future of watersheds (Wheeler and Root-Bernstein, 2020).

These questions of colonialism and collaboration have parallels in fire science. Indigenous fire practices were banned by early settler governments and early fire management agencies like the Forest Service. In an era of mega-fires and climate change, a recent emphasis on prescribed and cultural fire has brought forth new collaborative research that braids together Indigenous fire culture and practice, pyrogeography, and fire ecology (Marks-Block et al., 2021; Marks-Block and Tripp, 2021). Recent work from the Southwest Climate Adaptation Science Center has mapped out this longer history and new collaborations (Adlam et al., 2022). As prescribed fire practitioners work to gain more popular acceptance, how will fire ecologists work together to collaborate with local and Indigenous fire practitioners? How will climate vulnerability assessments be meaningfully co-produced and move away from settler-ascribed discourses of vulnerability (Tribe, 2019)?

In the rangeland world, there has been a slow 30-year pivot from conflict towards collaboration. In rangeland settings worldwide, ecological processes such as fire and grazing fall on a quilt of land ownership boundaries and administrative lines that represent distinct management objectives, personal beliefs, and values. Groups like the Quivira Coalition understood this and responded by creating the ideological space of the radical center where plural knowledge systems could potentially meet amidst the collaborative turn. Practically, this often occurred in rangeland headwater workshops to share erosion control techniques as well as gatherings where different ways of knowing rangeland were brought together (White, 2008).

These examples from water, fire, and range science illustrate the need for a working theory of coloniality and decolonizing methodologies that can inform how we structure our collaborations and research. This is especially important in the context of new policies promoting co-management and co-stewardship in public land management (Smith, 2023). Coloniality refers to long-standing patterns of power and knowledge production ensuing from colonialism. Colonialism identifies a distinct system and philosophy, while coloniality distinguishes a quality and condition that remains after formal colonial systems are reformed. Coloniality is a term that comes from the scholarship that interrogates history, knowledge production, culture, gender, labor, and intersubjective relations in post-colonial eras (Estes and Dunbar-Ortiz, 2020). A key insight is that structures and practices derived from settler colonialism and colonial governance continue to influence social institutions and relations in the present, even though they originally are derived from an era that many now believe is in the past. On the other hand, decoloniality is a way to, “re-learn the knowledge that has been pushed aside, forgotten, buried or discredited by the forces of modernity, settler-colonialism, and racial capitalism” (Project, 2024).

Linda Smith articulates the ongoing challenges for aspiring decolonial researchers in the recent third edition of *Decolonizing Methodologies,*

> Knowledge and the power to define what counts as real knowledge lie at the epistemic core of colonialism. The challenge for researchers of decolonizing methodologies as a set of knowledge-related critical practices is to simultaneously work with colonial and Indigenous concepts of knowledge, decentering one while centering the other. While this sounds straightforward, it is not. (Smith, 2012)

Decolonization as a term has been used in a wide variety of social movement and academic contexts, and it is a term that is gaining in popularity and thus subject to increasingly diverse critique. Criticisms include that the term is not ideologically synonymous with social justice, but includes an expanded focus on land, institutional relationships, political-economic relations, Indigenous knowledge, and governance (Asher, 2013; Dunlap, 2022; Fúnez-Flores et al., 2022).

In the fields of watershed, fire, and range management, Indigenous movements and governments are working to bring their lands back under Indigenous stewardship and co-management. This dissertation aims to support environmental scientists with frameworks for collaboration with the increasing number of local and regional Indigenous land reclamation efforts such as Wuda Ogwa and Bears Ears National Monument. Wuda Ogwa is the name of the ecological restoration project led by the Northwestern Band of the Shoshone Nation, who are reclaiming the land of the Bear River Massacre and working to heal ecological and human relations. The Bears Ears Intertribal Coalition (BEITC) recently issued a statement about the need for a:

> …new model of collaborative management between the Tribes, state and federal land agencies…In this new model, the traditional knowledge and place-based conservation strategies of Tribal communities will play a significant role in shaping efforts to conserve and plan a resilient future for this landscape that we all hold dear. (Coalition, 2021)

The main point from this literature review so far is that the current era holds an important opportunity for natural resource sciences in fields like fire ecology and watershed and range management to engage political ecology and decolonial methodologies in order to better co-produce with local and Indigenous collaborators. Between the history of colonialism and the future of climate change lies our current opportunity to nurture emergent strategies and practices.

This nurturing requires engagement with a growing field of decolonial research methodologies and ethics. This need is being discussed in diverse fields from decolonial education research (Patel, 2016), climate change adaptation (Whyte, 2017), and transdisciplinary collaboration (Wilmer et al., 2021a). The following diagram (Figure 1) proposes expanding the research ethical framework to include Representation, Self-Determination, Reciprocity, and Deference. Cross cutting themes in this proposal correspond to the domains in green in this diagram and are 1) attention to a beyond-human sphere of interests and ethics, and 2) acquiring skills as ethical practice.

Figure 1: Expanded Ethical Principles. Reproduced from Wilmer et al. (2021).

Another set of research ethics articulated by a range of Indigenous and decolonial collaborations are the Four Rs. These include Respect, Relevance, Responsibility, Reciprocity (McCubbin and Moniz, 2015). The final set of ethics, the CARE principles, deal with data sovereignty in ecological and biodiversity research (Jennings et al., 2023). Taken all together, the examples and ethics reviewed in this section lay the groundwork for the proposed case studies of the dissertation.

Knowledge systems and knowledge braiding

Scientists across a range of disciplines are recognizing the need to work across and between different knowledge systems. However, the term "knowledge systems" has been defined differently across disciplines and varies across at least three dimensions: spatial scale, temporal scale, and social scale (Varghese and Crawford, 2021). Knowledge systems enable communities to accumulate the experiences of many individuals over time, into practices and processes that enable greater insight than would be possible by any single individual (Emery, 1999). Within the three articles of this dissertation, there are multiple distinct knowledges including scientific, observational, cultural, and local. The use of the term 'braiding' (Kimmerer, 2015) instead of 'integrating' is to recognize the multiplicities of knowledges, power dynamics, and systems (Sidik, 2022).

A knowledge braiding process framework illustrates how actors, institutions, and processes are at the core of the five tasks required for successful collaboration across diverse knowledge systems (Tengö et al., 2017). The diagram in Figure 2 illustrates a knowledge braiding process that recognizes a multiplicity of knowledges as well as identifies points along the knowledge braiding process where addressing histories of colonialism, social power dynamics, and translations between knowledge systems are given priority.

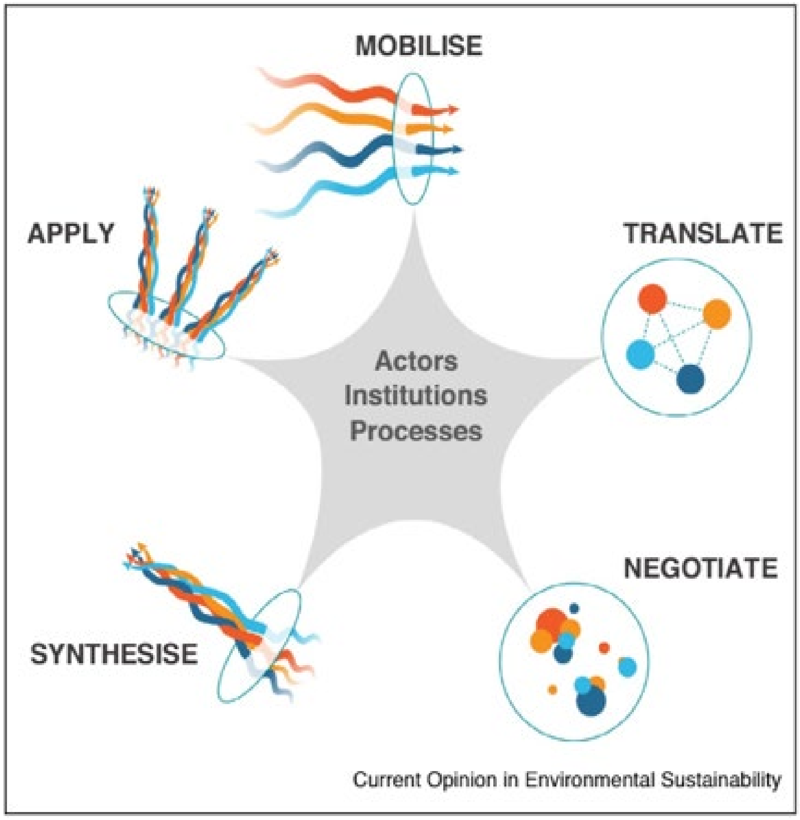

Figure 2: Knowledge weaving process. Reproduced from Tengö et al. (2017).

A review of knowledge system research shows that the field is quickly growing, resulting in several terms and frameworks that address a similar need (Varghese and Crawford, 2021). Research co-production emphasizes science conducted with and within society rather than happening apart from society and then delivered on a ‘loading dock’ through the academy or other government and civil society institutions (Enquist et al., 2017). Within sustainability studies, co-production is defined as an iterative and collaborative process involving diverse types of expertise, knowledge, and actors to produce context-specific knowledge and pathways towards a sustainable future (Norström et al., 2020). Four guiding principles of high-quality knowledge co-production in sustainability research are that it is context-based, pluralistic, goal-oriented and interactive. A related term is collaborative transdisciplinary science, which is an evolving term that is increasingly focused on “epistemologies (different ways of knowing, not just different knowledges), power, action and transformation of systems” (R. S. Reid et al., 2021). Another related framework is co-generation (Figure 3), which emphasizes the iterative, relational and positional aspects of knowledge creation.

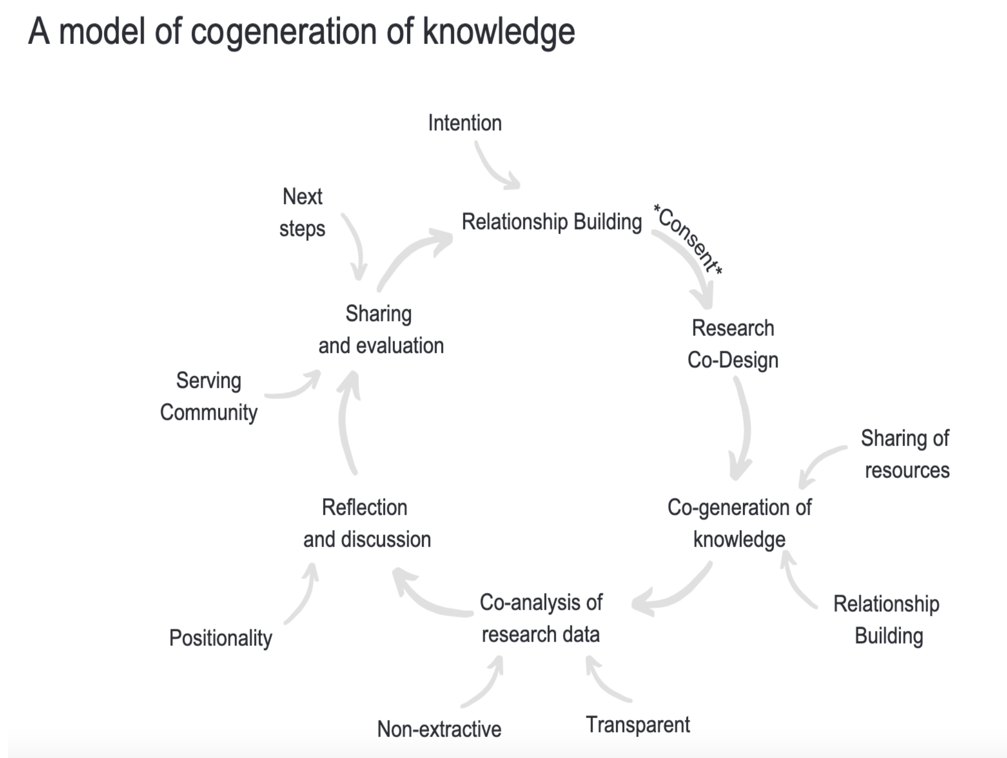

Figure 3: Co-generation model. Reproduced from Klein et al. (2022).

Wicked problems, collaborative adaptive management, and social learning

The most challenging watershed and rangeland issues facing the world are "wicked problems" that require complex and adaptive management arrangements. Wicked problems are difficult or impossible to solve because of incomplete, contradictory, and changing drivers that are often difficult to recognize (Rittel and Webber, 1973). Most of these issues need to be addressed at several scales simultaneously, ranging from local to global. They require action at the scale of large landscapes because the geographic scope of the issues often transcends the legal and geographic reach of existing jurisdictions and institutions. These issues face a reality where no single entity has the authority to address these types of cross-boundary issues, resulting in gaps in governance and a corresponding need to create formal and informal ways to work effectively across administrative boundaries, land ownerships, and political jurisdictions.

Collaborative adaptive management (CAM) is a framework developed for conservation and resource management contexts characterized by: (1) high degrees of uncertainty; (2) complexity resulting from multiple variables and non-linear interactions; (3) interconnectedness—among issues, across landscapes, and between people and place; and (4) persistent, possibly dramatic, change (Scarlett, 2013). The most challenging wicked resource management decisions present complex communication challenges, information challenges, coordination challenges, and action challenges. CAM is a framework to respond to these challenges. While these resource management questions are technical and complex, stakeholders also have to contend with distributional effects that often involve trade-offs. The role of scientists and technical experts is not to drop off an optimal solution at the loading dock (Cash et al., 2006), but to support continual learning and collaborative adaptive decision making. Four main principles of collaborative adaptive management are: (1) establishment of clear goals and objectives, (2) mechanisms for promoting participation, (3) clear roles and processes for shared learning, and (4) the dynamic management of the adaptive management programs themselves (Brymer et al., 2018). The experience of CAM laid the foundation for the currently expanding collaborative adaptive efforts that are growing to include new, and sometime previously marginalized partners.

There is a growing field documenting the design and implementation of collaborative adaptive rangeland management (Lubell et al., 2013; Roche, 2016; Roche et al., 2015). While this review focuses on rangelands, the CAM field also includes other natural resource contexts such as community-based forestry organizations (Fernandez-Gimenez et al., 2008). One of the better recent examples of testing that CAM can improve rangeland management is the Collaborative Adaptive Rangeland Management (CARM) experiment. This grazing experiment in northeastern Colorado tested continuous, rotational, and adaptive grazing systems to quantify the effect of CAM as well as document the CAM process (Augustine et al., 2020; Porensky et al., 2021; Wilmer et al., 2021b). The CARM experiment found that the benefit of CAM arose from the Stakeholder Group's ability to rotate cattle in response to spatiotemporal heterogeneity across the landscape—i.e., the ability to graze the "right pastures at the right time" (Derner et al., 2021). The CAM process in this study emphasized the provision of multiple ecosystem services, including grassland bird conservation rather than solely livestock production.

The CARM research team worked in parallel with the Stakeholder Group by regularly providing, analyzing, and interpreting biophysical and ecological monitoring data describing the outcomes of specific management decisions (Fernández-Giménez et al., 2019). Monitoring data that stakeholders used to make decisions included precipitation across different pastures; vegetation composition, structure, productivity, diversity, and residual biomass; wildlife habitat conditions and populations of key grassland bird species; livestock gains, diet quality, and cattle behaviors. Social scientists on the research team facilitated semi-structured discussions and consensus-building activities where stakeholders explored their diverse mental models of rangelands, interpreted data as a group, proposed potential management options, hypothesized potential outcomes, and ultimately made management decisions. CARM decisions were determined by consensus or a supermajority (> 75%) of the 11-member Stakeholder Group, which included ranchers, nongovernmental conservation group representatives, and state/federal land managers. The benefits of CARM came from the collaborative ability of the Stakeholder Group to identify multiple management objectives and effectively navigate tradeoffs while increasing livestock production above levels frequently associated with the high stocking densities. The CARM experiment represents an example of how collaborative rangeland partnerships can achieve both production and conservation objectives. A potential challenge in translating the CARM experiment to other contexts is the access to resources and expertise needed to create this data-management feedback.

In addition to design and process questions, implementation challenges should be considered a major focus for research. Social scientists are trying to create more effective ways of documenting practitioners' experiential knowledge to improve the practice of CAM (Beratan, 2014). When designing a CAM process, parties should consider the degree of collaborative decision making desired, the amount of resources that will be required, length of time necessary to design and establish the group, who will make decisions, and how decisions will be made (Miles, 2013).

For example, CARM social scientists produced the diagram in Figure 4 to illustrate how learning & management feedback loops worked in the Stakeholder Group. Figure 4 shows a diagram of an iterative and adaptive feedback loop characteristic of CAM and co-production approaches to science and management. Illustrating the learning processes and different cognitive pathways help identify how and where range managers and scientists engaged each other during the CARM grazing experiment. CARM facilitators make a caveat that the theorized pathways of social learning are sometimes multidirectional and there is the possibility that stakeholders can also forget and lose learning (Wilmer et al., 2021). This observation is also reflected in climate risk perception research around memory and forgetting (Beckage et al., 2018).

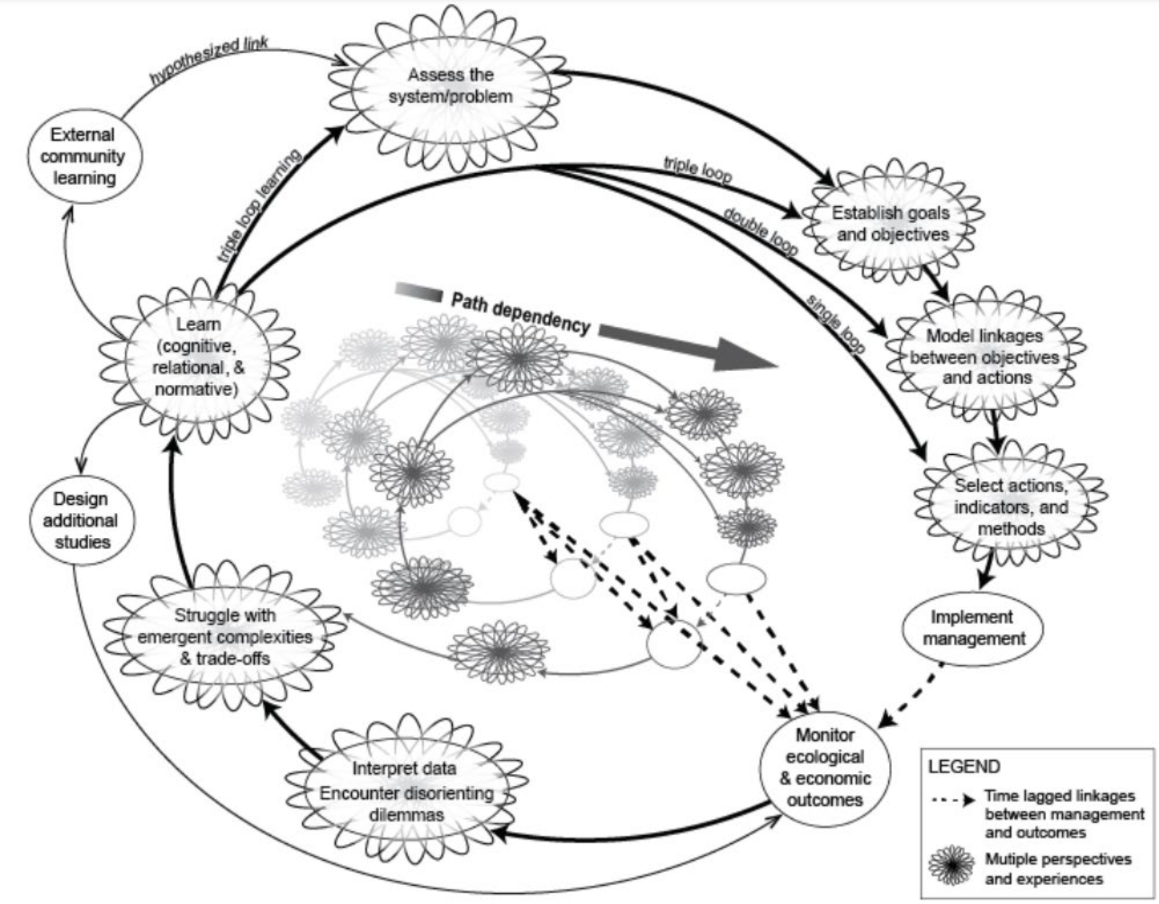

Figure 4: CARM leaning loop. Reproduced from Wilmer et al. (2021b).

Social learning can serve as a helpful framework for thinking about how learning happens in collaborative rangeland management projects. To connect this framework to previous concepts, a review of the literature found that well-designed CAM processes co-produce questions and facilitate social learning to communicate actionable findings. Social learning is a change in understanding that goes beyond the individual to become situated within wider communities of practice through social interactions between actors within social networks (Reed et al., 2010). Recent rangeland social science has moved towards documenting the collaborative process to identify where and how social learning happens, such as with the Bruneau-Owyhee Sage-Grouse Habitat Project (BOSH) in

Owyhee County, Idaho (Brymer et al., 2018). Figure 5 illustrates the process qualities that enable individual-level and social learning that can contribute to multiple outcomes at individual, network, and system scales.

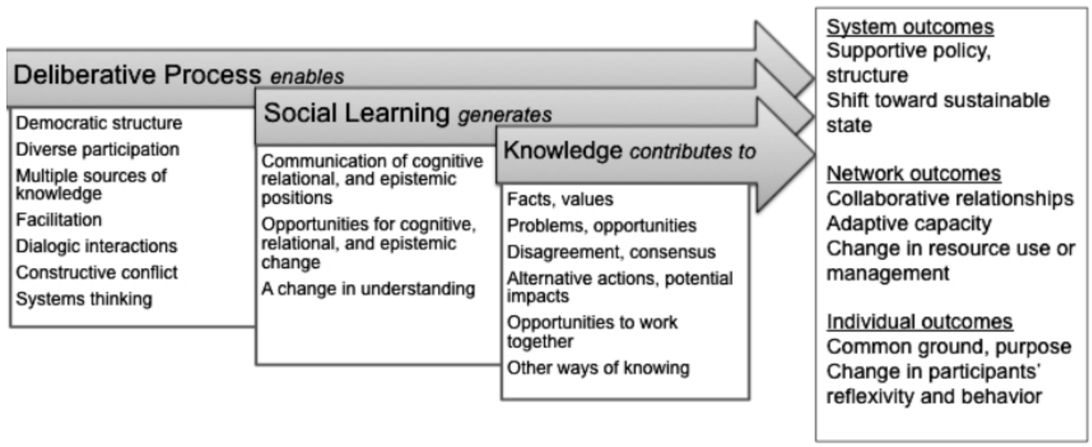

Figure 5: Social Learning Process. Reproduced from Brymer et al. (2018).

The results of the BOSH study suggest that, in addition to considering who is at the table in terms of diversity and representation, researchers and participants should also pay more attention to *how* participants converse. They recommend structuring activities to create more opportunities for stakeholder dialogue, question-answer exchanges, and constructive argumentation. The role of the facilitator is not to just get people to talk, but to talk to each other in deliberate ways that enable social learning, generate knowledge, and contribute to system, network, and individual outcomes. There also needs to be focus on the recruitment of a diverse representation of epistemologies and ways of knowing. The facilitative role is described in translational ecology theory as boundary spanning.

Boundary spanners can function and organize as individuals, organizations, networks, and more (Safford et al., 2017).

A number of projects and publications have recently emerged around the globe that demonstrate the potential of collaborative transdisciplinary approaches to rangeland research. In central Europe, researchers found that knowledge co-production with traditional herders helped identify grazing practices with conservation benefits. The ecologists and rangeland scientists worked closely with traditional herders to co-design research projects and work together in data collection, analysis and interpretation. They conclude that, “for efficient knowledge co-production we need not only the methodology of the social sciences but also a stronger participation of ecologists who can dig deeper into complex ecological issues” (Molnár et al., 2020). This observation is reflected in other examples that show how ecologists can come from a variety of backgrounds, such as the local Ilkisonko Maasai ‘ecological doctors.’ A community-based qualitative study with the Ilkisonko Maasai pastoralists in the Amboseli ecosystem of southern Kenya used an iterative multistage research process to address livestock and carnivore conflict. Researchers conducted interviews with more than 120 Maasai community members. They learned that,

> [H]erding best practices relevant to carnivore-conflict prevention are inseparable from those related to pasture management and livestock productivity and largely inseparable from traditional Maasai culture…This means that good herders, who have been called ‘ecological doctors,’ can support the vitality of not only plants and pastures but also lions, ecosystems, and entire human cultures. (Jablonski et al., 2020)

In a case from the Pamir Mountains of Kyrgyzstan, Tajikistan, and Afghanistan, a transdisciplinary process was used to bring together Indigenous ecological knowledge, climate science, co-produced knowledge, and collaboration outputs (Kassam, 2021).

What is unique about the Pamir case is the research team's attention to validating and testing plural ways of knowing with iterative community participation as well as to creating dynamic education and agricultural extension materials (Figure 6). Although conceptual diagrams are useful, there is much to learn from comparing how the complex reality of these collaborations matches up with conceptual model processes. These examples show how in this emerging transdisciplinary field of climate adaptation, headwater range management, and knowledge braiding there is variation in terminology, structure, and methodology. The implications of these examples for the proposed case studies of this dissertation are that there needs to be close attention to 1) *with whom* and *where* knowledge is co-produced; 2) *how* knowledge braiding processes are structured; and 3) the importance of feedback to the co-production process itself, such as the "triple loop" from the CARM example.

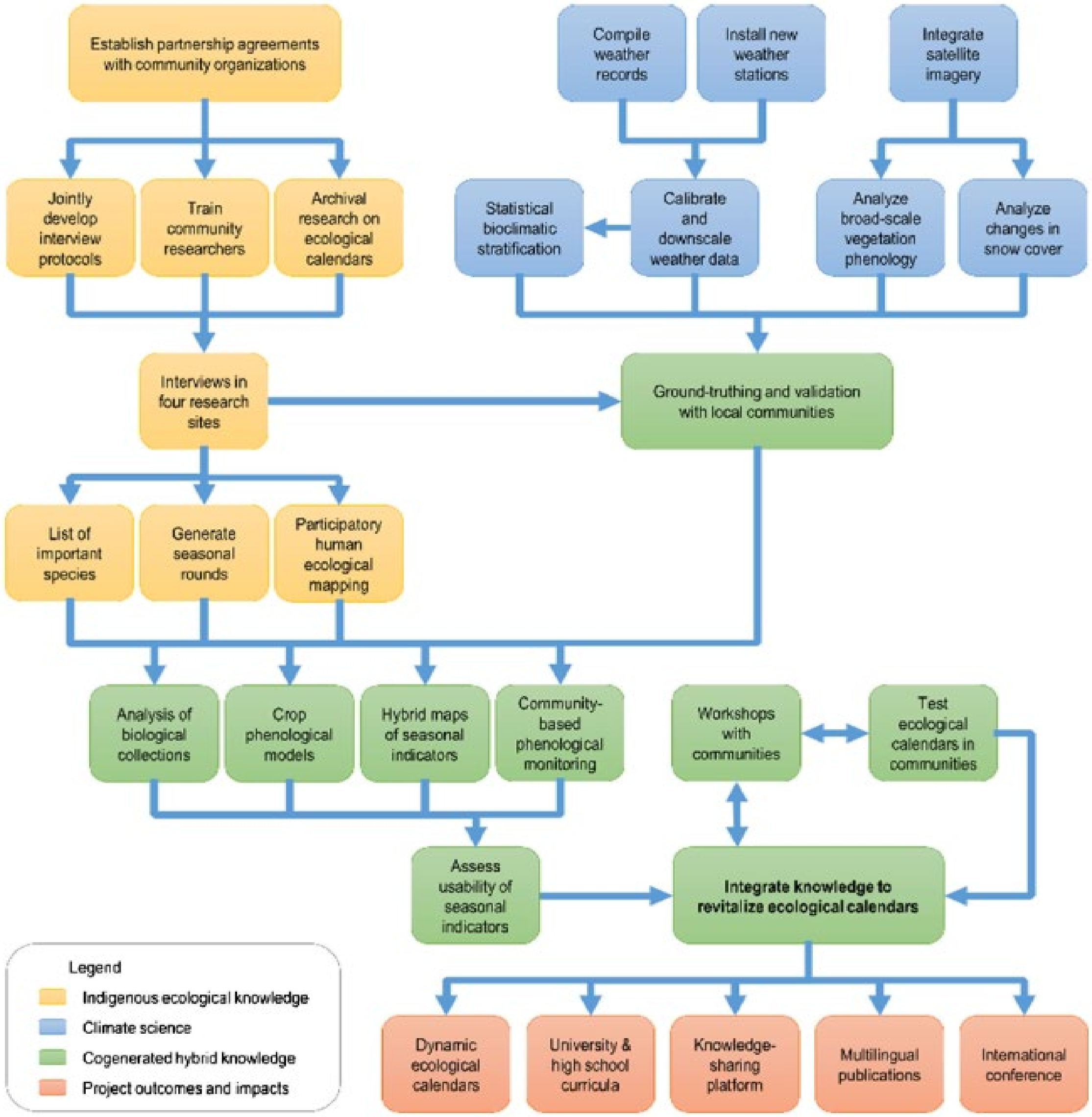

Figure 6: Transdisciplinary process in Pamir. Reproduced from Kassam (2021).

This review of the literature finds that collaborative adaptive approaches to rangeland and watershed research are gaining traction as methods to address wicked problems. Assessing rangeland headwater management in an era of climate change will require collaborative, co-produced research that meaningfully engages stakeholders in social learning. Future collaborative partnerships aimed at restoring or adapting working rangelands have a growing body of literature to support their design and implementation. Critical attention to history, marginalization, equity, knowledge braiding, and collaborative relationships in the process is crucial. Although managing rangelands has an array of newly available technologies such as remote sensing, embedded sensor networks, DNA sequencing, and animal breeding genetics, there is still a need for land-based learning and practical application of local, Indigenous and science knowledge. Future facilitators of collaborative rangeland partnerships will need working knowledge of emergent technology, social learning processes, and participatory governance structures. Transdisciplinary collaborative science within rangeland social ecological systems offers a hopeful way forward, but there is also a gritty reality of the difficult work ahead. As Robin Reid says in her Walking with Herders lecture: collaboration is not for the faint-hearted (Reid, 2016).

Dissertation Structure

This dissertation covers two case studies. The first is the Watershared conservation incentive program in Bolivia. The second is the Wuda Ogwa ecological restoration project led by the Northwestern Band of the Shoshone Nation.

Article One examines how the Watershared conservation incentive program interacts with grazing practices and cattle-based livelihoods in the Rio Grande watershed of Bolivia. The differences in management practices between participants and non-participants that are documented in this paper provide a foundation for Article Two, which explores the role of local field staff, who play a key role in translating conservation goals on the ground and improving production practices through technical assistance, monitoring, and facilitating collaboration between local government, non-governmental organizations, and local communities. Article Two explores how local field staff in the Watershared program work as boundary spanners, translators, and knowledge braiders to build the adaptive capacity of *campesinos* who are participating in the Watershared program. Article Three applies the knowledge braiding framework in the co-production of a climate-adapted stewardship strategy for ecological restoration at the Wuda Ogwa site in the US Intermountain West.

References

Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit, B., Takahashi, K., 2007. Assessment of adaptation practices, options, constraints and capacity., Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Adlam, C., Almendariz, D., Goode, R.W., Martinez, D.J., Middleton, B.R., 2022. Keepers of the Flame: Supporting the Revitalization of Indigenous Cultural Burning. Soc Natur Resour 35, 575–590. https://doi.org/10.1080/08941920.2021.2006385

Alexander, S.M., Provencher, J.F., Henri, D.A., Nanayakkara, L., Taylor, J.J., Berberi, A., Lloren, J.I., Johnson, J.T., Ballard, M., Cooke, S.J., 2021. Bridging Indigenous and Western sciences in freshwater research, monitoring, and management in Canada. Ecol Solutions Évid 2. https://doi.org/10.1002/2688-8319.12085

Alexander, S.M., Provencher, J.F., Henri, D.A., Taylor, J.J., Lloren, J.I., Nanayakkara, L., Johnson, J.T., Cooke, S.J., 2019. Bridging Indigenous and science-based knowledge in coastal and marine research, monitoring, and management in Canada. Environ Évid 8, 36. https://doi.org/10.1186/s13750-019-0181-3

Allen, C.R., Angeler, D.G., Fontaine, J.J., Garmestani, A.S., Hart, N.M., Pope, K.L., Twidwell, D., 2017. Rangeland Systems, Processes, Management and Challenges. Springer Ser Env Man 373–394. https://doi.org/10.1007/978-3-319-46709-2_11

Allison, L., 2023. New Era of Conservation.

Almaraz, M., Simmonds, M., Boudinot, F.G., Vittorio, A.V.D., Bingham, N., Khalsa, S.D.S., Ostoja, S., Scow, K., Jones, A., Holzer, I., Manaigo, E., Geoghegan, E., Goertzen, H., Silver, W.L., 2023. Soil carbon sequestration in global working lands as a gateway for negative emission technologies. Glob. Chang. Biol. 29, 5988–5998. https://doi.org/10.1111/gcb.16884

Asher, K., 2013. Latin American Decolonial Thought, or Making the Subaltern Speak. Geogr Compass 7, 832–842. https://doi.org/10.1111/gec3.12102

Assessment, M.E., 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Augustine, D.J., Derner, J.D., Fernández-Giménez, M.E., Porensky, L.M., Wilmer, H., Briske, D.D., Group, the C.S., 2020. Adaptive, Multipaddock Rotational Grazing Management: A Ranch-Scale Assessment of Effects on Vegetation and Livestock

Performance in Semiarid Rangeland. Rangeland Ecol Manag 73, 796–810. https://doi.org/10.1016/j.rama.2020.07.005

Beckage, B., Gross, L.J., Lacasse, K., Carr, E., Metcalf, S.S., Winter, J.M., Howe, P.D., Fefferman, N., Franck, T., Zia, A., Kinzig, A., Hoffman, F.M., 2018. Linking models of human behaviour and climate alters projected climate change. Nat Clim Change 8, 79–84. https://doi.org/10.1038/s41558-017-0031-7

Bennett, N.J., Dodge, M., Akre, T.S., Canty, S.W.J., Chiaravalloti, R., Dayer, A.A., Deichmann, J.L., Gill, D., McField, M., McNamara, J., Murphy, S.E., Nowakowski, A.J., Songer, M., 2022. Social science for conservation in working landscapes and seascapes. Front. Conserv. Sci. 3, 954930. https://doi.org/10.3389/fcosc.2022.954930

Beratan, K., 2014. Summary: Addressing the Interactional Challenges of Moving Collaborative Adaptive Management From Theory to Practice. Ecol Soc 19. https://doi.org/10.5751/es-06399-190146

Brand, F., Jax, K., 2007. Focusing the Meaning(s) of Resilience: Resilience as a Descriptive Concept and a Boundary Object. Ecol Soc 12. https://doi.org/10.5751/es-02029-120123

Briske, D.D., Joyce, L.A., Polley, H.W., Brown, J.R., Wolter, K., Morgan, J.A., McCarl, B.A., Bailey, D.W., 2015. Climate-change adaptation on rangelands: linking regional exposure with diverse adaptive capacity. Front Ecol Environ 13, 249–256. https://doi.org/10.1890/140266

Brown, A., 2017. Emergent strategy. AK Press, Edinburgh, Scotland.

Brunson, M., Huntsinger, L., Meredith, G., Sayre, N., 2021. The future of social science integration in rangelands research. Rangelands. https://doi.org/10.1016/j.rala.2021.08.007

Brymer, A.B., Wulfhorst, J., Brunson, M., 2018. Analyzing stakeholders' workshop dialogue for evidence of social learning. Ecol Soc 23. https://doi.org/10.5751/es-09959-230142

Burger, L.W., Evans, K.O., McConnell, M.D., Burger, L.M., 2019. Private lands conservation: A vision for the future. Wildl. Soc. Bull. 43, 398–407. https://doi.org/10.1002/wsb.1001

Burnham, M., Ma, Z., 2015. Linking smallholder farmer climate change adaptation decisions to development. Clim Dev 8, 1–23. https://doi.org/10.1080/17565529.2015.1067180

Calle, A., 2020. Partnering with cattle ranchers for forest landscape restoration. Ambio 49, 593–604. https://doi.org/10.1007/s13280-019-01224-8

Cash, D.W., Borck, J.C., Patt, A.G., 2006. Countering the Loading-Dock Approach to Linking Science and Decision Making. Sci Technology Hum Values 31, 465–494. https://doi.org/10.1177/0162243906287547

Cebrián-Piqueras, M.A., Filyushkina, A., Johnson, D.N., Lo, V.B., López-Rodríguez, M.D., March, H., Oteros-Rozas, E., Peppler-Lisbach, C., Quintas-Soriano, C., Raymond, C.M., Ruiz-Mallén, I., Riper, C.J. van, Zinngrebe, Y., Plieninger, T., 2020. Scientific and local ecological knowledge, shaping perceptions towards protected areas and related ecosystem services. Landscape Ecol 35, 2549–2567. https://doi.org/10.1007/s10980-020-01107-4

Chambers, J.M., Wyborn, C., Klenk, N.L., Ryan, M., Serban, A., Bennett, N.J., Brennan, R., Charli-Joseph, L., Fernández-Giménez, M.E., Galvin, K.A., Goldstein, B.E., Haller, T., Hill, R., Munera, C., Nel, J.L., Österblom, H., Reid, R.S., Riechers, M., Spierenburg, M., Tengö, M., Bennett, E., Brandeis, A., Chatterton, P., Cockburn, J.J., Cvitanovic, C., Dumrongrojwatthana, P., Durán, A.P., Gerber, J.-D., Green, J.M.H., Gruby, R., Guerrero, A.M., Horcea-Milcu, A.-I., Montana, J., Steyaert, P., Zaehringer, J.G., Bednarek, A.T., Curran, K., Fada, S.J., Hutton, J., Leimona, B., Pickering, T., Rondeau, R., 2022. Co-productive agility and four collaborative pathways to sustainability transformations. Glob. Environ. Chang. 72, 102422. https://doi.org/10.1016/j.gloenvcha.2021.102422

Chapman, M., Satterfield, T., Wittman, H., Chan, K.M.A., 2020. A payment by any other name: Is Costa Rica's PES a payment for services or a support for stewards? World Dev 129, 104900. https://doi.org/10.1016/j.worlddev.2020.104900

Coalition, T.B.E.I.-T., 2021. Coalition Recognizes President Biden's Decision To Restore Monument As Step Forward [WWW Document]. URL https://www.bearsearscoalition.org/bears-ears-national-monument-restored/ (accessed 24).

David-Chavez, D.M., Whyte, K.P., Laramie, M.B., Novak, R., Bruscato, N., Dockry, M., Johnson, M.K., Jones, C.E., Leonard, K., Lustig, A., 2023. Tribes and Indigenous Peoples-The Fifth National Climate Assessment.

Derner, J.D., Augustine, D.J., 2016. Adaptive Management for Drought on Rangelands. Rangelands 38, 211–215. https://doi.org/10.1016/j.rala.2016.05.002

Derner, J.D., Augustine, D.J., Briske, D.D., Wilmer, H., Porensky, L.M., Fernández-Giménez, M.E., Peck, D.E., Ritten, J.P., Group, the C.S., 2021. Can Collaborative Adaptive Management Improve Cattle Production in Multipaddock Grazing Systems? Rangeland Ecol Manag 75, 1–8. https://doi.org/10.1016/j.rama.2020.11.002

Dertien, J.S., Baldwin, R.F., 2022. Importance of private working lands for the conservation of neotropical birds on an urban-wilderness gradient. Glob. Ecol. Conserv. 38, e02200. https://doi.org/10.1016/j.gecco.2022.e02200

Dinan, M., Adler, P.B., Bradford, J., Brunson, M., Elias, E., Felton, A., Greene, C., James, J., Suding, K., Thacker, E., 2021. Making research relevant: Sharing climate change research with rangeland advisors to transform results into drought resilience. Rangelands 43, 185–193. https://doi.org/10.1016/j.rala.2021.08.004

Dunlap, A., 2022. 'I don't want your progress! It tries to kill … me!' Decolonial encounters and the anarchist critique of civilization. Globalizations 1–27. https://doi.org/10.1080/14747731.2022.2073657

Eaton, W.M., Burnham, M., Robertson, T., Arbuckle, J.G., Brasier, K.J., Burbach, M.E., Church, S.P., Hart-Fredeluces, G., Jackson-Smith, D., Wildermuth, G., Canfield, K.N., Córdova, S.C., Chatelain, C.D., Fowler, L.B., Hendawy, M.M.Z. elAbdeen, Kirchhoff, C.J., Manheim, M.K., Martinez, R.O., Mook, A., Mullin, C.A., Murrah-Hanson, A.L., Onabola, C.O., Parker, L.E., Redd, E.A., Schelly, C., Schoon, M.L., Sigler, W.A., Smit, E., Huysen, T. van, Worosz, M.R., Eberly, C., Rogers, A., 2022. Advancing the scholarship and practice of stakeholder engagement in working landscapes: a co-produced research agenda. Socio-ecological Pract Res 4, 283–304. https://doi.org/10.1007/s42532-022-00132-8

Elrick-Barr, C., Preston, B., Thomsen, D., Smith, T., 2014. Toward a new conceptualization of household adaptive capacity to climate change: applying a risk governance lens. Ecol Soc 19. https://doi.org/10.5751/es-06745-190412

Emery, A., 1999. Handbook of CIDA project planning and indigenous traditional knowledge. Report prepared for The Canadian International Development Agency, Hull, Quebec, Canada.

Enquist, C.A., Jackson, S.T., Garfin, G.M., Davis, F.W., Gerber, L.R., Littell, J.A., Tank, J.L., Terando, A.J., Wall, T.U., Halpern, B., Hiers, J.K., Morelli, T.L., McNie, E., Stephenson, N.L., Williamson, M.A., Woodhouse, C.A., Yung, L., Brunson, M.W., Hall, K.R., Hallett, L.M., Lawson, D.M., Moritz, M.A., Nydick, K., Pairis, A., Ray, A.J., Regan, C., Safford, H.D., Schwartz, M.W., Shaw, M.R., 2017. Foundations of translational ecology. Front Ecol Environ 15, 541–550. https://doi.org/10.1002/fee.1733

Escobar, A., 2016. Transiciones: a space for research and design for transitions to the pluriverse. Des Philosophy Pap 13, 13–23. https://doi.org/10.1080/14487136.2015.1085690

Estes, N., Dunbar-Ortiz, R., 2020. Examining the Wreckage. Mon Rev 1–7. https://doi.org/10.14452/mr-072-03-2020-07_1

Fernández-Giménez, M., Augustine, D., Porensky, L., Wilmer, H., Derner, J., Briske, D., Stewart, M., 2019. Complexity fosters learning in collaborative adaptive management. Ecol Soc 24. https://doi.org/10.5751/es-10963-240229

Fernandez-Gimenez, M., Ballard, H., Sturtevant, V., 2008. Adaptive Management and Social Learning in Collaborative and Community-Based Monitoring: a Study of Five Community-Based Forestry Organizations in the western USA. Ecol Soc 13. https://doi.org/10.5751/es-02400-130204

Fletcher, R., 2023. Failing Forward: The Rise and Fall of Neoliberal Conservation. University of California Press, Oakland, CA.

Fúnez-Flores, J.I., Beltrán, A.C.D., Jupp, J., 2022. Decolonial Discourses and Practices: Geopolitical Contexts, Intellectual Genealogies, and Situated Pedagogies. Educ Stud 58, 596–619. https://doi.org/10.1080/00131946.2022.2132393

Goldman, M.J., Nadasdy, P., Turner, M.D., 2010. Knowing Nature, Conversations at the Intersection of Political Ecology and Science Studies. https://doi.org/10.7208/9780226301440-022

Gómez-Baggethun, Erik, Groot, R. de, Lomas, P.L., Montes, and C., 2010. The History of Ecosystem Services in Economic Theory and Practice: From Early Notions to Markets and Payment Schemes. Ecological Economics. https://doi.org/10.1016/j.ecolecon.2009.11.007.

Green, L., Schmook, B., Radel, C., Mardero, S., 2020. Living Smallholder Vulnerability: The Everyday Experience of Climate Change in Calakmul, Mexico. J Lat Am Geogr. https://doi.org/10.1353/lag.0.0129

Haraway, D., 1988. Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. Feminist Stud 14, 575. https://doi.org/10.2307/3178066

Havstad, K.M., Brown, J.R., Estell, R., Elias, E., Rango, A., Steele, C., 2018. Vulnerabilities of Southwestern U.S. Rangeland-based animal agriculture to climate change. Climatic Change 148, 371–386. https://doi.org/10.1007/s10584-016-1834-7

Henri, D.A., Provencher, J.F., Bowles, E., Taylor, J.J., Steel, J., Chelick, C., Popp, J.N., Cooke, S.J., Rytwinski, T., McGregor, D., Ford, A.T., Alexander, S.M., 2021. Weaving Indigenous knowledge systems and Western sciences in terrestrial research, monitoring and management in Canada: A protocol for a systematic map. Ecol Solutions Évid 2. https://doi.org/10.1002/2688-8319.12057

Hruska, T., Huntsinger, L., Brunson, M., Li, W., Marshall, N., Oviedo, J.L., Whitcomb, and H., 2017. Rangelands as Social–Ecological Systems, in: Briske, D. (Ed.), Rangeland Systems: Processes, Management and Challenges, Springer Series on Environmental Management. https://doi.org/10.1007/978-3-319-46709-2

Jablonski, K.E., Merishi, J., Dolrenry, S., Hazzah, L., 2020. Ecological Doctors in Maasailand: Identifying Herding Best Practices to Improve Livestock Management and Reduce Carnivore Conflict. Frontiers Sustain Food Syst 4, 118. https://doi.org/10.3389/fsufs.2020.00118

Jennings, L., Anderson, T., Martinez, A., Sterling, R., Chavez, D.D., Garba, I., Hudson, M., Garrison, N.A., Carroll, S.R., 2023. Applying the 'CARE Principles for Indigenous Data Governance' to ecology and biodiversity research. Nat. Ecol. Evol. 7, 1547–1551. https://doi.org/10.1038/s41559-023-02161-2

Johnson, M., Campbell, L., Svendsen, E., 2020. Conceptualizing, analyzing, and supporting stewardship: examining the role of civil society in environmental governance. Ecol. Soc. 25. https://doi.org/10.5751/es-11970-250414

Kassam, K.-A., 2021. Transdisciplinary research, Indigenous knowledge, and wicked problems. Rangelands 43, 133–141. https://doi.org/10.1016/j.rala.2021.04.002

Keskitalo, E.C.H., Dannevig, H., Hovelsrud, G.K., West, J.J., Swartling, Å.G., 2011. Adaptive capacity determinants in developed states: examples from the Nordic countries and Russia. Reg Environ Change 11, 579–592. https://doi.org/10.1007/s10113-010-0182-9

Kimmerer, R.W., 2015. Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants. Milkweed Editions.

Klein, S., Lee, J.S., Courtney, S., Morehead-Hillman, L., Lau, S., Lewis-Smith, B., Sarna-Wojcicki, D., Woelfle-Hazard, C., 2022. Transforming Restoration Science: Multiple Knowledges and Community Research Cogeneration in the Klamath and Duwamish Rivers. Am. Nat. 200, 156–167. https://doi.org/10.1086/720153

Kremen, C., Merenlender, A.M., 2018. Landscapes that work for biodiversity and people. Science 362. https://doi.org/10.1126/science.aau6020

Litts, B.K., Tehee, M., Jenkins, J., Baggaley, S., Isaacs, D., Hamilton, M.M., Yan, L., 2020. Culturally disruptive research: a critical (re)engagement with research processes and teaching practices. Information Learn Sci 121, 769–784. https://doi.org/10.1108/ils-02-2020-0019

Lubell, M.N., Cutts, B.B., Roche, L.M., Hamilton, M., Derner, J.D., Kachergis, E., Tate, K.W., 2013. Conservation Program Participation and Adaptive Rangeland Decision-Making. Rangel Ecol Management 66, 609–620. https://doi.org/10.2111/rem-d-13-00025.1

Maestre, F.T., Bagousse-Pinguet, Y.L., Delgado-Baquerizo, M., Eldridge, D.J., Saiz, H., Berdugo, M., Gozalo, B., Ochoa, V., Guirado, E., García-Gómez, M., Valencia, E., Gaitán, J.J., Asensio, S., Mendoza, B.J., Plaza, C., Díaz-Martínez, P., Rey, A., Hu, H.-W., He, J.-Z., Wang, J.-T., Lehmann, A., Rillig, M.C., Cesarz, S., Eisenhauer, N., Martínez-Valderrama, J., Moreno-Jiménez, E., Sala, O., Abedi, M., Ahmadian, N., Alados, C.L., Aramayo, V., Amghar, F., Arredondo, T., Ahumada, R.J., Bahalkeh, K., Salem, F.B., Blaum, N., Boldgiv, B., Bowker, M.A., Bran, D., Bu, C., Canessa, R., Castillo-Monroy, A.P., Castro, H., Castro, I., Castro-Quezada, P., Chibani, R., Conceição, A.A., Currier, C.M., Darrouzet-Nardi, A., Deák, B., Donoso, D.A., Dougill, A.J., Durán, J., Erdenetsetseg, B., Espinosa, C.I., Fajardo, A., Farzam, M., Ferrante, D., Frank, A.S.K., Fraser, L.H., Gherardi, L.A., Greenville, A.C., Guerra, C.A., Gusmán-Montalvan, E., Hernández-Hernández, R.M., Hölzel, N., Huber-Sannwald, E., Hughes, F.M., Jadán-Maza, O., Jeltsch, F., Jentsch, A., Kaseke, K.F., Köbel, M., Koopman, J.E., Leder, C.V., Linstädter, A., Roux, P.C. le, Li, X., Liancourt, P., Liu, J., Louw, M.A., Maggs-Kölling, G., Makhalanyane, T.P., Issa, O.M., Manzaneda, A.J., Marais, E., Mora, J.P., Moreno, G., Munson, S.M., Nunes, A., Oliva, G., Oñatibia, G.R., Peter, G., Pivari, M.O.D., Pueyo, Y., Quiroga, R.E., Rahmanian, S., Reed, S.C., Rey, P.J., Richard, B., Rodríguez, A., Rolo, V., Rubalcaba, J.G., Ruppert, J.C., Salah, A., Schuchardt, M.A., Spann, S., Stavi, I., Stephens, C.R.A., Swemmer, A.M., Teixido, A.L., Thomas, A.D., Throop, H.L., Tielbörger, K., Travers, S., Val, J., Valkó, O., Brink, L. van den, Ayuso, S.V., Velbert, F., Wamiti, W., Wang, D., Wang, L., Wardle, G.M., Yahdjian, L., Zaady, E., Zhang, Y., Zhou, X., Singh, B.K., Gross, N., 2022. Grazing and ecosystem service delivery in global drylands. Science 378, 915–920. https://doi.org/10.1126/science.abq4062

Mahowald, H., 2020. Paying for Stewardship: A Western Landowners' Guide to Conservation Finance.

Marks-Block, T., Lake, F.K., Bird, R.B., Curran, L.M., 2021. Revitalized Karuk and Yurok cultural burning to enhance California hazelnut for basketweaving in northwestern California, USA. Fire Ecol 17, 6. https://doi.org/10.1186/s42408-021-00092-6

Marks-Block, T., Tripp, W., 2021. Facilitating Prescribed Fire in Northern California through Indigenous Governance and Interagency Partnerships. Fire 4, 37. https://doi.org/10.3390/fire4030037

McCoy, M.&, 2021. Ten Strategies for Climate Resilience in the Colorado River Basin.

McCubbin, Moniz, 2015. Ethical Principles in Resilience Research: Respect, Relevance, Reciprocity and Responsibility. Springer Netherlands, Dordrecht, pp. 217–229. https://doi.org/10.1007/978-94-017-9415-2_16

Medin, D.L., Bang, M., 2014. Who's asking?: Native science, western science, and science education. MIT Press.

Mikulewicz, M., 2019. Thwarting adaptation's potential? A critique of resilience and climate-resilient development. Geoforum 104, 267–282. https://doi.org/10.1016/j.geoforum.2019.05.010

Miles, J.P., 2013. Designing Collaborative Processes for Adaptive Management: Four Structures for Multistakeholder Collaboration. Ecol Soc 18. https://doi.org/10.5751/es-05709-180405

Miller, T., Baird, T., Littlefield, C., Kofinas, G., III, F.S.C., Redman, C., 2008. Epistemological Pluralism: Reorganizing Interdisciplinary Research. Ecol Soc 13. https://doi.org/10.5751/es-02671-130246

Molnár, Z., Kelemen, A., Kun, R., Máté, J., Sáfián, L., Provenza, F., Díaz, S., Barani, H., Biró, M., Máté, A., Vadász, C., 2020. Knowledge co-production with traditional herders on cattle grazing behaviour for better management of species-rich grasslands. J Appl Ecol 57, 1677–1687. https://doi.org/10.1111/1365-2664.13664

Nelson, R., Kokic, P., Crimp, S., Meinke, H., Howden, S.M., 2010. The vulnerability of Australian rural communities to climate variability and change: Part I—Conceptualising and measuring vulnerability. Environ Sci Policy 13, 8–17. https://doi.org/10.1016/j.envsci.2009.09.006

Norström, A.V., Cvitanovic, C., Löf, M.F., West, S., Wyborn, C., Balvanera, P., Bednarek, A.T., Bennett, E.M., Biggs, R., Bremond, A. de, Campbell, B.M., Canadell, J.G., Carpenter, S.R., Folke, C., Fulton, E.A., Gaffney, O., Gelcich, S., Jouffray, J.-B., Leach, M., Tissier, M.L., Martín-López, B., Louder, E., Loutre, M.-F., Meadow, A.M., Nagendra, H., Payne, D., Peterson, G.D., Reyers, B., Scholes, R., Speranza, C.I., Spierenburg, M., Stafford-Smith, M., Tengö, M., Hel, S. van der, Putten, I. van, Österblom, H., 2020. Principles for knowledge co-production in sustainability research. Nat Sustain 3, 182–190. https://doi.org/10.1038/s41893-019-0448-2

Ostrom, E., 1990. Governing the commons: The evolution of institutions for collective action. Cambridge University Press, Cambridge, UK.

Patel, L., 2016. Decolonizing Education Research: From Ownership to Answerability. Routledge, New York City, NY.

Porensky, L.M., Augustine, D.J., Derner, J.D., Wilmer, H., Lipke, M.N., Fernández-Giménez, M.E., Briske, D.D., Group, the C.S., 2021. Collaborative Adaptive Rangeland Management, Multipaddock Rotational Grazing, and the Story of the Regrazed Grass Plant. Rangeland Ecol Manag 78, 127–141. https://doi.org/10.1016/j.rama.2021.06.008

Pörtner, H.O., Roberts, D.C., Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., Okem, A., Rama, B., 2022. IPCC, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Project, D.H., 2024. What is Decoloniality? [WWW Document]. William & Mary. URL https://www.wm.edu/sites/dhp/decoloniality/ (accessed 24).

Radel, C., Schmook, Carte, Mardero, 2018. Toward a Political Ecology of Migration: Land, Labor Migration, and Climate Change in Northwestern Nicaragua. World Dev 108, 263–273. https://doi.org/10.1016/j.worlddev.2017.04.023

Reed, M.S., Evely, A.C., Cundill, G., Fazey, I., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C., Raymond, C., Stringer, L.C., 2010. What is Social Learning? Ecol Soc 15. https://doi.org/10.5751/es-03564-1504r01

Reid, A.J., Eckert, L.E., Lane, J., Young, N., Hinch, S.G., Darimont, C.T., Cooke, S.J., Ban, N.C., Marshall, A., 2021. “Two-Eyed Seeing”: An Indigenous framework to transform fisheries research and management. Fish Fish 22, 243–261. https://doi.org/10.1111/faf.12516

Reid, R., 2016. Walking with Herders (and others): Bringing Different People Together to Work with Nature.

Reid, R.S., Fernández-Giménez, M.E., Wilmer, H., Pickering, T., Kassam, K.-A.S., Yasin, A., Porensky, L.M., Derner, J.D., Nkedianye, D., Jamsranjav, C., Jamiyansharav, K., Ulambayar, T., Oteros-Rozas, E., Ravera, F., Bulbulshoev, U., Kaziev, D.S., Knapp, C.N., 2021. Using Research to Support Transformative Impacts on Complex, “Wicked Problems” With Pastoral Peoples in Rangelands. Frontiers Sustain Food Syst 4, 600689. https://doi.org/10.3389/fsufs.2020.600689

Riley, S.P., Abernethy, R., McKenzie, D.F., 2019. Case studies of scalable wildlife conservation in working landscapes. Wildl. Soc. Bull. 43, 363–371. https://doi.org/10.1002/wsb.998

Rittel, H.W.J., Webber, M.M., 1973. Dilemmas in a general theory of planning. Policy Sci 4, 155–169. https://doi.org/10.1007/bf01405730

Roberts, J., 2020. Political Ecology. Camb Encycl Anthropology. https://doi.org/10.29164/20polieco

Roche, L.M., 2016. Adaptive Rangeland Decision-Making and Coping with Drought. Sustainability-basel 8, 1334. https://doi.org/10.3390/su8121334

Roche, L.M., Schohr, T.K., Derner, J.D., Lubell, M.N., Cutts, B.B., Kachergis, E., Eviner, V.T., Tate, K.W., 2015. Sustaining Working Rangelands: Insights from Rancher Decision Making. Rangeland Ecol Manag 68, 383–389. https://doi.org/10.1016/j.rama.2015.07.006

Safford, H.D., Sawyer, S.C., Kocher, S.D., Hiers, J.K., Cross, M., 2017. Linking knowledge to action: the role of boundary spanners in translating ecology. Front Ecol Environ 15, 560–568. https://doi.org/10.1002/fee.1731

Sayre, N.F., 2017. The Politics of Scale. University of Chicago Press, Chicago. https://doi.org/10.7208/chicago/9780226083391.001.0001

Scarlett, L., 2013. Collaborative Adaptive Management: Challenges and Opportunities. Ecol Soc 18. https://doi.org/10.5751/es-05762-180326

Sidik, S.M., 2022. Weaving Indigenous knowledge into the scientific method. Nature 601, 285–287. https://doi.org/10.1038/d41586-022-00029-2

Smith, A.V., 2023. What does the nation's commitment to tribal co-stewardship mean for public lands? (Tribal co-stewardship takes shape) [WWW Document]. High Country News. URL https://www.hcn.org/issues/55.2/indigenous-affairs-public-lands-what-does-the-nations-commitment-to-tribal-co-stewardship-mean-for-publc-lands?utm_source=wcn1&;utm_medium=email&utm_campaign=2023-02-11-ICN (accessed 2.11.23).

Society for Ecological Restoration International Science & Policy Working Group. 2004. The SER International Primer on Ecological Restoration. www.ser.org & Tucson: Society for Ecological Restoration International.

Smith, L.T., 2012. Decolonizing methodologies: Research and indigenous peoples. Zed Books, London, England.

Steele, R., Hatfield, J.L., 2018. Navigating climate-related challenges on working lands: a special issue by the USDA Climate Hubs and their partners. Clim. Chang. 146, 1–3. https://doi.org/10.1007/s10584-017-2129-3

Tait, M.K., Brunson, M.W., 2021. Evaluating Cooperative Interactions and the Roles Organizations Play in Cross-Boundary Stewardship. Soc. Nat. Resour. 34, 925–942. https://doi.org/10.1080/08941920.2021.1900964

Teague, R., Kreuter, U., 2020. Managing Grazing to Restore Soil Health, Ecosystem Function, and Ecosystem Services. Frontiers Sustain Food Syst 4, 534187. https://doi.org/10.3389/fsufs.2020.534187

Tengö, M., Hill, R., Malmer, P., Raymond, C.M., Spierenburg, M., Danielsen, F., Elmqvist, T., Folke, C., 2017. Weaving knowledge systems in IPBES, CBD and beyond—lessons learned for sustainability. Curr Opin Env Sust 26, 17–25. https://doi.org/10.1016/j.cosust.2016.12.005

Thacker, E., 2022. 2022 Report to the Governor on Utah's Land, Water, and Air. Institute for Land, Air, and Water.

Tribe, K., 2019. Karuk Climate Adaptation Plan. Karuk Tribe.

Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., Schiller, A., 2003. A framework for vulnerability analysis in sustainability science. Proc National Acad Sci 100, 8074–8079. https://doi.org/10.1073/pnas.1231335100

Vallury, S., Smith, A.P., Chaffin, B.C., Nesbitt, H.K., Lohani, S., Gulab, S., Banerjee, S., Floyd, T.M., Metcalf, A.L., Metcalf, E.C., Twidwell, D., Uden, D.R., Williamson, M.A., Allen, C.R., 2022. Adaptive capacity beyond the household: a systematic review of empirical social-ecological research. Environ Res Lett 17, 063001. https://doi.org/10.1088/1748-9326/ac68fb

Varghese, J., Crawford, S.S., 2021. A cultural framework for Indigenous, Local, and Science knowledge systems in ecology and natural resource management. Ecol Monogr 91. https://doi.org/10.1002/ecm.1431

Vinyeta, K., 2022. Ikpíkyav (To Fix Again): Drawing From Karuk World Renewal To Contest Settler Discourses Of Vulnerability. University of Oregon.

Vinyeta, K., Whyte, K.P., Lynn, K., 2015. Climate change through an intersectional lens: gendered vulnerability and resilience in indigenous communities in the United States. Gen Tech Rep Pnw-gtr-923 Portland Or U S Dep Agric For Serv Pac Northwest Res Stn 72 P 923. https://doi.org/10.2737/pnw-gtr-923

Wainaina, P., Minang, P.A., Muthee, K., 2023. Relational values within landscape restoration: a review. Curr. Opin. Environ. Sustain. 64, 101335. https://doi.org/10.1016/j.cosust.2023.101335

Walker, B., Salt, D., 2012. Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Island Press.

Wheeler, H.C., Root-Bernstein, M., 2020. Informing decision-making with Indigenous and local knowledge and science. J Appl Ecol 57, 1634–1643. https://doi.org/10.1111/1365-2664.13734

White, C., 2008. Revolution on the Range: The Rise of a New Ranch in the American West. Island Press.

Whyte, K., Novak, R., Laramie, M.B., Bruscato, N.G., David-Chavez, D.M., Dockry, M.J., Johnson, M.K., Jr., C.E.J., Leonard, K., 2023. Tribes and Indigenous Peoples, in: Crimmins", ["A.R., Avery", "C.W., Easterling", "D.R., Kunkel", "K.E., Stewart", "B.C., Maycock"], "T.K. (Eds.), Fifth National Climate Assessment. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/nca5.2023.ch16

Whyte, K.P., 2017. “Indigenous Peoples, Climate Justice, and Decolonial Philosophy.”

Wilmer, H., Meadow, A.M., Brymer, A.B., Carroll, S.R., Ferguson, D.B., Garba, I., Greene, C., Owen, G., Peck, D.E., 2021a. Expanded Ethical Principles for Research Partnership and Transdisciplinary Natural Resource Management Science. Environ Manage 68, 453–467. https://doi.org/10.1007/s00267-021-01508-4

Wilmer, H., Schulz, T., Fernández-Giménez, M.E., Derner, J.D., Porensky, L.M., Augustine, D.J., Ritten, J., Dwyer, A., Meade, R., 2021b. Social learning lessons from collaborative adaptive rangeland management. Rangelands. https://doi.org/10.1016/j.rala.2021.02.002

Young, J., 1985. Cattle In The Cold Desert. University of Nevada Press, Reno.

CHAPTER 2

THE INTERACTION OF GRAZING LIVELIHOODS AND INCENTIVIZING WATERSHED CONSERVATION (ARTICLE 1)

Abstract

Rangelands across the world produce a suite of ecosystem services in addition to agricultural goods. Conservation incentive programs like Payment for Ecosystem Services (PES) create multifaceted incentive structures to encourage rangeland managers to prioritize watershed function, carbon sequestration, wildlife habitat, and other ecosystem services in addition to agricultural production. This research explores the interaction between a conservation incentive program, grazing livelihoods, and rangeland management by examining the Watershared program in Bolivia. Using a survey, semi-structured interviews, and participant observation, it shows how range management practices differ between Watershared participants and non-participants working in the same area. Ethnographic data also show how participants conceptualized their participation in Watershared, which emphasized care, reciprocity, and relational values. The results of the study suggest that instead of conceptualizing PES as a purely market mechanism, understanding how local partnerships can co-produce place-based strategies that support local livelihoods is a critical part of understanding how to durably incentivize ecosystem service provision on rangelands.

Introduction

Rangelands primarily used for grazing and livestock production are increasingly valued for a suite of ecosystem services that they provide (Briske and Coppock, 2023). In addition to producing food and fiber, working rangelands and forests can potentially support wildlife and biodiversity, carbon and water cycling, as well as human communities and cultures (Kremen et al., 2018). “Active rangeland stewardship” is proposed as a critical concept for maintaining and enhancing the ecosystem services provided by rangeland social-ecological systems because benefits flow from nature to people as well as from people to nature (Goodwin et al., 2023). In simple terms, active rangeland stewardship is ongoing collective action motivated by a plurality of values to care for a suite of ecosystem services and the rangeland communities who produce them. Active rangeland stewardship supports ecosystem services in rangelands in three key ways: avoiding conversion to cropland and development, restoration of degraded lands, and adaptive management (Sanderson et al., 2020). A current research need is to better understand how incentivizing conservation and active rangeland stewardship interacts with rural livelihoods that are based on agricultural production (Haggerty et al., 2023; Roche et al., 2021). Another research gap is understanding how transdisciplinary social-ecological collaboratives can increase the adoption rate of active rangeland stewardship practices with an explicit focus on building resilience to climate change risks (Dinan et al., 2021). Current literature proposes that an ‘agro-ecological transition’ from solely agricultural commodity production toward a more equitable and resilient stewardship is facilitated by a mix of policy, participatory action research, and on-the-ground relationships between scientists and ranchers that help adapt management methods

(Sachet et al., 2021). Improving environmental outcomes on rangelands is important because of their potential contribution to watershed health, climate change mitigation and adaptation, and biodiversity conservation in addition to growing demand for agricultural production (Magne et al., 2019; Porter et al., 2017; Tittonell, 2021).

One current strategy to improve environmental outcomes on rangelands is the concept of Payments for Ecosystem Services (PES). PES is defined as a set of voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services(Wunder, 2015). These ecosystem services include provisioning services, regulating services, supporting services, and cultural services (Costanza et al., 1997). Over the past decade, the definition of PES has been adapted to cover a variety of approaches for incentive-based conservation (Shapiro-Garza et al., 2020). Some of the contemporary variations in the North American rangeland management sector include carbon sequestration and payment for wildlife presence in addition to long-running initiatives like the Conservation Reserve Program (Hendricks and Er, 2018; Macon, 2020; Spackman and Allison, 2018). In the South American rangeland management context, recent conservation innovation includes a focus on forest protection, watershed stewardship, wildlife conservation, and silvopastoralism (Calle, 2020; Smith, 2024). PES programs often have dual goals of environmental conservation and socio-economic development and implement these goals by creating social and economic structures to support conservation in working landscapes (Benra et al., 2022). Understanding how these conservation incentive programs interact with rangeland management practices provides insight into how they try to meet these dual goals and affect environmental and livelihood outcomes. This interaction is even more critical now in a context of climate change because of the potential for rangelands to sequester carbon, support wildlife habitat and biodiversity, produce food for people, and improve water cycle functioning (IPCC, 2023; USGCRP, 2023).

This paper reports on a case study of a PES program in Bolivia – the Watershared Program – that can help address the need for enhanced understanding of the relationship between PES and cattle-based livelihoods, which are globally widespread. This study contributes to an emerging body of research on PES in grazing and rangeland socio-ecosystems by exploring linkages between livelihoods, range management practices, and participation in a PES program (Calle, 2020; Pagiola et al., 2007; Roche et al., 2021; Shen et al., 2022).

Analysis of data from this case study explores two linked research questions: (1) how does cattle ranching contribute to livelihoods in the Rio Grande-Valles Cruceños region of Bolivia? (2) how do rangeland management practices vary between Watershared participants and non-participants? The first question provides context for the second and primary research question; while the second question provides insight into how the Watershared program may be interacting with participants' range management practices. I analyze data from surveys, semi-structured interviews, and participant observation to answer these two research questions and to understand how the implementation of incentive-based conservation programs may support smallholder farmers' and ranchers' capacity to adapt to climate change. The evidence from this study shows how Watershared's combination of relevant incentive materials, conservation contracts, and technical assistance works to find locally desirable ways to change grazing practices in ways that support livelihoods and support *campesinos'* stewardship and care of local watersheds.

Literature Review

Grazing, conservation efforts and climate resilience

Cattle ranching is identified as a driver of, and potential solution to, environmental problems including deforestation and climate change (Rojas-Downing et al., 2017). Grazing management that myopically focuses on maximizing production has caused degradation of watersheds and rangelands worldwide (Teague and Kreuter, 2020). Rangeland researchers are calling for transformational collaborative research situated in both the role that grazing plays in rural livelihoods and cultures as well as the complex role it plays in local ecologies (Reid et al., 2021). There is global interest in improving grazing management practices to regenerate ecosystem function, improve watershed health, increase biodiversity, and mitigate/adapt to climate change (Scoones, 2022). The past century has seen a range of attempts to improve grazing management. In the United States, legal frameworks like the Taylor Grazing Act and the science of rangeland management came out of ecological crises caused by colonization, exploitation, and overgrazing (Sayre, 2017).

While there is growing evidence of grazing management improvements yielding ecological and social benefits, there is also a history of attempted improvements negatively impacting smallholder ranchers. In northern Mexico, attempts to improve cattle genetics and production hurt smallholder ranchers' livelihoods due to increases in input costs (Perramond, 2010). Poorly designed grazing improvement projects also have had a negative track record, such as the World Bank failures in the Sahel where policy between 1968 and 1980 tried to replace pastoralism with sedentary ranching (Gonin and Gautier, 2015). Understanding the political ecology and history of attempted grazing system improvements and pitfalls is important because there is now a large push underway to address the climate and biodiversity impacts of the global food system.

Improving grazing management is a potential strategy to both mitigate and adapt to climate change (DeLonge and Basche, 2018; Gosnell et al., 2019). Two main themes of grazing land adaptive management are flexibility and learning under uncertainty (Derner et al., 2023). There are four general strategies that ranchers can use to deal with climate change impacts like drought and precipitation variability: 1) predict it using weather and climate forecasting tools, 2) track it, 3) employ conservative stocking rates, or 4) utilize inherent spatial variability to maintain ecosystem function and livestock production (Derner and Augustine, 2016). Research suggests that mixed crop and livestock agroecological systems can support sustainable smallholder climate adaptation. A meta-analysis of mixed crop-livestock farms found more sustainable practices compared to industrial monocropping, but, in an important distinction, found that a small scale of operation does not predict sustainability (Rudel et al., 2016). To adapt to a changing climate, development, extension, and climate adaptation agencies should prioritize smallholder farmers for tailored policies and co-produced research that help minimize environmental impact and mitigate climate change risk (Herrero et al., 2010). Research recommends that smallholders should be supported by improved access to markets, new crop and livestock varieties, emergent technologies, and knowledge transfers, and that this support should be framed by an explicit understanding of gender, marginalization, and climate vulnerability (Owange, 2023). Other practical considerations for adaptive strategies by grazing land managers amidst a changing climate include (1) collaborative science–management partnerships becoming more mainstream, (2) co-produced research with managers and researchers at ranch scales, (3) development of communities of practice and associated learning opportunities, and (4) continued co-development and advancement of technologies and tools that result in high uptake adoption by ranch managers (Derner et al., 2023). The main point here is that while grazing can contribute to climate change and biodiversity loss, a growing scientific literature shows how to improve adaptive grazing management. The next needed area of growth is how to make grazing management resilient to climate change.

Smallholder ranchers and farmers are potentially vulnerable to climate change impacts like drought, increasing climate variation, and loss of forage and crop productivity (Burnham and Ma, 2015) . These biophysical vulnerabilities are mediated by human conditions such as socio-political institutions and economic structures (Radel et al., 2018; Turner et al., 2003). Adaptive capacity is defined as, “the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behavior and in resources and technologies” (Adger et al., 2007). Analysis of adaptive capacity at the individual and household scale focuses on social, economic, and natural capital (Siders, 2019). There is also a push to think beyond household scales to imagine and improve climate adaptive capacity that works at multiple scales and institutional levels (Vallury et al., 2022). Recent research in Mexico on smallholder climate vulnerability found that smallholders’ own perceptions of their vulnerability are likewise shaped by situational and social differences, including access to community and household resources and variations in livelihood activities (Green et al., 2020). This research on the Watershared program contributes to the adaptive capacity literature by investigating whether conservation incentive programs can support the adaptive capacity of smallholder farmers and ranchers together with pursuing more traditional conservation goals like forest and water conservation.

Conservation incentive programs may increase capacity to adapt to climate change by supporting practices that improve grazing management and watershed resilience to drought and precipitation variability. Reducing riparian degradation through managerial investments in grazing distributional practices like fencing for rotational grazing, improved forage nutrition, mineral distribution, and range riding can provide an opportunity for ecological restoration and improved riparian ecosystem functioning (Derose et al., 2020; Goodwin et al., 1997; Papanastasis, 2009). Research on cattle exclusion from riparian zones found that streambank fencing combined with cattle watering infrastructure improved riparian health and prevented water quality degradation (Miller et al., 2010). Prior livestock exclusion research from the 1980s and 1990s found mixed results due to poor study design and agenda-driven research (Sarr, 2002). More recent evidence points to the importance of active human management like range riders who move cattle off of riparian areas (Roper and Saunders, 2021). The need for active human management of grazing cattle that builds off cattle's social behavior, and ecological processes is a common theme in more recent rangeland management literature (Bailey et al., 2019; Brunson and Burritt, 2009; Burritt, 2012). These advances in research are part of the evidence base that supports active rangeland stewardship as a key concept in both the production of ecosystem service and adaptive capacity to climate change risks.

What do we know about why people change their grazing practices?

This question has been considered by agricultural, conservation, and extension scientists for almost a century and there are several main theories developed in response. Innovation diffusion theory was the foundation of extension agriculture outreach methods since the mid-20th century (Stephenson, 2003). The theory describes an adoption curve where innovation is initially adopted by a small group of innovative farmers and diffused from farmer to farmer. Over the past 30 years, the theory was criticized for individual-blame bias, favoring large wealthy farmers and increasing inequities in rural areas. Rural sociologists observed that the application of innovation diffusion theory in developing countries had undesirable consequences (Goss, 1979). The theory assumed benefits resulting from the adoption of innovations would spread and become homogeneous, yet experiences from Latin America showed a widening inequality gap.

In response to these critiques and shortcomings, alternative theories were developed alongside research into determinants and barriers to adopt. A common contemporary framework is the theory of planned behavior. This theory describes how attitudes, subjective norms, and perceived behavioral control influence intentions, which influence behavior. Applications of this theory emphasize knowledge and education as drivers of attitude changes (Senger et al., 2017; Tama et al., 2021). In addition to theory, scholars have explored determinants and barriers to innovation adoption in agriculture. Several meta-reviews found that there were very few consistent determinants of adoption

(Baumgart-Getz et al., 2012; Knowler and Bradshaw, 2007). Variables most often positively associated with conservation included education, capital, income, farm size, access to information, positive environmental attitudes, and social networks (Prokopy et al., 2008). An updated meta review found that attitudes toward a program or practice emerged as the strongest predictor of adoption (Prokopy et al., 2019). Other important variables include farmer identity, actively seeking and using information and conservation/stewardship ethic. This ethic and stewardship identity describe a ranchers' sense of responsibility toward land management that values the health of the land and the well-being of people (Eaton et al., 2019). Finally, economic values drive innovation adoption. Conventional thinking is that the most important factor in conservation practice adoption is that it makes a farmer money, directly or indirectly (Hoag et al., 2012). Economic and ecological factors often intermix to create adoption barriers such as high initial costs, water limitations, and ranch conditions (Che et al., 2023).

Scholars and practitioners working at the intersection of range management and socio-ecological systems are finding that there is a context-specific mix of factors that affect adoption of new practice as well as behavior and cultural change (Smith et al 2023). Some of these main factors are land access, trusted technical assistance, financial capital and incentives, supply chains, strategic communications, research and science, and policy reform (O'Connor, 2020). There are also unpredictable and affective factors that spark transformational adaptation such as crisis, epiphany, and exposure to alternative pathways (Gosnell et al., 2019). Research shows how non-material subjective factors associated with feelings, emotions, virtues, drives, and motivations can play an important role (Wilmer and Fernández-Giménez, 2016). There is also an expanding interest in understanding feedback loops that involve ongoing experiential social learning and growing critical consciousness to achieve agroecological system transformations (Brymer et al., 2020; Meredith et al., 2021).

PES in grazing and rangeland socio-ecosystems

There is also a recently growing body of research studying the interactions between PES programs and rangeland socio-ecological systems. In the context of grassland degradation in Inner Mongolia due to overgrazing and cropland expansion, China's pilot Grassland Ecological Compensation Policy (GECP) program pays livestock herders to compensate for reductions in grazing intensity or the cessation of grazing activities. The GECP is one of the world's largest rangeland PES programs and is showing some positive ecological results across multiple studies using remotely sensed normalized difference vegetation index data as the indicator of outcome (Wei et al., 2022; Zhou et al., 2023). In a study that analyzed the effects of payment levels and socioeconomic factors on herders' willingness to participate in the GECP, results showed that households with lower herding income, older age, higher education, larger grassland areas, and worse social relationships are more inclined to participate in the GECP (Shen et al., 2022). Conservation payment levels and these socioeconomic factors significantly affected herder response. A prior study found that the GECP improved grassland quality to only a small extent but had a large positive effect on income (Hou et al., 2021). However, it also exacerbated existing income inequality among herders within their local communities. Another recent study from Inner Mongolia points out that although the overall ecosystem services in the study area have improved over the past 20 years, grazing pressure management should be strengthened to improve the resilience of ecosystem services to future climate conditions (Li et al., 2021).

Several studies from Central and South America have also analyzed the intersection between ranching and PES programs. In Colombia, ranchers' top motivations for adopting different silvopastoral systems were improving cattle productivity, protecting the environment, accessing technical assistance, and recovering soil fertility (Calle 2020). In a surprising finding, ranchers ranked PES and monetary incentives as the least important motivations, while extension agents considered them as key factors for forest and riparian buffer protection. Another study from Ecuador found that grazing was significantly reduced by almost 20% over a ten-year period and that households continued to refrain from grazing even after experiencing payment loss (Hayes et al., 2022). An important theme to emerge in many of these PES and grazing studies results is the importance of aligning project objectives with community conservation and livelihood goals.

There is a need for more co-produced research on how PES interacts with grazing livelihoods. Rural livelihoods are complex, multidimensional, and context-specific (Scoons, 1998). Sustainable development literature defines livelihoods as the capabilities, assets, and activities that comprise a means of living while also recognizing that there is often a seasonality and inter-annual variation to rural livelihoods (Chambers and Conway, 1992). Resiliency literature emphasizes that livelihoods are sustainable if they can cope with and recover from shocks and stresses (Vercillo, 2016). Because potential shocks and stresses, such as climate change, are deeply intertwined with local and global ecologies, there is a need for an interdisciplinary social and ecological lens (Sayre et al., 2013). Feminist political ecology emphasizes consideration of the intersectional, emotional, affective and relational aspects of livelihoods (Radel et al., 2023). Finally, there is a need to consider justice and equity concerns such as access to opportunities that are shaped by power and the political dimensions of livelihoods. Research into these concerns and dimensions includes labor migration, gendered aspects of livelihoods, climate change adaptation, and social movements working to change livelihood conditions (Deere et al., 2018; Green et al., 2020; Jakobsen and Nielsen, 2024; Nunan et al., 2022) .

The political ecology of Bolivian cattle grazing

Deforestation in Bolivia has increased in recent years, with fires and land clearance for expanding soy farming and cattle ranching identified as the main drivers (Butler, 2021). Bolivian cattle ranching was historically driven by the proximity to local markets and led to the replacement of forest by pasture, particularly in the lowlands on the eastern side of the Andes Mountains (Struelens et al., 2017). Today, the dynamics of the Bolivian cattle market are changing, and new issues are arising with the increase in beef exports. The most common grazing system involves semi-intensive range operations on medium-and large-scale units located mainly around Santa Cruz, in the Amazonian north, and in the Chiquitania dry forest (Müller et al., 2014, 2013) . The largest share of cattle-driven deforestation results from large-scale ranches owned by traditionally wealthy families who have access to extensive land areas, though some Brazilian capital also plays an important role, especially in areas near the Brazilian border (Müller et al., 2012). Information released by the Bolivian Institute of Foreign Trade shows the volume of beef exports between 2019 and 2020 increased by 296% and, in 2020, Bolivia exported more than 14 million kilos of beef with the top export markets in China and Peru, with profits of over 60 million dollars reportedly benefiting just a few ranchers (Valencia, 2021). According to Oscar Ciro Pereyra, president of Bolivia's Cattle-ranchers Confederation, there is a desire to expand exports to Chile, Russia, Ecuador and other markets (Yamei , 2020). The larger political-ecological context that frames this study is the expansion of the Bolivian cattle industry responding to export markets and fed by larger ranches in the eastern side of Santa Cruz. This export strategy is similar to other Bolivian development strategies centered around soy and methane gas industries that have been the economic engine of eastern Bolivia and the source of national funding for municipalities and national poverty alleviation. Local environmental activists and researchers point out that policies promoting the expansion of agriculture are driving deforestation and wildfire caused by land clearance (Butler 2021).

In the Rio Grande watershed and the Valles-Cruceños area where our study site is located, extensive grazing, slash and burn agricultural clearance techniques, known as *chaquear*, and logging are the primary threats to forest and water quality. Bolivian NGOs like *Fundación Natura Bolivia* are calling attention to how cattle damage riparian areas through overgrazing and compacting soils. The impacts of grazing-induced ecological degradation include reducing forest regeneration, increased erosion, water sedimentation, and pollution. Because most people living in the study area rely on surface water for drinking and irrigation, this ecological degradation also has an impact on people's quality of life and livelihoods.

Data and Methods

Study area

This study collected data in four municipalities in the Department of Santa Cruz in Bolivia: Vallegrande, Postrervalle, Pucara, and Samaipata. This area is located approximately 125 kilometers southwest of the capital city of Santa Cruz (Figure 1). This study area is of particular social and hydrological importance because it contains the Rio Grande and the main watershed for this city, which is one of the fastest growing cities in South America and a major agribusiness hub and economic engine for Bolivia (Cantini et al., 2019).

Many of the people interviewed for this research described themselves as a *campesino* or *del campo*, but it is not assumed that all residents primarily or solely identify in this way. There are many identities of rural landowners and land stewards in the study area. The area is home to diverse people, livelihoods, and geographies. There are also highland indigenous, internal, and international migrants who moved to the larger Santa Cruz region to start agricultural operations (Nobbs-Thiessen, 2020). Municipal livelihood data give a broad overview of municipal demographics, agricultural land use percentages, and the top three crops and livestock in the study area (Table 1).

Table 1: Municipal livelihood data from the Bolivia National Institute of Statistics (2019) and agricultural data from the Bolivia Agricultural Census (2013). Agriculture and livestock production are common livelihood activities in the area, and the fishing livelihoods come from proximity to large rivers like the Rio Grande.

Municipality	Population	Top three livelihoods	Percent of total land in production	Top three crops by yield	Top three livestock
Vallegrande	18,202	Agriculture, livestock production, fishing	36.4%	Beans, corn, potatoes	Bees, cattle, pigs
Postrervalle	2,112	Agriculture, livestock production, fishing	53.9%	Potatoes, sugar cane, green beans	Cattle, bees, pigs
Pucarà	1,763	Agriculture, livestock production, fishing	40.3%	Potatoes, oats, apples	Bees, cattle, pigs
Samaipata	10,524	Agriculture, livestock production, beekeeping	23.0%	Tomatoes, potatoes, green beans	Bees, cattle, pigs

Watershared case study background

The PES variant explored in this case study is the Watershared program in Bolivia, which was developed by the non-governmental organization (NGO*) Fundación Natura Bolivia* (FNB). Watershared offers conservation contracts to *campesinos,* rural farmers and ranchers, who receive material incentives like water pipe, fencing, pasture seed, bee boxes, fruit trees, and construction supplies in exchange for protecting an agreed upon area of their land for three years. The amount of incentive materials corresponds with the amount of land enrolled. Although Watershared contracts are a hybrid form of PES, FNB does not use the terminology of PES in the Bolivian political context, where there is historical skepticism about market-based conservation mechanisms (Hines, 2022; Müller et al., 2013). FNB instead frames the contracts as Reciprocal Watershed Agreements, or *Acuerdos Reciprocos de Agua (ARA)*. This framing emphasizes social and ecological reciprocity, while building funding partnerships with local municipalities and water-user associations to offer in-kind incentives to *campesinos* (McWherter et al 2023). In Bolivia's Rio Grande-Valles Cruceños region, these Watershared-protected areas are usually riparian zones and headwater streams. Headwaters are the origin and source of a river, in this case the Rio Grande, which is a tributary of the Amazon River. Overgrazing, overcropping, and excessive timber harvesting in these headwaters pose risks of environmental degradation including erosion, water pollution, and loss of water sources. The highest level of ARA contracts stipulates that *campesinos* exclude cattle from riparian conservation areas and halt forest clearing for the three-year length of the contract. Other levels of ARA contacts allow for cattle in the conservation area and focus on halting forest clearance. Previous research on Watershared has explored impacts on water quality (Pynegar et al., 2018), participant motivations (Authelet et al., 2021), and administrative implementation (Bauchet et al., 2020).

Data collection

A team of US and Bolivian researchers surveyed a random sample of Watershared participants and non-participants in person between 2018 and 2021. After disruptions during the Covid pandemic, the survey data collection was finished and data were cleaned in 2022. The final dataset includes a total of 984 households, of whom 546 had at least one program participant (participant households) and 438 had none (non-participant households). The survey instrument was designed and implemented in conjunction with a Randomized Control Trial (RCT) to evaluate the effect of unconditional (vs conditional) PES program design on participation and outcomes (Bauchet et al, forthcoming). The survey data allow for comparison of rangeland and watershed management practices between participants and non-participants.

In 2019, the author conducted 77 semi-structured qualitative interviews (34 with Watershared participants, 35 with non-participants, and 8 with other key informants). These interviews took place in nine communities across the four municipalities. Within each community, the researchers used a combination of purposive and snowball sampling to recruit interviewees who were participants and non-participants in the Watershared program offered in their community. These interviews mostly occurred at interviewees' houses and farms and consisted of an hour-long interview conducted in Spanish. Field researchers stopped conducting interviews in each community upon reaching data saturation, when the team assessed that additional interviews did not provide researchers with new information or themes. The sampling design of interviewing individuals in both conditional and unconditional communities (as well as participants and non-participants) corresponded with the related RCT and survey design.

Participant observation by the author consisted of assisting with working cattle on a Watershed-participating family ranch in the Vallegrande municipality. Activities included participating in the moving of cattle to grazing sites on foot and horseback, helping with roping and doctoring cattle to carry out rabies vaccinations, and milking cattle for dairy production. The field research team also participated in FNB events like ARA field schools that trained municipal staff in program development as well as contract-signing ceremonies between FNB staff and participants known locally as *entregas*. Participant observation also included accompanying local FNB field staff while they distributed incentive materials and helped troubleshoot material installation. The field team also attended a field day where program funders, FNB staff, and local political leadership met to discuss the impact of the Watershared program.

Table 2: The distribution of community member qualitative interviews across communities and program participation status.

Community	Municipality	Conditionality	Participants	Non-Participants	Total
1	Postrervalle	Unconditional	1	3	4
2	Postrervalle	Conditional	7	4	11
3	Pucara	Conditional	5	1	6
4	Pucara	Unconditional	6	14	20
5	Samaipata	Unconditional	3	1	4
6	Samaipata	Conditional	3	3	6
7	Samaipata	Conditional	2	2	4
8	Vallegrande	Conditional	1	2	3
9	Vallegrande	Unconditional	6	5	11
		TOTALS	**34**	**35**	**69**

Note: A total of 69 of the 77 interviews conducted were with community members and eight were with other stakeholders and key informants including government (judicial, community, or municipal) and NGO staff who operated across multiple communities.

Data analysis

Livelihood data from the survey included reported income, cattle ownership rates, and grazing and land management practices. Survey data were processed with SPSS software (Version 28) to generate descriptive statistics. Grazing management and agricultural practice data from the survey were also processed with SPSS using cross-tabulation and a Pearson's Chi-square test for statistical significance of differences between Watershared participant and non-participant responses. Also known as a Chi-square test for independence, this test evaluates the distribution of a relationship between two categorical variables. By comparing the distribution of reported rangeland management practices between participants and non-participants, this identifies if the practices are correlated with, and therefore may be related to, participation in Watershed. While this test can help identify grazing practices that are associated with Watershed participation, it cannot confirm if participation caused a change in these practices. Additional qualitative methods complement, contextualize, and clarify the results of survey data analysis.

Qualitative data analysis used thematic coding methods to identify recurring themes, patterns, and categories in the interview dataset (Saldaña, 2016; Timmermans and Tavory, 2012). This analysis of interview data used the NVivo software package. The qualitative coding process was iterative and collaborative among the research team. An initial codebook, a set of thematic codes, was developed before the coding process based on PES and rangeland management literature. The codebook was subsequently revised based on interview data, the coding process, team memoing, and a separate review for intercoder reliability.

Available interview data include qualitative descriptions of *campesino* livelihoods and perceptions of Watershared participation that shed light on experiences of program participation and its impacts on their practices and the livelihood outcomes. The thematic codes that were used to analyze interviews for this paper include 1) livelihood strategies, 2) changes in agricultural practices, 3) livestock management, and 4) water management. Field notes and photographs from participant observation of cattle management practices were inductively analyzed and memoed to add critical nonverbal contexts that contribute further descriptive depth to codes and themes identified in interviews about how ranching contributes to *campesino* livelihoods (Phillippi and Lauderdale, 2018).

Results

How cattle ranching contributes to campesinos' livelihoods

Findings indicate that cattle are an important, although not exclusive, part of rural livelihoods in the Rio Grande-Valles Cruceños study area. For surveyed participants in Watershared, 77% reported their household owned cattle; while for surveyed non-participants, only 63% did (Chi-square = 22.891; $p<0.001$). This statistically significant difference reflects that the Watershared program is intentionally engaging *campesinos* who are involved in cattle ranching because that is the demographic best positioned to take the conservation actions involved in Watershared. The difference also may reflect the fact that owning land to put into conservation is necessary to participate in Watershared. Not owning land makes it more difficult to own cattle because it otherwise requires leased or rented grazing land, which decreases ranching profitability.

Reported cattle ownership numbers also varied for participants and non-participants. Overall, the majority reported owning under 100 head with a few large herds that topped out around 450 head. Of the 537 survey participants who reported owning cattle, the mean number of cattle owned by participants was 20 with a standard deviation of 39 while for non-participants it was 12 with a standard deviation of 24 (t-test p=0.004, equal variances not assumed). Data on the size of herds were not gathered during the 2018 surveys.

Survey data show that most respondents have a diverse agricultural income coming not just from the sale of all classes of livestock including cattle, pigs, chickens, and other animals (26% of mean total income) but also from fruits (21%) and crops (16%) (Table 3). For those households with cattle, respondents reported selling a mean of 3 cows or calves in the last year (n=690). The reported mean price for cattle per head was 1894 Bolivianos (Bs) (about 700 USD PPP) with a standard deviation of 903 Bs (n=397). This cattle price statistic includes bulls, cows, calves, and heifers, which contributes to the large standard deviation. For the much smaller portion (2%) of households with income from milk, the mean income from milk in the month before the survey was 472 Bs (or 175 USD PPP; 13% of mean total income). For those producing and selling cheese (9% of respondents), the mean income from cheese in the month before the survey was 1083 Bs (or 401 USD PPP; 30% of mean total income). Only 4% of respondents reported honey income, and they averaged 1229 Bs/month income (or 455 USD PPP), which represents 34% of the average monthly income. Beekeeping equipment is an incentive offered by the Watershared program.

Table 3: Reported monthly income and income from select agricultural sales.

Income source	Households reporting income: No. and percent	Mean reported monthly income in Bolivianos (Bs)	Mean reported monthly income in US dollars*	As percent of average monthly income for all households
Total monthly income	984; 100%	3636 Bs (n=984)	$1347	100%
Livestock (all animal sales)	983; 99%	961 Bs (n=983)	$356	26%
Fruits	984; 100%	770 Bs (n=984)	$285	21%
Crops	983; 99%	584 Bs (n=983)	$216	16%
Honey	37; 4%	1229 Bs (n=28)	$455	34%
Milk	17; 2%	472 Bs (n=15)	$175	13%
Cheese	86; 9%	1083 Bs (n=79)	$401	30%

*Adjusted for purchasing power parity.

Land ownership patterns are important context to understanding local livelihoods. The mean amount of reported cultivated land by ARA participants was 6.1 hectares, with an additional 14.5 hectares of pasture and 81.5 hectares of forest. Mean values reported by ARA non-participants were 2.7 ha cultivated (t-test $p<0.001$), 6.1 ha in pasture (t-test $p<0.001$), and 44.6 ha in forest (t-test $p<0.001$). The main type of land ownership in the area is private, with 96% of participants and 83% of non-participants reporting private individual titles (N=973; Chi square=41.437, $p<0.001$). The National Institute of Agrarian Reform (INRA), a public entity of the Ministry of Rural Development and Lands, is carrying out a titling process known as *saneameinto* (or restructuring) where *campesinos* can request title. The presence of INRA's *saneameinto* work was a topic that came up in many interviews and participant observations. Using cattle and agriculture as part of one's livelihood strategies requires land and some form of tenure right for that land, so the *saneameinto* process is important for many Bolivian *campesinos*. An important local aspect of cattle livelihoods is that many *campesinos* own land parcels in several communities and move their cattle from one parcel to another, a practice known locally as *traslado.* The ability to move cattle is critical for good range management because movement allows for a rest in grazing pressure that allows vegetation to regrow. This movement known as transhumance also allows livestock producers to respond to seasonal forage availability and spatio-temporal heterogeneity. According to an FNB field staff member, "In the majority of cases, people have their land holdings in two or three communities and they rotate their livestock." Survey data reflected this land ownership pattern, and 58% of all participant survey respondents reported owing more than one plot of land (Table 4). Among non-participants, only 42% reported owning more than one plot of land.

Table 4: Number of land plots owned by all survey respondents (N=977).

Number of plots	Participants: Frequency	Participants: Percent	Non-participants: Frequency	Non-participants: Percent
0	0	0	37	8.5
1	229	42.3	215	49.3
2	157	29.0	116	26.6
3	95	17.6	46	10.6
4	32	5.9	14	3.2
5	15	2.8	6	1.4
6	5	0.9	2	0.5
7	3	0.6	0	0
8	2	0.4	0	0
9	1	0.2	0	0
10	1	0.2	0	0
11	1	0.2	0	0
Total	541	100	436	100

Cattle provide an income source in between harvests of crops as well as an important source of nutrition. A common way that cattle are sold in the Valles-Cruceños area is to *comerciantes,* merchants who travel through the region by truck, buying cattle to take to local markets. Selling small numbers of cattle to *comerciantes* provides a cash flow when other agricultural goods like crops and fruit are not yet ready for sale. Survey data and participant observation show how cattle make up parts of people's livelihoods beyond selling animals. Despite a lack of electricity that makes refrigeration difficult, participant observation and interviews found cooperative and practical ways that *campesinos* work with cattle to maintain their nutritional needs. Communities included in the survey had low access to year-round electricity from power lines, with 31 of the 48 communities reporting not having year-round access to electricity. With community butchering, a cow is slaughtered and split between several families so all of the meat is used. Some of this meat is also preserved as a dried meat product known as *charque,* which is then rehydrated in soups and other dishes. In the field, we observed how *campesinos* manage a source of protein without consistent refrigeration. A total of 56% of survey respondents with cattle reported eating at least one or more of their cows in the past year (N=652).

Interviews and participant observation show an affective and historical relationship to cattle ranching, in addition to the material relationship through current livelihood activities. An elderly *campesino* said, "But my intention is, until I die, to have even two cows, but I always want them, the thing is that I love animals very much. I like them a lot and that is also why I can't go anywhere else, I would miss my beloved animals."[2] Another young rancher described how his family had raised cattle for six generations in the Santa Cruz area since the arrival of the Spanish. His description of his family's history was intertwined with his identity as a *ganadero,* or cattle rancher. During an afternoon of roping cattle with his family to administer vaccines, we used braided rawhide lassos that are common in the *vaquero* tradition that stretches from Argentina to northern Nevada. As an uncle described the local rawhide braiding and roping traditions to the younger family members, he spoke about their care for the cattle as connecting them to their own histories and family legacies. In addition to multigenerational ranching families, we also interviewed first generation cattle ranchers and people who described their knowledge coming from multiple sources including multigenerational cattle ranchers, family members who studied animal science, and migrants who bring new ranching knowledge.[3]

Differences in range management practices between Watershared participants and nonparticipants

Range management practices used by Watershared participants and nonparticipants were studied by participant observation, semi-structured interviews, and a survey. Our analysis of the survey data found statistically significant differences in

[2] *Pero mi intención es, hasta morir tener aunque sea dos vacas, pero quiero tener, es que mucho quiero a los animales, me gustan mucho; y es por eso también que no puedo irme a otra parte, tengo mucha pena de mis animalitos.*

[3] *¿Nuestros padres y nuestros abuelos, son ganaderos. Así la traemos. Yo tengo hermano también veterinario…Que él viene, trabaja en la ciudad…Yo, la verdad, aprendí de mi padre…Uno ha nacido con eso ya, con ese conocimiento…También trabajé de ganadero-- de vaquero por allá por Tachuelo, eran unos turcos, unos chatures, tales chatures, se apellidan Chatur. Yo ahí aprendí a cómo se hace el manejo de ganado mecanizado.*

practices reported by Watershared participants and non-participants for fencing off water sources, adoption of pasture management techniques, and development of irrigation systems and cattle water ponds (Table 5). The following statistical results for cattle management practices are restricted to survey respondents who reported owning cattle at the time of the survey. By comparing reported management practice between participants and non-participants, we can understand if there are practices associated with participation. This association helps us understand how participants are engaging the Watershared program to address both water conservation issues as well as support their own livelihoods.

Fencing

Watershared participation is associated with riparian fencing practices for cattle-owning families. Riparian fencing is designed to address water quality issues associated with cattle grazing by keeping animals off the banks of waterways to reduce sediment erosion and improve riparian vegetation cover. There was widespread agreement between Watershared participants (95%) and nonparticipants (96%) that unmanaged cattle can impair water quality (Chi-square=0.989; p=0.320). Among the non-participating households who also reported owning cattle, 37% reported having fenced their water sources to keep cattle out; while among cattle-owning Watershared-participating households, 48% did (see Table 5; Chi-square = 7.193; p = 0.007). The difference in this management practice is likely both because barbed wire is an incentive that is offered through the Watershared program and because riparian cattle exclusion is a stipulation in ARA contracts. Exclusion from the conservation area is expected for the three years under the ARA contract, and the contract can be subsequently renewed.

While protecting water sources was the primary use of fencing incentive materials, some interviewees described using the barbed wire to protect their *huertas,* household gardens, from free-ranging livestock. Participant observation also saw examples of *campesinos* who used the wire for rotational grazing purposes. The interviews demonstrated that some *campesinos* viewed the expansion of fencing positively for social reasons of encouraging respect for property boundaries. Some also reported management advantages to increased fencing, such as not losing livestock.

Pasture seed

Interviews described how a traditional grazing management practice in the area was to let cattle freely roam in forested and riparian areas. Ranchers referred to this extensive management as *ganado suelto,* or loose cattle. This practice contrasts with a more intensive system of management where cattle graze in fenced and managed pastures. Interviews with *campesinos* and FNB staff detailed how improved pasture grass seed is a Watershared material incentive that is used to improve the forage productivity of these managed pastures. As explained by an FNB key informant, FNB offers pasture grass seed as an incentive in order to produce more nutritious forage for cattle using a smaller amount of land. FNB's field staff reported that they offer technical advice on how to plant and manage grazing pasture in conjunction with the provision of the seed and later as a part of ARA monitoring visits. The planting of pasture (in the last 12 months) is another management practice we found to differ between cattle-owning Watershared participants (41%) and non-participants (27%) (see Table 5; Chi-square=7.243; p=0.007). A Watershared participant described a visit from a FNB *tecnico* to the participant's land holding where they both reviewed land use and the functionality of pasture seeds that were provided as incentive. The participant described how *FNB tecnicos* also shared grazing management knowledge so that *campesinos* can improve their conservation practices.[4]

Water infrastructure

Irrigation systems and cattle water pond development are another set of management practices where survey data show a difference between Watershared participants and non-participants. There is a statistically significant difference between cattle-owning participants (34%) and non-participants (25%) on the reported use of an irrigation system (see Table 5; Chi-square=7.431; p=0.006). The development of water sources for irrigation is a large part of what the Watershared program offers in terms of materials, knowledge, and connecting participants to other sources of water development funds from national and municipal sources.

Developing water sources for cattle outside riparian areas allows *campesinos* to conserve streams and springs while still maintaining their cattle production livelihoods. Survey results found a difference between cattle-owning participants (29%) and non-participants (18%) around use of any constructed water source for cattle (see Table 5; Chi-square=7.080; p=0.008). This difference may be explained by the fact that ARA participants are eligible to receive materials like pipe and troughs to construct water sources and participants also receive technical advice from FNB field staff about how to design and use water developments. Participant observation and interview data show

---

[4] *…El técnico viene a ver también, sí, le dan una capacitación, y el técnico viene a ver si lo sembró o no lo sembró. Pero sí nació muy bueno, muy bien la semilla…Vienen y explican y dan cursillos, así que ya la gente que estaba retrasada ya se está actualizando.*

widespread interest in developing water sources for drinking and irrigation, suggesting access to materials and knowledge is the barrier, not interest. There is also a difference between participants (24%) and non-participants (17%) with cattle for reported use specifically of a water retention pond, or *atajado*, in a nearby field (see Table 5; Chi-square=3.567; p=0.059). By slowing, sinking, and spreading water, these ponds are designed to reduce the negative outcome risks of drought and precipitation variability. Participants' ponds were constructed with heavy equipment funded by local municipal governments so that irrigation equipment distributed by Watershared could be used to water crop fields as well as provide cattle drinking sources. Interviewed participants reported that they were able to extend the growing season with this infrastructure from one to two crop cycles.

The findings around the use of fencing, pasture seed, and water infrastructure show evidence that the materials offered by Watershed are both useful and relevant to *campesino* livelihoods. Findings from the livelihood data show the diversified agricultural income streams that support *campesinos.* The design of Watershared's incentives may contribute to further diversification of agricultural livelihoods by supporting enterprises like honey and fruit production.

Table 5: Summary of reported range management practices. Apart from the reporting of cattle ownership, analysis of all other variables is restricted to survey respondents who reported cattle ownership at the time of the survey.

	Watershared participants	**Non-Participants**	**Chi-square value**	**p value**	**Sample size**
Own cattle	77%	63%	22.891	<0.001	983
Fenced water sources	48%	37%	7.193	0.007	580
Planted pasture seed (last 12 months)	41%	27%	7.243	0.007	364
Developed irrigation system	34%	25%	7.431	0.006	695
Used any constructed water source for cattle	29%	18%	7.080	0.008	440
Constructed *atajado* pond in nearby field	24%	17%	3.567	0.059	633

Technical assistance, sources of knowledge, and shared narratives

Technical assistance to participants is provided by FNB field staff and involves troubleshooting the application of material incentives as well as teaching about conservation and land management principles. Survey analysis found a significant difference between participants and non-participants in reported rates of being offered technical assistance in the last 12 months (Table 6). This statistical result was consistent between cattle owners and the full set of sampled households including those who did not report cattle ownership. Other survey results provide more evidence about the impact of knowledge exchange between FNB staff and participants. Seventy three percent of Watershared participants reported learning about watershed management from FNB staff, 21% reported learning about irrigation management, 16% reported learning about livestock management, 73% reported learning about forest management, 7% reported learning about beekeeping, and 14% reported learning about climate change. Only 2% of participants reported learning nothing from FNB staff.

Participant observation of cattle management illuminated that *campesinos* use a number of sources to gain knowledge to improve their production practices. On an afternoon of working cattle, young ranchers were learning traditional roping techniques from elderly *campesinos* as well as looking up medication dosage recommendations on their smartphones. They spoke about local cattle associations offering workshops on production techniques and on newly available technologies like rabies vaccinations. Several had studied agricultural sciences at technical universities in cities like Vallegrande and Santa Cruz.

Table 6: Reported technical assistance.

	Watershared participants	**Non-participants**	**Chi-square value**	**p value**	**Sample size**
Cattle owners: Reported received technical assistance in the past 12 months.	21%	12%	7.529	0.006	514
All respondents: Reported received technical assistance in the past 12 months.	23%	13%	11.044	<0.001	768

The interview dataset provides insight into how improving cattle management practices is connected to a larger consciousness-building process where participants identify with stewarding and caring for the well-being of the watershed and their neighbors. One Watershared participant spoke about how he plans to manage the conservation area after his contract expires:

> For me, I'm going to continue to manage my cattle outside of the sensitive watershed area. Because I am one of those convinced that if I care, I care to have water for myself and for my animals and also for the neighbors. Because the damage is not only to me, but also for others, because the water comes out and continues its course to other families, but if we degrade the headwaters, it dries up, I am affected and even more, the other families. But I personally am going to continue protecting the watershed.

This participant's description of his motivation for improving his cattle management practices illustrates how he has the ability to take care of the watershed and the many relationships that rely on the water. His description evokes the relational values of taking care of his land, water, animals, and neighbors. Another interviewee describes how his education about range management knowledge improved as a result from workshops led by FNB:

> They (FNB) teach about having to divide a pasture into three or four parts so that at one time we have a cow in a pasture, at another time another, at another time another, so cows are not remaining on a pasture all year long. That and everything is based on terrain.

In both previous interview quotes, the participants are describing a process where they are conceptualizing their livelihoods intertwined with their local ecology.

Evidence from participant observation shows how Watershared organizers engaged in social recognition that upheld local norms as a way to co-produce a narrative about the meaning of participating in Watershared. This social recognition happened at the semi-public *entregas,* the events where participants signed Watershared contracts in front of a crowd of FNB representatives, local municipal officials, and their *campesino* neighbors. After the signing ceremony, many photos were taken with participants and officials in front of incentive materials. As we observed at several *entragas*, this social recognition for engaging in improved grazing management was part of the story that Watershared organizers and their partners in municipal governments told, often revolving around local values of reciprocity and care. This story also reflected a core philosophy underlying Watershared, which is that "people who provide water share it, people who benefit from water share the benefits" (FNB 2024). In the case of grazing management, 'providing water' means excluding cattle from riparian areas for the duration of the contract so as to limit erosion and allow for riparian vegetation to regrow. Socially recognizing and materially incentivizing the ecological and relational values of improved grazing management is part of how Watershared builds consciousness around caring for watersheds by aligning incentives and building local capacity for improving range and water management.

As described in interviews, burning forest to clear land for pasture and crops (*chaquear*) is a local land management practice that follows a pattern where forested areas are cut and burned, the regrowth is grazed, and then the area is planted with crops. Within Watershared contracts, there is a stipulation against cutting and burning new forest. Most interviewees shared a sentiment that the 'right' thing to do was *no chaquear*, or not to burn, particularly in the headwaters.[5] This sensibility about limiting burning and deforestation was shared by messaging from local municipalities and regulations in the regional protected area called the Rio Grande-Valles Cruceños Natural Integrated Management Area (ANMI). An added complexity shared by several ranchers during participant observation is that fire is used for vegetation management to control shrubs

[5] *Si uno no las chaquea así se secan las vertientes, no se secan, en vez de perderse la misma agua crece más. Mientras que si lo chaqueamos hasta donde está el vertiente se seca y va perdiendo agua ya.*

and weeds. This issue of burning shows some incongruity where local knowledge and conservation knowledge do not always align. At a regional larger scale, wildlife and deforestation are considered negative issues, and at a local scale, *chaquear* is part of traditional land management practices. Interviews and participant observation showed examples of where Watershared participants spoke of learning the importance to not *chaquear,* particularly in the headwater areas known as *vertientes.*

Discussion

Evidence from our survey, interviews, and participant observation shows how cattle are part of *campesinos'* livelihoods in economic, cultural, affective, and ecological dimensions. While cattle grazing is only one component in *campesinos'* diverse economic livelihoods, it plays a unique role by transforming sunlight and inedible vegetation into human nutrition and livelihoods. Interviews and participant observation found that *ganadero* ranching culture in the Valles Cruceños region is perceived as part of some people's identities and this is reflected in family history and material culture. These ethnographic data show flexibility and adaptability on the part of ranchers who are able to change their management practices to better care for water sources and their downstream neighbors. The evidence from this study shows how Watershared's combination of relevant incentive materials, conservation contracts, and technical assistance works to find locally desirable ways to change grazing practices that are identified by both conservation scientists and local *campesinos* as a source of water quality impairment. Promoted grazing and water developments improve participants' livelihoods by conserving riparian areas and addressing agricultural needs while encouraging care and stewardship of Rio Grande headwaters.

These findings add to a growing literature demonstrating how PES programs can support active rangeland stewardship and local livelihoods by improving management practices while also engaging more-than-market values such as relational values (Chapman et al., 2020; Kernecker et al., 2021). Relational values refer to a normative human sense of connection or kinship with other living things, reflective and expressive of care, identity, belonging and responsibility, and congruent with notions of what it means to live a 'good life' (Klain et al 2017). A prior study of Watershared found that participants' motivations include payments and pro-nature instrumental values, which researchers interpreted as an example of how external incentives enable behavior changes motivated by participants' perceptions of environmental benefits they receive from the management changes (Bottazzi et al, 2018). Interview evidence from this study shows how participants' descriptions of caring for their watersheds, forests, livestock, and local communities are intertwined with livelihood, identity, emotional connection to their animals, and a sense of responsibility for their neighbors. Evidence from participant observation of Watershared community events shows how local values around reciprocity are deeply woven into the language used by FNB and their institutional partners. The use of a relational values frame emphasizes how participants perceive their active stewardship and care in regards to their wider web of relationships and responsibilities.

We found significant differences in grazing and water management practices between Watershared participants and non-participants that include fencing water sources, planting pasture grasses, and constructing irrigation and water retention systems.

Conserving riparian areas and headwater forests through Watershared agreements provides ecological and hydrological benefits to the watershed, which potentially make them more resilient to climate change. Seventeen percent of the interviewed *campesinos* mentioned increasing climate variability, and increasing the capacity to better manage water was a frequent concern in nearly every interview. A growing body of socio-ecological research suggests these integrated watershed management and restoration practices can build social and hydrological resilience to climate change risks like drought and increased precipitation variability (Skidmore et al., 2022; Norman et al., 2022; Scaramudo et al., under review). For example, by developing *atejados,* or water retention ponds, participants are potentially building wildlife habitat as well as slowing, sinking, and spreading water to mitigate drought risks (Taylor et al., 2012). Participant observation in this study found evidence from *campesinos'* experience that *atejados* and the irrigation infrastructure provided by Watershared helped them increase their harvest yield. Qualitative evidence in this study also points towards participant perceptions around understanding these practices as being connected to being good neighbors and stewards of land and animals. Evidence from Watershared shows how locally tailored PES programs can support livelihoods and amplify participants' relational values around caring for watershed, rangeland, and human community well-being.

Watershared's support for grazing management improvement, agricultural livelihood diversification, as well as watershed health shows it is possible to expand the conservation frame to include coupled social-ecological system resilience. The evidence in this study shows that *campesinos* already have diverse agricultural livelihoods and FNB's approach to Watershared is geared towards increasing diversity as a way to build more resilient socio-agroecosystems. Watershared helps improve the resilience of *campesinos'* range management practices by offering relevant material incentives to improve cattle distribution and movement on the landscape. These incentives also help improve grazing management by improving pasture productivity and protecting water sources while developing water infrastructure for both humans and livestock. The flexible choice of incentives supports agricultural enterprise diversification, which supports both conservation and livelihood resilience (Kiani et al 2021). Watershared's use of local field staff and collaborations with municipalities connects participants with extension-like services. These connections contribute to building ecological and agricultural knowledge in ranching communities and building relationships between participants and other management resources.

Does Watershared's interaction between watershed conservation and grazing management build adaptive capacity to climate change? Adaptive capacity is theorized as an emergent and evolving quality rooted in local culture, tied to place-based understandings and relationships, and connected to local legitimacy (Smith 2023). The potential ways in which Watershared contributes to adaptive capacity include ecological dimensions like conserving intact headwaters so that the water cycle is protected from erosion from riparian degradation, water quality degradation, increased temperatures through forest cover loss, and loss of habitat. Another dimension is the rangeland management practices such as supporting improved grazing productivity. The evidence in this study shows how practices associated with Watershared participation helps to improve grazing through four mechanisms. The first is fencing that allows for more shaping of cattle behavior such as mitigating riparian degradation as well as pasture rotation to avoid overgrazing. The second is providing pasture seeds to improve forage production and animal nutrition. The third is developing water retention ponds and cattle drinking infrastructure that allows for better grazing distribution on the landscape. Water retention ponds combined with irrigation incentive materials allow participants to extend their growing season, increase crop yields, and mitigate drought risks. The fourth is amplifying existing livelihood patterns of agricultural diversification through the offering of incentives like bee boxes and fruit trees. Livelihood data show that people are already engaged in diverse agricultural operations so these incentives help amplify already existing practices with additional resources and knowledge.

Conservation incentive programs like Watershared may contribute to building new local institutions to address scale mismatch in climate adaptation. Spatial-scale mismatch occurs where the boundaries of governing organizations do not align with the environmental systems that they govern (Sayles and Baggio, 2017). Providing spatially and temporarily relevant climate data and adaptation strategies to farmers and ranchers is a major issue that a number of scholars are working to address through novel and emergent collaborative institutions (Smith et al., 2021). The way that Watershared builds local institutions is by organizing funding collaborations between water user groups, local municipalities, and international donors. In the process of organizing these funds that enable Watershared contracts, FNB brings together disparate groups that have an interest in improved local watershed management. Attention to local relationships and plural values in Watershared supports the co-producing of novel cross-boundary institutions that stack functions in supporting working landscapes (Baxter and Land, 2023; Aldworth and Schultz 2023). Examples of stacking functions in this study include improving grazing management, building hydrological resilience, and nurturing relationships that bridge between creative governance and grassroots mobilization.

Framing PES beyond markets has been a theme since the idea of PES encountered resistance from implementation site communities who associated it with larger neoliberal projects (Wunder and Vargas, 2005). Improving hydrological management and social recognition for being a good neighbor has found traction with the local communities who are participants in the Watershared program (Bremer et al., 2023). This study shows evidence of how improving grazing and watershed management fits into these local values of reciprocity. A key aspect of the neoliberal political imagination was to separate economic rationality from the social context (Polanyi, 1944). A take-away from Waterhared is that the material incentive's use value is embedded in the social and ecological fabric of Rio Grande and Valles Cruzeños. Social recognition and material incentives that improve ranchers' capacity to care for the watershed through improving grazing management is a compelling lesson for other rangeland PES programs. Designing the incentive structure to provide diverse and relevant materials for diverse agricultural livelihoods is an example of how PES can meet local needs and create interest.

The use of fire in range management is gaining increasing interest with paradigms like pyric-herbivory and Indigenous fire practices providing increasing social and ecological breakthroughs (Fuhlendorf et al., 2009; Marks-Block et al., 2021). Watershared contracts are designed to limit forest clearance from the slash and burn swidden agricultural practice known locally as *chaquear.* In Bolivia, recent catastrophic wildfires caused by land clearance for agriculture have brought national and international attention to the fire issue. Fire is an area for future research where rangeland ecology and PES theory and practice could benefit from more mutual engagement and critical review.

One potential theoretical contribution of this paper is the application of its findings to understanding the differences and synergies between managing for conservation outcomes and social-ecological system resilience. Managing and designing incentives for rangeland resilience requires an understanding of coupled social and ecological systems as well as the flexibility, adaptability, and context specificity needed by both land managers and PES program designers. This paper brings two literatures in conversation to one another. The first is the geography of PES programs with its emphasis on plural conservation values and the situated agency of local communities to shape conservation implementation (Shapiro-Garza et al., 2020). The second is rangeland management literature that seeks to address resilience and adaptive capacity in the context of climate change and livelihoods amidst working landscape conservation (Smith et al., 2023).

Rangeland management theory and practice is in a moment of critical growth that involves synthesizing and applying concepts like ecosystem services, working lands conservation, and climate adaptation. While these ideas have been present for several decades, there is increasing urgency to apply them to rangelands and forests that support livelihoods as well as biodiversity, carbon sequestration, water cycling, and cultural values. Successfully co-producing science to guide management in these working lands is considered the next frontier in nature conservation (Naugle et al., 2019). Ranchers whose livelihoods are intertwined with working lands are in a unique position to collaborate with conservation organizations to co-produce PES designs that address local conditions and livelihood needs.

Conclusion

The results from this study contribute to the emerging working lands conservation frontier by providing evidence of how the Watershared program interacts with grazing livelihoods and watershed management in the Rio Grande-Valles Cruceños of Bolivia. Qualitative data show how participants conceptualized their participation in Watershared, which emphasized care, reciprocity, and relational values. Social recognition, technical assistance, and relational value frames are motivations that extend beyond market values that frame some PES programs. Yet the value of the incentive materials is in both its social recognition of care and stewardship as well as the use value to agricultural operations. Understanding local stewardship norms helps PES programs assemble a relevant framing that engages a plurality of potential local values.

Evidence in this study shows how Watershared's combination of relevant incentive materials, conservation contracts, and technical assistance is addressing livelihood needs and finding locally desirable ways to change grazing practices. The combination of aligning incentives and technical assistance provides a compelling model for future rangeland conservation incentive programs. A key lesson is that building working land conservation programs to address complex rangeland and climate adaptation challenges requires robust attunement to local livelihoods, cultures, and ecologies.

This study contributes evidence that can help increase the adoption rate of active rangeland stewardship practices with an explicit focus on building resilience to climate change risks. The results of the study suggest that instead of conceptualizing PES as a purely market mechanism, understanding how local partnerships can co-produce place-based strategies that support local livelihoods is a critical part of understanding how to durably incentivize ecosystem service provision on rangelands.

The case study findings show that Watershared supports active rangeland stewardship by braiding together local livelihood needs with conservation science goals while providing materials and education to improve livestock and crop production. Promoted grazing and water developments improve participants' livelihoods by conserving riparian areas and addressing agricultural needs while encouraging care and stewardship of headwaters. More broadly, these findings show how a PES program can support active rangeland stewardship and local livelihoods by improving management practices while also engaging more-than-market values such as relational values.

The main lessons for rangeland conservation incentive initiatives are that program designs need context specificity such as land tenure, agricultural operation diversity, local ecological processes/dynamics, and local knowledge. Managing rangelands for resiliency is enhanced by building relationships between participants and local organizations that can help with matching funding, technical assistance, and local legitimacy. Future research into these topics should consider more collaborative co-produced research with PES program implementers and participants that can assess the durability and longevity of these conservation incentive programs on grazing practices.

References

Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit, B., Takahashi, K., 2007. Assessment of adaptation practices, options, constraints and capacity., Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribition of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Tyler Aldworth, Courtney Schultz, 2023. Institutions That Influence Cross-Boundary Forest Management: Four Cases of Shared Stewardship in Practice, *Journal of Forestry*, Volume 121, Issue 5-6, September/November 2023, Pages 432–442, https://doi.org/10.1093/jofore/fvad030

Bailey, D.W., Mosley, J.C., Estell, R.E., Cibils, A.F., Horney, M., Hendrickson, J.R., Walker, J.W., Launchbaugh, K.L., Burritt, E.A., 2019. Synthesis Paper: Targeted Livestock Grazing: Prescription for Healthy Rangelands. Rangeland Ecol Manag 72, 865–877. https://doi.org/10.1016/j.rama.2019.06.003

Baumgart-Getz, A., Prokopy, L.S., Floress, K. 2012. Why farmers adopt best management practice in the United States: A meta-analysis of the adoption literature. Journal of Environmental Management, Volume 96, Issue 1. ttps://doi.org/10.1016/j.jenvman.2011.10.006.

Baxter, J., Land, S., 2023. What does collaborative capacity make possible? Prevailing perspectives on the relationship between collaborative capacity and landscape stewardship outcomes. California Landscape Stewardship Network.

Benra, F., Nahuelhual, L., Felipe-Lucia, M., Jaramillo, A., Bonn, A., Jullian, C., 2022. Balancing ecological and social goals in PES design – Single objective strategies are not sufficient. Ecosyst Serv 53, 101385. https://doi.org/10.1016/j.ecoser.2021.101385

Bremer, L.L., Nelson, S., Jackson, S., Izquierdo-Tort, S., Lansing, D., Shapiro-Garza, E., Echavarría, M., Upton, C., Asquith, N., Isyaku, U., Asiyanbi, A., He, J., Pascual, U., 2023. Embedding local values in Payments for Ecosystem Services for transformative change. Curr. Opin. Environ. Sustain. 64, 101354. https://doi.org/10.1016/j.cosust.2023.101354

Briske, D.D., Coppock, D.L., 2023. Rangeland stewardship envisioned through a planetary lens. Trends Ecol. Evol. 38, 109–112. https://doi.org/10.1016/j.tree.2022.09.012

Brunson, M.W., Burritt, E.A., 2009. Behavioral Factors in Rotational Grazing Systems. Rangelands 31, 20–25. https://doi.org/10.2111/1551-501x-31.5.20

Brymer, A.L.B., Toledo, D., Spiegal, S., Pierson, F., Clark, P.E., Wulfhorst, J.D., 2020. Social-Ecological Processes and Impacts Affect Individual and Social Well-Being in a Rural Western U.S. Landscape. Frontiers Sustain Food Syst 4, 38. https://doi.org/10.3389/fsufs.2020.00038

Burnham, M., Ma, Z., 2015. Linking smallholder farmer climate change adaptation decisions to development. Clim Dev 8, 1–23. https://doi.org/10.1080/17565529.2015.1067180

Burritt, B., 2012. Training Livestock to Leave Streams and Use Upland.

Butler, R.A., 2021. Rallying the public to save Bolivia's forests: Q&A with Gina Méndez [WWW Document]. Mongabay. URL https://news.mongabay.com/2021/05/rallying-the-public-to-save-bolivias-forests-qa-with-gina-mendez/

Calle, A., 2020. Partnering with cattle ranchers for forest landscape restoration. Ambio 49, 593–604. https://doi.org/10.1007/s13280-019-01224-8

Cantini, F., Castelli, G., Foderi, C., Garcia, A.S., Armentia, T.L. de, Bresci, E., Salbitano, F., 2019. Evidence-Based Integrated Analysis of Environmental Hazards in Southern Bolivia. Int J Environ Res Pu 16, 2107. https://doi.org/10.3390/ijerph16122107

Chambers, R., Conway, 1992. Sustainable Rural Livelihoods: Practical Concepts for the 21st Century. IDS Discussion Paper 296.

Che, Y., Feng, H., Hennessy, D.A., 2023. Will adoption occur if a practice is win-win for profit and the environment? An application to a rancher's grazing practice choices. Ecol. Econ. 209, 107826. https://doi.org/10.1016/j.ecolecon.2023.107826

Costanza, R., d'Arge, R., Groot, R. de, Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., Belt, M. van den, 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260. https://doi.org/10.1038/387253a0

DeLonge, M., Basche, A., 2018. Managing grazing lands to improve soils and promote climate change adaptation and mitigation: a global synthesis. Renew Agr Food Syst 33, 267–278. https://doi.org/10.1017/s1742170517000588

Derner, J.D., Augustine, D.J., 2016. Adaptive Management for Drought on Rangelands. Rangelands 38, 211–215. https://doi.org/10.1016/j.rala.2016.05.002

Derner, J.D., Wilmer, H., Stackhouse-Lawson, K., Place, S., Boggess, M., 2023. Practical considerations for adaptive strategies by US grazing land managers with a changing climate. Agrosystems, Geosci. Environ. 6. https://doi.org/10.1002/agg2.20356

Derose, K.L., Battaglia, C.F., Eastburn, D.J., Roche, L.M., Becchetti, T.A., George, H.A., Lile, D.F., Lancaster, D.L., McDougald, N.K., Tate, K.W., 2020. Riparian health improves with managerial effort to implement livestock distribution practices. Rangel J 42, 153. https://doi.org/10.1071/rj20024

Dinan, M., Adler, P.B., Bradford, J., Brunson, M., Elias, E., Felton, A., Greene, C., James, J., Suding, K., Thacker, E., 2021. Making research relevant: Sharing climate change research with rangeland advisors to transform results into drought resilience. Rangelands 43, 185–193. https://doi.org/10.1016/j.rala.2021.08.004

Eaton, Weston & Eanes, Francis & Ulrich-Schad, Jessica & Burnham, Morey & Church, Sarah & Arbuckle Jr, J. & Cross, Jennifer. (2019). Trouble with Sense of Place in Working Landscapes. Society & Natural Resources. 32. 1-14. 10.1080/08941920.2019.1568653.

Fuhlendorf, S.D., Engle, D.M., Kerby, J., Hamilton, R., 2009. Pyric Herbivory: Rewilding Landscapes through the Recoupling of Fire and Grazing. Conserv. Biol. 23, 588–598. https://doi.org/10.1111/j.1523-1739.2008.01139.x

Gonin, A., Gautier, D., 2015. Shift in herders' territorialities from regional to local scale: the political ecology of pastoral herding in western Burkina Faso. Pastor 5, 7. https://doi.org/10.1186/s13570-015-0023-z

Goodwin, C.N., Hawkins, C.P., Kershner, J.L., 1997. Riparian Restoration in the Western United States: Oveview and Perspecive. Restor Ecol 5, 4–14. https://doi.org/10.1111/j.1526-100x.1997.tb00200.x

Goodwin, J., Porensky, L.M., Meiman, P., Wilmer, H., Derner, J.D., Iovanna, R., Monlezun, A.C., Vandever, M.W., Griggs, J., Price, F., Spiegal, S., Padilla, N., Voth, D., Maher, A., O'Connor, R., Hoover, D., Pluhar, J., Estep, C., Fox, W., 2023. Rangeland Ecosystem Services: Connecting nature and people (Report).

Gosnell, H., Gill, N., Voyer, M., 2019. Transformational adaptation on the farm: Processes of change and persistence in transitions to 'climate-smart' regenerative agriculture. Global Environ Change 59, 101965. https://doi.org/10.1016/j.gloenvcha.2019.101965

Goss, K., 1979. Consequences of Diffusion of Innovations. Rural Sociology v44 n4.

Green, L., Schmook, B., Radel, C., Mardero, S., 2020. Living Smallholder Vulnerability: The Everyday Experience of Climate Change in Calakmul, Mexico. J Lat Am Geogr. https://doi.org/10.1353/lag.0.0129

Haggerty, J.H., Epstein, K., Bennett, D.E., Milton, B., Nowlin, L., Martin, B., 2023. Rangeland Wildlife Ecology and Conservation 933–967. https://doi.org/10.1007/978-3-031-34037-6_27

Hayes, T., Murtinho, F., Wolff, H., López-Sandoval, M.F., Salazar, J., 2022. Effectiveness of payment for ecosystem services after loss and uncertainty of compensation. Nat Sustain 5, 81–88. https://doi.org/10.1038/s41893-021-00804-5

Hendricks, N.P., Er, E., 2018. Changes in cropland area in the United States and the role of CRP. Food Polic. 75, 15–23. https://doi.org/10.1016/j.foodpol.2018.02.001

Herrero, M., Thornton, P.K., Notenbaert, A.M., Wood, S., Msangi, S., Freeman, H.A., Bossio, D., Dixon, J., Peters, M., Steeg, J. van de, Lynam, J., Rao, P.P., Macmillan, S., Gerard, B., McDermott, J., Seré, C., Rosegrant, M., 2010. Smart Investments in Sustainable Food Production: Revisiting Mixed Crop-Livestock Systems. Science 327, 822–825. https://doi.org/10.1126/science.1183725

Hoag, D., A. E. Luloff, and D. L. Osmond. 2012. Lessons Learned from the NIFA CEAP: How Farmers and Ranchers Make Decisions on Conservation Practices. NC State University, Raleigh, NC.

Hou, L., Xia, F., Chen, Q., Huang, J., He, Y., Rose, N., Rozelle, S., 2021. Grassland ecological compensation policy in China improves grassland quality and increases herders' income. Nat. Commun. 12, 4683. https://doi.org/10.1038/s41467-021-24942-8

IPCC, 2023. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland.

Knowler, D., Bradshaw, B. 2007. Farmers' adoption of conservation agriculture: A review and synthesis of recent research. Food Policy, Volume 32, Issue 1, https://doi.org/10.1016/j.foodpol.2006.01.003.

Li, Xiaobing, Lyu, X., Dou, H., Dang, D., Li, S., Li, Xiang, Li, M., Xuan, X., 2021. Strengthening grazing pressure management to improve grassland ecosystem services. Global Ecol Conservation 31, e01782. https://doi.org/10.1016/j.gecco.2021.e01782

Macon, D., 2020. Paying for the presence of predators: An evolving approach to compensating ranchers. Rangelands 42, 43–52. https://doi.org/10.1016/j.rala.2020.03.001

Magne, M.-A., Martin, G., Moraine, M., Ryschawy, J., Thenard, V., Triboulet, P., Choisis, and J.-P., 2019. An Integrated Approach to Livestock Farming Systems' Autonomy to Design and Manage Agroecological Transition at the Farm and Territorial Levels, in: Agroecological Transitions: From Theory to Practice in Local Participatory Design. https://doi.org/10.1007/978-3-030-01953-2

Marks-Block, T., Lake, F.K., Bird, R.B., Curran, L.M., 2021. Revitalized Karuk and Yurok cultural burning to enhance California hazelnut for basketweaving in northwestern California, USA. Fire Ecol 17, 6. https://doi.org/10.1186/s42408-021-00092-6

Meredith, B.G., Bean, A., Brymer, A.B., Friedrichsen, C., Hurst, Z., 2021. Integrating human dimensions within the LTAR network to achieve agroecological system transformation. Rangelands. https://doi.org/10.1016/j.rala.2021.05.002

Miller, J., Chanasyk, D., Curtis, T., Entz, T., Willms, W., 2010. Influence of streambank fencing with a cattle crossing on riparian health and water quality of the Lower Little Bow River in Southern Alberta, Canada. Agr Water Manage 97, 247–258. https://doi.org/10.1016/j.agwat.2009.09.016

Müller, R., Müller, D., Schierhorn, F., Gerold, G., Pacheco, P., 2012. Proximate causes of deforestation in the Bolivian lowlands: an analysis of spatial dynamics. Reg Environ Change 12, 445–459. https://doi.org/10.1007/s10113-011-0259-0

Müller, R., Pacheco, P., Montero, J.C., 2014. The context of deforestation and forest degradation in Bolivia: Drivers, agents and institutions. CIFOR. https://doi.org/10.17528/cifor/004600

Müller, R., Pistorius, T., Rohde, S., Gerold, G., Pacheco, P., 2013. Policy options to reduce deforestation based on a systematic analysis of drivers and agents in lowland Bolivia. Land Use Policy 30, 895–907. https://doi.org/10.1016/j.landusepol.2012.06.019

Naugle, D.E., Allred, B.W., Jones, M.O., Twidwell, D., Maestas, J.D., 2019. Coproducing Science to Inform Working Lands: The Next Frontier in Nature Conservation. Bioscience 70, 90–96. https://doi.org/10.1093/biosci/biz144

O'Connor, J., 2020. Barriers For Farmers & Ranchers To Adopt Regenerative Ag Practices In The US. Patagonia.

Owange, N., 2023. Strengthening Livestock Systems through Climate Smart and Gender Sensitive Approaches.

Pagiola, S., Ramírez, E., Gobbi, J., Haan, C. de, Ibrahim, M., Murgueitio, E., Ruíz, J.P., 2007. Paying for the environmental services of silvopastoral practices in Nicaragua. Ecol Econ 64, 374–385. https://doi.org/10.1016/j.ecolecon.2007.04.014

Papanastasis, V.P., 2009. Restoration of Degraded Grazing Lands through Grazing Management: Can It Work? Restor Ecol 17, 441–445. https://doi.org/10.1111/j.1526-100x.2009.00567.x

Perramond, E., 2010. Political Ecologies of Cattle Ranching in Northern Mexico: Private Revolutions. University of Arizona Press.

Porter, J.R., Howden, M., Smith, P., 2017. Considering agriculture in IPCC assessments. Nat Clim Change 7, 680–683. https://doi.org/10.1038/nclimate3404

Prokopy, L.S., Floress, K., Arbuckle, J.G., Church, S.P., Eanes, F.R., Gao, Y., Gramig, B.M., Ranjan, P., Singh, A.S., 2019. Adoption of agricultural conservation practices in the United States: Evidence from 35 years of quantitative literature. J. Soil Water Conserv. 74, 520–534. https://doi.org/10.2489/jswc.74.5.520

Prokopy, L.S., Floress, K., Klotthor-Weinkauf, D. and Baumgart-Getz, A. 2008.Journal of Soil and Water Conservation September 2008, 63 (5) 300-311; DOI: https://doi.org/10.2489/jswc.63.5.300

Radel, C., Carte, L., Johnson, R.L., Schmook, B., 2023. Emotions and gendered experiences of livelihood migration: memos from Nicaragua and Guatemala. Gend., Place Cult. ahead-of-print, 1–10. https://doi.org/10.1080/0966369x.2023.2249251

Radel, C., Schmook, Carte, Mardero, 2018. Toward a Political Ecology of Migration: Land, Labor Migration, and Climate Change in Northwestern Nicaragua. World Dev 108, 263–273. https://doi.org/10.1016/j.worlddev.2017.04.023

Reid, R.S., Fernández-Giménez, M.E., Wilmer, H., Pickering, T., Kassam, K.-A.S., Yasin, A., Porensky, L.M., Derner, J.D., Nkedianye, D., Jamsranjav, C., Jamiyansharav, K., Ulambayar, T., Oteros-Rozas, E., Ravera, F., Bulbulshoev, U., Kaziev, D.S., Knapp, C.N., 2021. Using Research to Support Transformative Impacts on Complex, “Wicked Problems” With Pastoral Peoples in Rangelands. Frontiers Sustain Food Syst 4, 600689. https://doi.org/10.3389/fsufs.2020.600689

Roche, L.M., Saitone, T.L., Tate, K.W., 2021. Rangeland Ecosystem Service Markets: Panacea or Wicked Problem? Frontiers Sustain Food Syst 5, 554373. https://doi.org/10.3389/fsufs.2021.554373

Rojas-Downing, M.M., Nejadhashemi, A.P., Harrigan, T., Woznicki, S.A., 2017. Climate change and livestock: Impacts, adaptation, and mitigation. Clim Risk Management 16, 145–163. https://doi.org/10.1016/j.crm.2017.02.001

Roper, B.B., Saunders, W.C., 2021. How Cattle and Wild Ungulate Use of Riparian Areas Effects Measures of Streambank Disturbance. Rangeland Ecol Manag 74, 32–42. https://doi.org/10.1016/j.rama.2020.08.009

Rudel, T., Kwon, O.-J., Paul, B., Boval, M., Rao, I., Burbano, D., McGroddy, M., Lerner, A., White, D., Cuchillo, M., Luna, M., Peters, M., 2016. Do Smallholder, Mixed Crop-Livestock Livelihoods Encourage Sustainable Agricultural Practices? A Meta-Analysis. Land 5, 6. https://doi.org/10.3390/land5010006

Sachet, E., Mertz, O., Coq, J.-F.L., Cruz-Garcia, G.S., Francesconi, W., Bonin, M., Quintero, M., 2021. Agroecological Transitions: A Systematic Review of Research

Approaches and Prospects for Participatory Action Methods. Frontiers Sustain Food Syst 5, 709401. https://doi.org/10.3389/fsufs.2021.709401

Saldaña, 2016. The coding manual for qualitative researchers. SAGE, Thousand Oaks, California, USA.

Sanderson, J.S., Beutler, C., Brown, J.R., Burke, I., Chapman, T., Conant, R.T., Derner, J.D., Easter, M., Fuhlendorf, S.D., Grissom, G., Herrick, J.E., Liptzin, D., Morgan, J.A., Murph, R., Pague, C., Rangwala, I., Ray, D., Rondeau, R., Schulz, T., Sullivan, T., 2020. Cattle, conservation, and carbon in the western Great Plains. J. Soil Water Conserv. 75, 5A-12A. https://doi.org/10.2489/jswc.75.1.5a

Sarr, D.A., 2002. Riparian Livestock Exclosure Research in the Western United States: A Critique and Some Recommendations. Environ Manage 30, 516–526. https://doi.org/10.1007/s00267-002-2608-8

Sayles, J.S., Baggio, J.A., 2017. Social–ecological network analysis of scale mismatches in estuary watershed restoration. Proc. Natl. Acad. Sci. 114, E1776–E1785. https://doi.org/10.1073/pnas.1604405114

Sayre, N.F., 2017. The Politics of Scale. University of Chicago Press, Chicago. https://doi.org/10.7208/chicago/9780226083391.001.0001

Sayre, N.F., McAllister, R.R., Bestelmeyer, B.T., Moritz, M., Turner, M.D., 2013. Earth Stewardship of rangelands: coping with ecological, economic, and political marginality. Front Ecol Environ 11, 348–354. https://doi.org/10.1890/120333

Scoones, I., 2022. Livestock, methane, and climate change: The politics of global assessments. Wiley Interdiscip Rev Clim Change. https://doi.org/10.1002/wcc.790

Scoons, I., 1998. Sustainable Rural Livelihoods: A Framework for Analysis. IDS Working Paper, issue 72.

Senger, I., Borges, J.A.R., Machado, J.A.D., 2017. Using the theory of planned behavior to understand the intention of small farmers in diversifying their agricultural production. J. Rural Stud. 49, 32–40. https://doi.org/10.1016/j.jrurstud.2016.10.006

Shapiro-Garza, E., McElwee, P., Hecken, G.V., Corbera, E., 2020. Beyond Market Logics: Payments for Ecosystem Services as Alternative Development Practices in the Global South. Dev Change 51, 3–25. https://doi.org/10.1111/dech.12546

Shen, W., Zhou, T., Chang, H., Qiu, X., Liu, Y., Sun, H., Zhai, X., Yang, H., Liu, G., Yang, W., 2022. Responses of grazing households to different levels of payments for ecosystem services. Ecosyst Heal Sustain. https://doi.org/10.1080/20964129.2022.2052762

Smith, A.P., Vallury, S., Metcalf, E.C., 2023. Social dimensions of adaptation to climate change in rangelands: a systematic literature review. Clim. Chang. 176, 180. https://doi.org/10.1007/s10584-023-03648-4

Smith, A.P., Yung, L., Snitker, A.J., Bocinsky, R.K., Metcalf, E.C., Jencso, K., 2021. Scalar Mismatches and Underlying Factors for Underutilization of Climate Information: Perspectives From Farmers and Ranchers. Front. Clim. 3, 663071. https://doi.org/10.3389/fclim.2021.663071

Smith, J.E., 2024. In Colombia, a Park for Anacondas and Anteaters, Where Ranchers Are Now Rangers - The New York Times [WWW Document]. New York Times. URL https://www.nytimes.com/2024/01/16/science/colombia-park-manacacias.html (accessed 1.21.24).

Spackman, C., Allison, C., 2018. Carbon Sequestration on Rangelands: A Primer.

Stephenson, G. 2003. The Somewhat Flawed Theory of The Extension Service. The Journal of Extension. Volumn 41, Number 4.

Struelens, Q., Pomar, K.G., Herrera, S.L., Huanca, G.N., Dangles, O., Rebaudo, F., 2017. Market access and community size influence pastoral management of native and exotic livestock species: A case study in communities of the Cordillera Real in Bolivia's high Andean wetlands. Plos One 12, e0189409. https://doi.org/10.1371/journal.pone.0189409

Tama, R.A.Z., Ying, L., Yu, M., Hoque, M.M., Adnan, K.M., Sarker, S.A., 2021. Assessing farmers' intention towards conservation agriculture by using the Extended Theory of Planned Behavior. J. Environ. Manag. 280, 111654. https://doi.org/10.1016/j.jenvman.2020.111654

Timmermans, S., Tavory, I., 2012. Theory Construction in Qualitative Research: From Grounded Theory to Abductive Analysis. Sociol Theor 30, 167–186. https://doi.org/10.1177/0735275112457914

Tittonell, P., 2021. Beyond CO2: Multiple Ecosystem Services From Ecologically Intensive Grazing Landscapes of South America. Frontiers Sustain Food Syst 5, 664103. https://doi.org/10.3389/fsufs.2021.664103

Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., Schiller, A., 2003. A framework for vulnerability analysis in sustainability science. Proc National Acad Sci 100, 8074–8079. https://doi.org/10.1073/pnas.1231335100

USGCRP, 2023. Fifth National Climate Assessment. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/nca5.2023

Vallury, S., Smith, A.P., Chaffin, B.C., Nesbitt, H.K., Lohani, S., Gulab, S., Banerjee, S., Floyd, T.M., Metcalf, A.L., Metcalf, E.C., Twidwell, D., Uden, D.R., Williamson, M.A., Allen, C.R., 2022. Adaptive capacity beyond the household: a systematic review of empirical social-ecological research. Environ Res Lett 17, 063001. https://doi.org/10.1088/1748-9326/ac68fb

Valencia, Carolina Méndez. 2021. Ganadería en Bolivia: se amplía la exportación, se reducen los bosques. Accessed 7/3/24. https://www.raibolivia.org/ganaderia-en-bolivia-se-amplia-la-exportacion-se-reducen-los-bosques/

Vercillo, S., 2016. Sustainable Livelihoods and Rural Development. Canadian Journal of African Studies / Revue canadienne des études africaines 50, 326–328. https://doi.org/10.1080/00083968.2015.1106713

Wei, C., Zhou, Y., Kong, J., 2022. Evidence regarding the ecological benefits of payment for ecological services programs from China's grassland ecological compensation policy. Front. Environ. Sci. 10, 989897. https://doi.org/10.3389/fenvs.2022.989897

Wilmer, H., Fernández-Giménez, M.E., 2016. Some years you live like a coyote: Gendered practices of cultural resilience in working rangeland landscapes. Ambio 45, 363–372. https://doi.org/10.1007/s13280-016-0835-0

Wunder, S., 2015. Revisiting the concept of payments for environmental services. Ecol Econ 117, 234–243. https://doi.org/10.1016/j.ecolecon.2014.08.016

Wunder, S., Vargas, M.T., 2005. Beyond "Markets." The Ecosystem Marketplace, Katoomba Group.

Yamei, Wang. 2020. Bolivian cattle ranchers see "long standing dream" of exporting beef to China come true. XinguaNet. Accessed 7/3/2024. http://www.xinhuanet.com/english/2020-01/10/c_138693228.htm

Zhou, T., Yang, H., Qiu, X., Sun, H., Song, P., Yang, W., 2023. China's grassland ecological compensation policy achieves win-win goals in Inner Mongolia. Environ. Res. Commun. 5, 031007. https://doi.org/10.1088/2515-7620/acc1d9

CHAPTER 3

IMPLEMENTING CONSERVATION INCENTIVE PROGRAMS WITH A RELATIONAL APPROACH TO CARE-BASED STEWARDSHIP (ARTICLE 2)

Abstract

Recent research into Payments for Ecosystem Services asks if these conservation incentive programs are best understood as a payment for services or as support for stewardship. The literature also identifies a gap in scholarship on how program implementation shapes this understanding. This paper contributes to filling this gap by exploring the role of field staff in how the Watershared conservation program is implemented on the ground and how their specific role facilitates the participation of farmers and ranchers in the Rio Grande-Valles Cruceños area of Bolivia and additionally may support smallholder adaptation to climate change. Based on a mixed-methods approach including a survey, semi-structured interviews, and participant observation, this paper explores how Watershared's field staff are critical to the organization of Reciprocal Watershed Agreements through their knowledge and translation of local agricultural systems and farmer and rancher needs. This allows Watershared to offer relevant material as incentive for conserving riparian and forest areas, organize collaborations with municipalities to address local needs, and deliver extension-like services focusing on both grazing improvement and agricultural diversification practices. Field staff engagement in these activities builds local relationships and validates local stewardship norms. This case study suggests that conservation program field staff can play a critical role in the promotion of relational values that support watershed-scale conservation as well as build

the capacity to adapt local communities to climate change risks. This case study shows how a relational approach to care-based stewardship is engendered by field staff through activities attuned to local agency, care, and knowledge as three important dimensions of stewardship.

Introduction

Recent research into Payments for Ecosystem Services (PES) asks if these conservation incentive programs are best understood as a payment for services or as support for stewardship (Chapman et al., 2020; Lliso et al., 2020). The literature also identifies a gap in scholarship on how program implementation shapes participants' understanding of conservation incentive programs (Calle, 2020; Haenn, 2016; Roche et al., 2021). Interest is also growing in how relational values animate stewardship action among farmers and ranchers (Chapman et al., 2019; Himes and Muraca, 2018; Messick and Serenari, 2023; White et al., 2022). This paper presents the case study of a Bolivian conservation incentive program to examine how one specific aspect of implementation – the approaches and activities of field staff – relates to building stewardship and relational values. It then further reflects on the potential contribution of these efforts to supporting the climate adaptation of smallholder farmers and ranchers.

Relational values include preferences, principles, and virtues about human-nature relationships and are part of an emerging theory of value within environmental sciences literature that is widening the views of values to extend beyond the intrinsic worth of nature itself and the instrumental values of what nature does for humans (Chan et al., 2018). Another dimension of this research is theorizing how relational values provide a key to pluralistic valuation of ecosystem services (Ishihara, 2018). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services defines relational values as,

> …desirable, meaningful, and often reciprocal relationships - beyond means to an end - between humans and nature, and among humans (including across generations) through nature (e.g. sense of place, spirituality, responsibility, care, reciprocity, stewardship). (IPBES, 2022)

The concept of stewardship has a deep multi-disciplinary history and is generally used to describe the careful, wise, and responsible management of something entrusted to one's care. Stewardship is emerging as a boundary-spanning concept that shifts environmental sciences away from, “techno-managerial, control-oriented approaches to landscape and environmental management, policy and planning, towards those that prioritize participatory, cross-scale, and trans-disciplinary engagements rooted in shared values” (Enqvist et al., 2018, pg 18). Research is needed at the intersection of relational values and stewardship, and, in particular, case studies are needed that explore three overlapping dimensions of stewardship – care, knowledge and agency (West et al., 2018).

This paper contributes to this research need by exploring the role of field staff in facilitating the participation of farmers and ranchers in the Watershared conservation program in the Rio Grande-Valles Cruceños area of Bolivia. This case study shows how a relational approach to care-based stewardship is engendered by PES program field staff who are knowledgeable of local needs and are attuned to participants’ agency, care, and knowledge. This allows the conservation program to support stewardship by offering livelihood-relevant materials as incentive for conserving riparian and forest areas, organize collaborations with municipalities to address local livelihood needs, and deliver extension-like services focusing on both grazing improvement and agricultural diversification practices. This paper argues that the dual production of both agricultural livelihoods and ecosystem services is facilitated by the PES program field staff who can translate between local needs, norms, and values and conservation goals. These research results show how field staff for conservation programs can play a critical role in the promotion of relational values that support watershed-scale conservation, as well as potentially building adaptive capacity to climate change risks. The Watershared program suggests a potential pathway to build participants' climate adaptive capacity with the integrated provision of relevant incentive materials, extension-like assistance, and nurturing a change of mental models, behaviors, and socio-ecological assumptions. Field staff, through their approach and activities, promote participants' sense of care and stewardship, knowledge of environmental risks, and the agency to address climate and environmental risks through both individual and collective action.

Watershared and Acuerdos Recipricos de Agua

The Watershared program in Bolivia organizes Reciprocal Watershed Agreements, in Spanish, *Acuerdos Recipricos de Agua* (ARAs). ARAs are offered to *campesinos,* rural farmers and ranchers, who receive in-kind material incentives like irrigation pipe, fencing, bee boxes, fruit trees, and construction supplies in exchange for protecting an agreed-upon area of their land for three years. ARA contracts stipulate that *campesinos* exclude grazing and cropping from riparian areas and halt forest clearing in the conservation area for the length of the contract. In Bolivia's Rio Grande-Valles Cruceños region, these Watershared-designated areas are usually headwater forests, protecting the origin and source of the Rio Grande, a tributary of the Amazon River.

Grazing, cropping, and timber harvesting in these headwaters pose risks of environmental degradation including deforestation, erosion, water pollution, and loss of water sources.

The Watershared program is organized by the non-governmental organization Fundación Natura Bolivia (FNB). FNB was founded in 2003 and, by 2023, the Watershared model had been implemented in 80 municipalities in Bolivia. This effort has resulted in 270,000 water users contributing to funds that incentivize 27,689 families to participate in conserving 623,604 million hectares of forests (FNB 2023). The implementation and development of Watershared is often in collaboration with local municipal governments. The funding sources behind Watershared are an assemblage of water user organizations like water cooperatives and irrigation associations as well as local government and international donors. Although influenced by the theory of PES, Watershared does not use the language of PES in the Bolivian political context, where there is skepticism about market-based conservation (Bétrisey et al., 2018; Hines, 2022; Müller et al., 2013). Watershared emphasizes a focus on social and ecological reciprocity while building funding partnerships with local municipalities and water-user associations to offer in-kind incentives to *campesinos* in exchange for conservation practices to protect the watershed.

Literature Review

The literature review for this paper is framed by three questions: What is Payment for Ecosystem Services (PES)? Can PES support stewardship? Can PES support smallholder climate adaptation?

What is Payment for Ecosystem Services?

Initially Payment for Ecosystem Services (PES) was defined by scholars and environmental economists as a set of voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services (Wunder, 2015). These ecosystem services include provisioning services, regulating services, supporting services, and cultural services (Costanza et al., 1997). Over the past decade, the definition of PES has been adapted to cover a variety of approaches for incentive-based conservation (Shapiro-Garza et al., 2020). PES programs often have dual goals of environmental conservation and socio-economic development (Bauchet et al., 2020) and implement these goals by creating social and economic structures to support conservation in working landscapes (Benra et al., 2022).

For more than a decade, PES has moved from theory to practice around the world (Kaiser et al., 2021). There is currently widespread enthusiasm for PES and similar conservation incentive programs amongst economists, scientists, politicians, and civil society organizations. There is also critique of PES around its ecological effectiveness and its impacts on social justice (Rodríguez-de-Francisco et al., 2019; Shapiro-Garza et al., 2020). As PES programs have been, and continue to be, implemented around the world, the definition of PES has been adapted to cover a variety of approaches for incentive-based conservation (Bauchet et al., 2020). In practice, PES varies around the type of transaction, the ecosystem services targeted, the types of payments utilized, the actors involved and their roles, and in their proposed goals (Sattler and Matzdorf, 2013).

Criticisms of PES have focused on the potential to increase inequality, marginalization, and the alienation of human-ecological relationships (Dunlap and Sullivan, 2020). This alienation is sometimes referred to as the crowding out of intrinsic conservation motivations (Ezzine-de-Blas et al., 2019; Kerr et al., 2013). Another critique of PES is directed at conditionality (Ma et al., 2017), which potentially reduces participation by poorer and more marginalized community members (Muñoz-Piña et al., 2008; Rodríguez-de-Francisco et al., 2019; Vatn, 2010). Marginalization describes both a process and a condition that prevents individuals or groups from full participation in social, economic, and political life, and it derives from exclusionary relationships based on power (Alakhunova et al., 2015). The concern is that the design of PES programs could potentially exacerbate marginalization by benefiting already wealthy and powerful interests while remaining inaccessible or unhelpful for the already marginalized.

The origins of PES are intertwined with a neoliberal economic paradigm that views human-nature relations as a market exchange between ecological service-users and service providers (Pagiola et al., 2007). Geographers have long pointed out that, in practice on the ground, PES programs are often hybridized by local actors and embody a wider range of motivations and values (Shapiro-Garza, 2013). These hybridized PES programs contribute to alternative theorizations of PES that show how the concept is not solely neoliberal because local hybridized programs may strengthen both state regulation and local involvement in ecological management (McElwee et al., 2020; Shapiro-Garza et al., 2020). Scholarship critical of neoliberal conservation points out that human societies' relationships with the non-human world are historically richer and more complex than the idea of nature as an input to production governed by market transactions (Apostolopoulou et al., 2021). Prior transdisciplinary socio-ecological research has identified the need to explore where conservation, restoration, and adaptation require and engender cooperation, collaboration, conviviality, solidarity and care (Martin, 2022; Massarella et al., 2021). A critical reframing of PES as support for stewardship contributes to expanding conservation incentive programs beyond neoliberal framings to include more relational values and world building processes (Fletcher and Büscher, 2020).

Rather than mainly conceptualize PES as a transaction structured around a payment for services, conservation incentive programs can benefit from embracing a multiplicity of local hybridizations that empowers the agency of participants to engage and create local institutions and governance structures. Considering these debates and the growing number of empirical case studies, contemporary PES literature offers an updated definition of PES as, "incentives to align individual and/or collective land-use decisions with the social interest in the management of natural resources" (Bremer et al., 2023; Muradian et al., 2013).

If, as the anthropologist Paige West observed, conservation is our government now, what are the participatory, just, and transformative examples of conservation incentive programs that might take stewardship beyond both fortress and neoliberal conservation (West, 2006)? There are potentially transformative benefits of a locally attuned PES program. One benefit is a collaborative transformation of participants and related institutions. This potential transformation revolves around understanding the human-nature connection more intimately and activating individual and collective power to care for surrounding ecosystems, humans, and more-than-human beings (Agrawal, 2005; Chao and Celermajer, 2023). Another transformative potential for PES is the potential for amplifying local worldviews, knowledges, and values into scaled-up policy through social organizing around PES (Bremer et al., 2023).

Can PES support stewardship?

In PES and stewardship literatures, various scholars have identified the need to better understand the role of knowledge systems, boundary spanners, and translators in adapting PES to local conditions and contexts (Hecken et al., 2019; Joslin, 2020; Robinson et al., 2016). Translators work with ecologists, stakeholders, and decision makers to co-develop research that addresses the sociological, ecological, and political contexts of an environmental problem (Eaton et al., 2022; Enquist et al., 2017). Boundary spanners are institutions, groups, or individuals that bridge the divide between information producers and users (such as ecological scientists and ranchers), enable communication between these two groups, and are accountable to both groups (Safford et al., 2017). Knowledge systems refers to an emerging paradigm that works at the interface of plural ways of knowing the world (Varghese and Crawford, 2021). In addition to academic and scientific knowledge, Indigenous and local knowledge systems include social and ecological understandings, practices and beliefs about the relationship of living beings with one another and their environment (Kimmerer, 2015). Plural knowledge systems are seen as increasingly important to providing theories, methods, and practices for adaptive ecosystem management (Tengö et al., 2017).

These theoretical ideas have found resonance in several published PES and conservation case studies. A recent qualitative study of participants in a Costa Rican PES program emphasized how the program is perceived as “support for stewardship” (Chapman et al., 2020). Despite official program language about PES, local intermediaries seem to have ‘translated’ the program framing into language appropriate for the farmers they worked with, including both the significance of the monetary benefit as well as the purpose for protecting the forest. The Chapman et al. study found that contextual factors such as the municipal government participation and differently scaled (local/national/international) funding opportunities also influenced the ways the program was framed and implemented on the ground. Even without actively translating programs, intermediaries can shape the way farmers perceive PES programs based on existing relationships that provide agricultural extension and assistance. In the Costa Rican case, farmers may have categorized the PES program more with the organization they worked with than with the source of the funding and perceived it as another form of rural development assistance. Chapman and colleagues recommend that future research examine the “work of translation” and what factors impact choices around how to describe the program (Chapman et al., 2020).

Another relevant PES study found that technical assistance and experimentation can facilitate the cultural change needed for ranchers to embrace alternative production practices such as silvopastoral tree planting (Calle, 2020). Calle interviewed ranchers and extension agents in Colombia who collaborated on a Forest Landscape Restoration project. The study concluded that ranchers are not guided exclusively by profit maximization and that personal and environmental concerns also play a role in cattle ranchers’ decision-making. In addition, Calle found an important discrepancy between ranchers and extension agents in their perception about the importance of the PES incentive. Ranchers ranked the payment much lower as a motivation and a preferred incentive for adoption than did extension agents, demonstrating the importance of considering motivations for rancher participation in conservation programs. Non-market motivation highlights the importance of theorizing plural knowledge systems, relational values, and perceptions of stewardship and the potential of post-neoliberal conservation paradigms like conservation basic income and convivial conservation (Fletcher and Büscher, 2020; Krauss, 2021; Massarella et al., 2021). The findings in the Calle study also resonate with insights from North American rangeland social science that assumptions about ranchers' disregard for nature need reexamination because ranchers can be critical partners for the transformation of the existing extensive production model (Brunson and Huntsinger, 2008). The Colombian study also highlights the conceptual and practical connection between changing grazing practices and the field staff who help facilitate the changes. This paper continues this research trajectory by sharing evidence of how field staff play a key role as boundary spanners and translators.

The importance of translation, boundary spanning, and technical assistance are key findings from these two South and Central American studies and this insight tracks with recent findings from research around PES and ranchers in the US. In a study of California rangeland cattle producers' perceptions of PES programs, researchers found that "trust in a market broker was key" (Roche et al., 2021). Another finding comes from early attempts to study the Chicago Carbon Exchange and land-based ecosystem services such as rangeland carbon sequestration. Researchers observed that a key role was that of aggregators: the people who organized the land-based credits and delivered them to a market (LeRoy and Elias, 2022). Discussion about this aggregator role emphasized learning to manage risk and the importance of estimating potential change, realistic measurements, and keeping people informed about market dynamics. The conceptual connection here is that markets are embedded in social and ecological relationships and there are key actors who translate across boundaries to enable conservation incentive programs to work. Another main idea is that the economic activities of PES programs are embedded in historically shaped and politically influenced institutions at the site of implementation. In contrast to neoliberal market fundamentalism, these examples from the translation of theory to practice reflect Polanyi's observations on the social embeddedness of markets (Polanyi, 1944). This embeddedness potentially creates opportunities for the original neoliberal economic theory of PES to be adapted, hybridized, and transformed. The research presented here explores how field staff in the Watershared case study from Bolivia might function as translators, boundary spanners, and trusted conservation brokers while implementing the conservation program.

Can PES support smallholder climate adaptation?

In the literature on rangeland and smallholder[6] climate adaptation, researchers are calling for more direct engagement with unique smallholder and marginalized range communities' climate vulnerabilities (Reid et al., 2021). We need a better understanding of the role that conservation incentive program field staff play in the direct engagement of farmers and ranchers who are trying to practice watershed stewardship and improve rangeland management practices. Research on supporting climate-adapted agriculture

---

[6] While the definition should be context specific, smallholder agriculture generally refers to operations with less than two hectares (5 acres) of land (Bagheramiri and Shaal, 2020).

highlights the importance of local risks and the particular needs and priorities of smallholder farmers (Chandra et al., 2017). While climate change is a global issue, the way it plays out in the lives of smallholder agricultural producers presents unique vulnerabilities (Green et al., 2020). Smallholder farmers' concerns and priorities often come from their situated daily experiences. This can include concerns about livelihoods, land expropriation, gender differences, and responsive governance institutions at all scales. Three social and political processes that exacerbate smallholder farmer vulnerability in the face of climate change are economic inequality, unequal power relations, and social injustice (Islam and Winkel, 2017). Many conservation and climate adaptation initiatives are trying to design their programs to be "pro-poor" and simultaneously address environmental and social development issues. A recent report from the International Institute for Sustainable Development argued that researchers and policymakers concerned with addressing hunger and creating climate-smart agriculture policies should engage directly with smallholder farmers in co-research, planning, and decision-making (Debucque et al., 2020).

Climate change adaptation involves adjusting practices, processes, and responses to the threat of climate change (Adger et al., 2007). Adaptive capacity is theorized as the preconditions that shape people's and institutions' ability to anticipate and respond to perceived or current stresses by mobilizing and managing scarce resources for resilience (Smith et al., 2023). Building adaptive capacity of social systems (households, communities, organizations, and nations) has become an important adaptation effort as groups with greater adaptive capacity are expected to be better positioned to reduce vulnerability to climate change risks (Siders, 2019). Within development literature, scholars have emphasized the need to make PES both “pro-poor and pro-adaptation” (Sand, 2012). One way of addressing this need is to explore how PES programs might build the adaptive capacity of the individuals, households, communities, and ecosystems where they are implemented. At the ecosystem scale, conserving ecosystem functions such as water cycles, soil health, and biodiversity help buffer climate change impacts like drought, heat, and precipitation variability (Wertz-Kanounnikoff et al., 2011).

Methods

Study area

This Watershared case study is located in eastern Bolivia, with data collected in four municipalities in the Department of Santa Cruz: Vallegrande, Postrervalle, Pucara, and Samaipata. Vallegrande is also the name of the biggest city in the four municipalities and is the location of an FNB office where many of the field staff are based. FNB also has an office in the capital city of Santa Cruz where administrative and scientific staff are based. This paper uses “field staff” to refer to the FNB staff who work out of the Vallegrande office and who live and work in the rural communities where the ARA contracts are organized. Staff from the Santa Cruz office often travel to rural communities to help with organization and implementation as well.

Data for this study come from semi-structured interviews (n: 98), two field seasons of participant observation conducted in 2018 and 2019, and a survey (n: 984). A team of US researchers and Bolivian enumerators surveyed 984 Watershared participants and non-participants in person between 2018 and 2021. The survey was first pilot tested in Bolivia by a team that included the author. A Bolivian survey team was then trained and deployed in 2019, using a stratified random sampling design. Despite disruptions during the Covid pandemic, surveying was finished by 2021. Survey data were cleaned and analysis started in 2022. The survey instrument was designed and implemented in conjunction with a Randomized Control Trial (RCT) to evaluate the effect of unconditional PES program design on participation and outcomes (McWherter et al., under review; Bauchet et al., under review). Several of the survey questions and part of the interviews (see below) address this paper's research on the role of FNB field staff in program implementation.

From May to July 2019, the author and two other graduate students conducted 77 semi-structured interviews (34 with Watershared participants, 35 with non-participants, and 8 with other stakeholders and key informants including from judicial, local, and municipal government and FNB field staff who operated across multiple communities). In August 2021, one of the other graduate students completed another 21 interviews with Watershared participants. The interviews took place in nine communities across the four municipalities, with two communities selected per municipality. In total, 90 of the 98 interviews conducted were with community members.

Within each community, the researchers used a combination of purposive and snowball sampling to recruit interviewees who were participants and non-participants in the Watershared program offered in their community. These interviews mostly occurred at interviewees' houses and farms and consisted of an hour-long interview conducted in Spanish. Researchers stopped conducting interviews in each community upon reaching data saturation, when the team assessed that additional interviews did not provide new information or themes.

Participant observation by the author was conducted at two ARA contract signing events known as *entregas,* a field school organized by FNB to train municipal officials in how to implement the ARA model, and implementation site visits organized with FNB administrators and municipal officials. This participant observation included direct observations of field staff interactions with program participants.

Data analysis

This research used thematic and descriptive coding methods to analyze the qualitative data (Tavory and Timmermans, 2013; Timmermans and Tavory, 2012; Vila-Henninger et al., 2022). Themes and categories from PES, relational values, and range management literature were used to create a codebook that guided the coding of interview data content in NVivo software (Saldaña, 2016). All interviews were recorded and then transcribed in the original Spanish, and the authors translated between the Spanish transcripts and the English codebook. Three coders, including the author, used multiple memo and revision cycles to refine the codebook and ensure team inter-coder reliability.

Analysis of the survey data for this paper focused on how participants and non-participants perceived their relationship to FNB field staff and their environment using simple descriptive statistics. Relevant survey questions included perceived climate risks, what sort of knowledge exchange is relevant to their livelihoods, and how they (participants only) relate to the role of field staff in monitoring and extension support. The author used SPSS software to explore and describe survey responses.

Findings

Field staff in the Watershared conservation program engage in three types of activities that facilitate participation of farmers and ranchers to support stewardship and address rural livelihood needs in the Rio Grande-Valles Cruceños area of Bolivia. The first is offering relevant material incentives to *campesinos* while framing the conservation program in a way that is responsive to local values, norms, and needs. The second type of activity is organizing conservation alliances with municipalities to collaboratively address water, grazing, and climate adaptation challenges in local communities. The third type of activity is performing extension-like services with *campesinos* in both grazing improvement strategies and agricultural diversification. When considered as an integrated approach to program facilitation, these three types of activities show how field staff translate and braid together conservation objectives, grazing management, and agricultural practices in the Rio Grande-Valles Cruceños of Bolivia.

Field staff make sure conservation incentives are relevant materials to local livelihoods and program framing is responsive to local values and norms

The Watershared program is framed on the ground by FNB field staff, and then described by participants in the interviews, as emphasizing relational values associated with care, reciprocity, community well-being, and institution-building. The offering of reciprocal watershed agreements to potential participants, as witnessed through participant observation of *entregas*, specifically engaged local relational values such as a desire to be a helpful neighbor and local environmental benefits as important motivations for participation. This framing's resonance with local values is reflected in the survey results where the majority of participants (71%) and half the non-participants (53%) reported trusting that FNB shared their values (Chi square=6.981; p=0.008).

In qualitative interviews, program participating community members described the role of FNB field staff in terms of relationships that support participants' agency and consciousness to steward their watershed. One participant described field staff's monitoring efforts as part of an accompanying relationship that supported their caring labor and stewardship in this way:

> Yes, for three years they [FNB field staff] have accompanied us. We have fulfilled the preferred plan [ARA contract] and now on our own account, we are taking care of our part. Because they have given us some classes, how to conserve, the benefits, so we have already created consciousness and we are also working, protecting [the watershed].[7]

The participant here highlighted their own agency to protect the watershed even after the three-year ARA contract was up. Rather than crowding out motivation, Watershared's facilitation approach appears to amplify the participant's sense of care, agency and knowledge. This description of creating consciousness of caring for water sources was echoed in multiple other interviews. Rather than perceiving an ARA contract as a market exchange, interviewees described ARA as relationship building, training (*capacitación)* and helping (*ayuda*) participants to care (*cuidar*) for their forests and water. In our 98

[7] *Sí, durante tres años nos han acompañado. Ya se ha cumplido el plan que se prefiere y ya nosotros ya por nuestra cuenta, ya cuidamos nuestra parte, ya. Porque nos han dado algunas clases, cómo conservar, los beneficios, así que nosotros ya hemos creado conciencia y estamos trabajando también, protegiendo.*

interviews, the word *cuidar* was used 511 times, *ayuda* was used 453 times, and *capacitación* 289 times. These ways of describing ARA extended to the field staff: one FNB field staff described this process of creating consciousness as learning "to care for what is yours." Described in this consciousness-creating frame, the role of Watershared field staff is to help find ways to care for the forests and watersheds that reciprocally support participants' agency and stewardship.

Likewise, FNB field staff described the material incentives that were given to ARA participants not in terms of their market exchange value but, rather, as help for protecting water sources and improving agricultural production practices. As a member of FNB's field staff said,

> The ARA is framed precisely as conserving a place where there is already forest. That is, you preserve your land with an already existing forest. Why are you going to conserve it? Because we want to prevent the entry of livestock there, prevent clearings in that place, prevent fires or other types of activities that damage that forest. And precisely for this conservation, we give incentives, if that family is a rancher, for example, and their cattle enter that place, and we want to protect, what do we give to that rancher? We give him barbed wire so that he can make his pasture in another place where it will not affect here and we also give him forage seed so that he can have his cows in that other place and not here where it was affecting the watershed.[8]

[8] *Claro, el ARA se va enmarcado precisamente en conservar un lugar que ya hay bosque. O sea, usted conserva su lugar que ya existe bosque. ¿Por qué lo va a conservar? Porque queremos evitar el ingreso de ganado ahí, evitar de que existan desmontes en ese lugar, evitar de que existan incendios u otros tipos de actividades que fregue a ese bosque. Y precisamente por esa conservación, nosotros le damos incentivos, si es un ganadero esa familia por ejemplo y su ganado ingresa a ese lugar, y queremos proteger, ¿qué le damos nosotros a ese ganadero? Le damos alambre para que él pueda hacer su pastizal en otro lugar donde no sea muy afectado acá y le damos también semilla forrajera o algo de forrajero, para que en ese lugar tenga sus vacas y no acá donde estaba afectando a la toma de agua, por ejemplo.*

Participants also described how their conservation actions and the material incentives involved in ARA help their neighbors and community to participate as well:

> I really like that there is participation. It's like if other people see a person participating, and they're not there yet, I have to be there so that other people will become interested and take note that they also can get this help.[9]

While the framing around local values is important, the incentive materials are also important because they address the livelihood and conservation needs of participants. When asked why people want to participate, one participant emphasized the practical benefits for their agricultural livelihoods:

> …Because people want to get the plants (fruit tree starts), they want to get wire to fence off the place where they are going to put bees, fence off where they will plant fruit trees. These plants will do well if protected, if the cows can't enter to step on it or knock it down.[10]

The use value is a compelling aspect of the incentive materials that functions well with field staff's repeated community visits. Allowing space for people to change their minds when they see their neighbors participating and receiving incentive materials creates expanded opportunities to join Watershared. One participant shared this story:

> What happens is that here in the community, when the (FNB field staff) technician comes to give a talk about the project, some are not interested. They tell him that they are not interested and also that they don't want to take steps to protect his watershed or his forest. But when the material arrives, they say: "Why didn't I get in? [laughs]. Why didn't you put me in? They didn't put me in," and sometimes he himself is the one who didn't want to. But when he sees it, the material is being distributed, his eyes are already shining to see it, the material being delivered there, right?[11]

---

[9] *Porque me gusta, me agrada mucho que haya la participación, así también otra gente ven a una persona, pero si está ya-- ya no puede estar, no, yo tengo que estar para que así otra persona también tenga interés y se haga notar, que tengan esa ayuda.*

[10] *Porque ellos querían que les den las plantas, que les den el alambre para que encierren el lugar donde iban a poner las abejas, encierren la parte que iban a poner las plantas. Porque la planta es bien que no lo toque nada, porque si no la vaquita entra, lo pisa, lo tumba.*

[11] *Lo que pasa es que también aquí en la comunidad, cuando viene el técnico a hacer la charla para entrar al proyecto, medio que no le toma interés, no. Le digo que no le*

Another participant described both the materials and the conservation workshops offered by FNB field staff as collaboration with the local municipal government that yielded both immediate and future environmental benefits. This description of longer ecological timeframes shows how reciprocal and relational values are understood between participants, implementing institutions, local watersheds, and future generations:

> We have gone through forest conservation workshops a little bit, they have given us workshops like that. And also the Natura project through the agreement with the mayor's office, there are projects where in exchange for conserving a quantity of hectare or slope, they give us help; whether in wire, in pipes, polytube, all that and we have to conserve this land. There is level one, level two that have entered the area where I have also benefited from watershed conservation, there in the community of San Marcos, yes. I like to conserve the slopes, perhaps the vegetation or trees like that, where it is not necessary not to cut down indiscriminately, because well, it takes hundreds and hundreds of years for a tree to grow and to cut it down, dismantle it discriminately without making good use of it, a good management plan, I think it is not fair. I am of that criterion of taking a little care of the vegetation and the springs, because they are the water supply for the future, right?[12]

---

toman interés y también de que no quiere cumplir a veces a proteger su cuenca o su bosque. Pero ya cuando llega el material ahí dice: "¿Por qué yo meter? [risas]. ¿Por qué no me pusiste? No me pusieron a mí", y a veces él mismo es el que no quiere, Pero ya cuando lo ve que se está repartiendo el material, ya le brillan los ojos por verlo, el material ahí entregándose, ¿no?

[12] *Bueno. Nosotros un poquito hemos pasado talleres de conservación de bosques, nos han dado talleres así. Y también el proyecto Natura por medio del convenio con la alcaldía, hay proyectos donde uno a cambio de conservar una cantidad de hectárea o vertiente, nos dan una ayuda; ya sea en alambre, en cañerías, politubo, todo eso y tenemos que conservar este terreno. Hay el nivel uno, nivel dos que han entrado a la zona donde yo he sido beneficiado también con conservación de vertientes, allá en la comunidad de San Marcos, sí. A mí me gusta conservar lo que es las vertientes, tal vez la vegetación o los árboles así, a donde no es necesario no talar indiscriminadamente, porque bueno, son cientos y cientos de años donde tarda para crecer una árbol y para talarlo, desmontarlo discriminadamente sin hacerle un buen uso, un buen plan de manejo, creo que no es justo. Yo soy de ese criterio de un poquito cuidar lo que es la vegetación y las vertientes, porque en ellas está el abastecimiento de agua para el futuro, ¿no?*

While the framing of ARA contracts and material incentives are important, researchers also observed instances of FNB field staff making important contributions to equitable and inclusive participation. At one ARA contract signing event (*entrega)*, several of the participants did not have vehicles to bring their irrigation tubing back to their crop fields. FNB field staff were able to accommodate this need by providing trucks as well as GPS elevation data to make sure the tubing was deployed in the right location so water would flow to the participants' crops. These sort of field details were observed as a larger pattern of reciprocity and accompaniment between participants and FNB staff that address potential inequities in the program implementation such as lack of vehicles. Another example from an *entrega* highlights how field staff contribute to gender equity outcomes. At the *entrega,* a representative from the municipality was mistakenly describing a female participant using the common pronoun "*El"* which refers to a man. A young female FNB field staffer jumped up to the mic, exclaiming, "*Ella*!", prompting the crowd to recognize the agency of the female participant. These sorts of everyday field staff actions potentially help expand participation recognition to include people whose experiences with marginalization, such as through gender and wealth inequality, might have otherwise limited their participation.

Field staff organize partnerships with municipalities to collaboratively address water, grazing, and climate adaptation challenges in local communities

Participant observation in 2019 demonstrated how FNB staff engaged both rural communities and municipal governments in local water politics and water development. In one example, a female *Alcaldia* (Mayor) was contacted by another female leader from a rural community. The community leader asked the *Alcaldia* for help to develop a drinking water source because children were getting sick from agricultural pollution in the community's only water source. The *Alcaldia* then approached FNB staff, who then approached a large landowner where a water source is located and organized an atypical "ARA" and the logistics of an 80 km water pipeline. The FNB field staff in this situation were thrust into local development politics and, in this case, successfully found a win-win arrangement and also labeled it ARA. In this interaction, participant observation documented how the action of the field staff made it possible for the local community to engage the PES program and municipal partners with social organizing that resulted in obtaining material benefits to their community.

However, FNB staff are not always successful in negotiating local water politics. In another example, multiple individuals described how a wealthy landowner's cattle were defecating in a different town's drinking water intake and making people sick downstream. Although there were several attempts to negotiate an ARA to exclude cattle from the intake area, the landowner refused. Local interviewed residents described how the landowner's son was a wealthy lawyer for a large supermarket chain in the capital Santa Cruz and they felt powerless to change the situation. Even though the Watershared program has many successes, the difficulties of land, wealth, and power inequality still can limit field staff action and shape outcomes, showing continued challenges to the ARA approach.

Researcher observation of *entregas* showed ongoing efforts to build relationships between FNB and local municipal governments. These local relationships potentially add to ARA's legitimacy as well as create additional funding opportunities. Data from the survey showed that ARA participants (31%) were significantly more likely to report trust in municipal government to deliver on promises when compared to non-participants (24%) (Chi square=5.246; p=0.022). Interviews with FNB staff showed that they are savvy both in their interpersonal relationships and program designs that engage local municipal governments.

Survey data and participant observation of Watershared's collaboration with municipalities showed a desire to connect the intertwined issues of watershed management and climate adaptation. About half of the survey respondents (46%) reported losing crops due to drought or flood in the previous season and, of those with cattle, 23% reported not having enough water for the cattle. Twelve of the interviews were coded for mentioning challenges with increasing climate variability. These interviewees talked about changing planting dates, a loss of water sources, and increases in heat. One interviewee specifically mentioned how Watershared participation mitigated the impact of drought and floods because the program helped keep watershed forests intact.[13] Researchers observed field staff engaged in a relevant collaboration between Watershared and local municipalities to jointly fund irrigation water developments. The municipality provided heavy equipment to construct ponds (*atejados)*, while Watershared organized ARAs to provide *campesinos* with irrigation infrastructure like polytubes and sprinkler heads. This joint funding and project development addressed material needs associated with increased climate variability.

---

[13] *"Al margen de que nosotros estamos cuidando, ahorita hay escasez de agua, porque es peor si hubiéramos chaqueado, más hubiera sido."*

Field staff perform extension-like services with campesinos in both grazing improvement strategies and agricultural diversification

Analysis of the interview data indicates that monitoring associated with ARA contracts is perceived as part of an ongoing relationship with FNB field staff that also includes knowledge exchange and engagement with the social networks associated with municipal government and rural development agencies. Researchers observed that participants valued the relationships to FNB field staff because they informally function as agro-ecological extension agents. Field staff helped answer technical questions and connected participants to agricultural resources like rabies vaccination clinics and other governmental assistance like water infrastructure development programs. Our interview data show examples of how participants perceived field staff monitoring as part of relationship building and accountability:

> [The technician] follows us up. We have to take care [of the forest], not cut, not burn. We are caring [for the land]. [The technician] comes and sees. They see the land, the hill, the waters, and everything. They check everything and see if we are taking care of the forest or the water… if it is true or if we are lying.[14]

Other interviewed participants connected the importance of monitoring to preventing water resource degradation based on their own experience: "[Monitoring] is very

---

[14] *Sí, nos hace seguimiento. Tenemos que-- él nos da seguimiento y tenemos que cuidar y no chaquear, no quemar, no--. Nos da seguimiento Natura [risas]. Está cuidando, está cuidando, viene y ve, él ve las tierras, el cerro, las aguas, todo. Va y ve todito y mira. Si estamos cuidando el bosque o el agua, y va y mira si estamos cuidando, si es verdad o es que les mentimos. Ellos van y miran así a los cerros, a las montañas.*

important, because before we cut all over the riverbank. We didn't know until they (FNB) talked about this and gave us workshops".[15]

These extension-like services play an important role because the field staff help participants see how their activities are linked together to achieve landscape-scale impacts on watershed functionality. Survey respondents report learning the most from FNB field staff about forest and watershed management (Table 7). This survey result tracks our findings from the interview data where participants describe their mental model of the local ecosystem and how their agricultural activity affects the landscape health. One of the most common themes in the interview data was the importance of refraining from clearing vegetation from landscapes near water sources, which was often described as *vertientes or cuencas de agua.*

Table 7: What did surveyed participants report learning from FNB field staff?

	Percent of participants who reported learning (n=196)
Forest management	73%
Watershed management	73%
Livestock management	16%
Irrigation management	21%
Climate change	14%
Beekeeping	7%

[15] *Fue bien importante, porque antes -como le digo- chaqueábamos por toda la orilla del río. No sabía uno [inaudible] hacía [inaudible] han hablado de eso, nos han pasado talleres y bien.*

Discussion

The findings in this study show how supporting both ecosystem services provision and agricultural livelihoods is facilitated by on-the-ground PES program field staff who are able to translate between local needs, norms, and values and conservation goals. Rather than emphasizing a transactional exchange for the market value of an ecosystem service, evidence from this study shows an emphasis on the reciprocal relationships between participants and their watershed as well as participants and Watershared field staff. Framing that emphasizes reciprocal support for stewardship and incentives that meet local needs are examples of how a conservation incentive program is able to adapt and be responsive to local values and conditions.

Watershared's field staff organize Reciprocal Watershed Agreements by braiding together knowledge of local agricultural livelihoods and landscape-scale conservation needs. A main landscape-scale conservation challenge in the Rio Grande-Valles Cruceños area is to reduce watershed degradation due to land clearing and overgrazing in the headwater areas known as *cuencas de agua.* In this region, there are protected areas such as national parks and 'integrated management areas' with land use restrictions. There is also a significant amount of private land that can also play an important role in working lands conservation, with 96% of Watershared participants and 83% of non-participants reporting private individual land titles (see Article 1). Understanding local livelihoods and how the Watershared program can help meet their needs is enabled by field staff who deeply understand both the land and the people in this area. Field staff are often themselves from these communities, and their day-to-day jobs keep staff in constant contact with community needs. Our findings show that this contact happens during monitoring visits, community events like *entregas,* and workshops where staff are delivering extension-like services. Field staff knowledge about local livelihood needs means that FNB is able to offer livelihood-relevant material as incentive for conserving riparian and forest areas, organize collaborations with municipalities to address local livelihood needs, and deliver extension-like services focusing on both grazing improvement and agricultural diversification practices. These organizational strategies, made possible by the activities of the field staff, build local relationships and validate local stewardship norms of care and reciprocity. These findings support the idea that field staff for various conservation programs can play a critical role in the promotion of relational values that support watershed-scale conservation, as well as potentially build the capacity to adapt local communities to climate change risks. This paper describes this multifaceted strategy as a relational approach to care-based stewardship.

One of the main implications of our findings is the importance of relationships that support participants' agency and consciousness to steward their watershed. Monitoring associated with Watershared participation was perceived as part of an ongoing relationship to the FNB field staff that also includes care, knowledge exchange, and engagement with the social and political networks associated with municipal government and rural development agencies. Our participant observation found that rural communities are engaging both local municipalities and the Watershared program in ways that require FNB staff to navigate the local politics of water development and governance. The skill and strategic judgment required by field staff to navigate local politics successfully is an area of study that needs more attention because understanding how to build staff's social and political finesse is a potential way to expand the impact of conservation incentive programs.

Watershared's approach to organizing a conservation incentive program shows possibilities of where it can also help participants build adaptive capacity to climate change. Climate change poses unique risks to small scale farmers and ranchers that are exacerbated by social and historical marginalization. The risks in this study area to smallholder agricultural livelihoods include increasing droughts, floods, fire, decreasing crop production, and heat stress to animals and people. Livelihood diversification is a potential climate resilience strategy to spread out risk and nurture multiple income streams. Watershared incentive materials such as fruit trees and bee boxes are ways to support participants diversifying their household income stream. Incentives materials that reduce drought and flood risk could potentially also have an important impact on building climate adaptation capacity at the household level. Findings from participant observation and interviews show how this capacity is ecological, agricultural, and social. For example, conserving a headwater riparian area could mean reducing stormwater scour and erosion due to sturdy vegetative cover that reduces the velocity of stormwater. Watershared's support to develop irrigation and drinking water systems can help smallholders adapt crop and livestock production to face increasing drought risk. Finally, conservation collaboratives that involve material incentives can also build social networks between individuals, households, NGOs, and local governments that contribute to place-based understandings of climate risks and potential adaptation actions.

There is a need to design PES programs so that incentive materials and co-produced knowledge about agricultural resilience is prioritized. Conservation incentive programs have the potential to help build local capacity to adapt to climate change by employing field staff who understand local livelihood needs and can provide material incentives that address unique climate risks and vulnerabilities. Evidence in this study shows how Watershared works to build relationships between participants, NGOs, and local municipalities. These relationships build adaptive capacity because participants better understand the resources that are available to help like irrigation infrastructure, crop diversification, and improving ecosystem functionality. Supporting participants' knowledge about environmental and climate change risks is another way that PES programs can address adaptive capacity in addition to promoting the conservation of ecosystem functions like intact forests that assist in a healthy water cycle. Only 15% of participants reported learning about climate change from FNB, and this topic of climate change adaptation is an area where the program could continue to grow. Despite strong positions on climate and environmental issues, the national Bolivian budget is not currently prioritizing climate adaptation (Sanchez et al 2023). If central governments are doing little to support local climate adaptation efforts, programs like Watershared are an alternative way to build local adaptive capacity.

This case study provides insight into these adaptive capacity issues by exploring how Watershared field staff facilitate participation and engagement across scales from individual, household, community, to watershed. PES projects benefit from local field staff who practice relationship building that empowers the agency of participants to engage and create local institutions and governance structures. By analyzing qualitative interviews, survey data, and participant observation with local level field staff in the Watershared conservation program, it documents a relational approach to care-based stewardship. The findings illuminate how field staff navigate and braid together knowledge of local agricultural livelihood needs and knowledge of landscape-scale conservation needs. This analysis addresses a broader issue about how to design and organize effective, just, and transformational conservation incentive programs. Findings in this study suggest that field staff play a unique role in the promotion of relational values that support watershed-scale conservation as well as building participating farmers and ranchers' capacity to adapt to climate change risks. The Watershared program demonstrates a potential pathway to build participants' climate adaptive capacity with the integrated provision of conservation incentive materials, extension assistance, and nurturing a change of mental models, behaviors, and socio-ecological assumptions. Field staff, through their approach and activities, promote participants' sense of care and stewardship, knowledge of environmental risks, and the agency to address climate and environmental risks through both individual and collective action.

Transdisciplinary scholars increasingly are demonstrating the importance of collaborative translational relationships between scientists, farmers, and ranchers in achieving multi-functional agricultural and conservation objectives (Kennedy and Brunson, 2007; Reid et al., 2021; Wilmer et al., 2021). The knowledge dimension of stewardship benefits from empowering knowledge co-production that braids local livelihood needs, economic diversification, analysis of power (marginalization, gender, inequality), and adaptive capacity to climate change. Field staff who understand local livelihoods, norms, and values are in a unique position to co-produce hybrid PES designs that address multi-functional needs and nurture a participatory sense of stewardship that amplifies care, pluralistic knowledge, and agency (Galarza-Villamar et al., 2024).

Conclusion

How PES programs are implemented, including the role of field staff in that implementation, shapes participants' understanding of the relational values embodied in a conservation incentive program and whether PES is payment for services or support for stewardship. Using data from a survey, interviews, and participant observation, this research explored how case study field staff facilitate the participation of farmers and ranchers in the Watershared conservation program in the Rio Grande-Valles Cruceños area of Bolivia. The main argument is that a relational approach to care-based stewardship is engendered by PES program field staff attuned to local needs, agency, care, and knowledge.

PES field staff support stewardship by providing the translation work necessary for the organization to offer livelihood-relevant materials as incentive for conserving riparian and forest areas, organizing collaborations with municipalities to address local livelihood needs, and delivering extension-like services focusing on both grazing improvement and agricultural diversification practices. This case study shows how field staff for conservation programs can play a critical role in the promotion of relational values that support watershed-scale conservation, as well as build the capacity to adapt local communities to climate change risks. More attention is needed to understand how relational values are expressed within communities and how external efforts to promote environmental conservation may interact with these relational values.

References

Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit, B., Takahashi, K., 2007. Assessment of adaptation practices, options, constraints and capacity., Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribition of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Agrawal, A., 2005. Environmentality, Technologies of Government and the Making of Subjects 201–230. https://doi.org/10.1515/9780822386421-009

Alakhunova, N., Diallo, O., Campo, del, M., I., Tallarico, &, W., 2015. Defining marginalization: An assessment tool. George Washington University: Elliot School of International Affairs & the World Fair Trade Organization-Asia.

Apostolopoulou, E., Chatzimentor, A., Maestre-Andrés, S., Requena-i-Mora, M., Pizarro, A., Bormpoudakis, D., 2021. Reviewing 15 years of research on neoliberal conservation: Towards a decolonial, interdisciplinary, intersectional and community-engaged research agenda. Geoforum 124, 236–256. https://doi.org/10.1016/j.geoforum.2021.05.006

Bagheramiri, Z., Shaal, F.K., 2020. Zero Hunger. Encycl Un Sustain Dev Goals 775–786. https://doi.org/10.1007/978-3-319-95675-6_47

Bauchet, J., Asquith, N., Ma, Z., Radel, C., Godoy, R., Zanotti, L., Steele, D., Gramig, B.M., Chong, A.E., 2020. The practice of Payments for Ecosystem Services (PES) in the Tropical Andes: Evidence from program administrators. Ecosyst Serv 45, 101175. https://doi.org/10.1016/j.ecoser.2020.101175

Bauchet, J., Ma, Z., Radel, C., Zanotti, L., McWherter, B. Godoy, R. Under review. Support, don't coerce: Impacts of unconditional Payments for Ecosystem Services. Science.

Benra, F., Nahuelhual, L., Felipe-Lucia, M., Jaramillo, A., Bonn, A., Jullian, C., 2022. Balancing ecological and social goals in PES design – Single objective strategies are not sufficient. Ecosyst Serv 53, 101385. https://doi.org/10.1016/j.ecoser.2021.101385

Bétrisey, F., Bastiaensen, J., Mager, C., 2018. Payments for ecosystem services and social justice: Using recognition theories to assess the Bolivian Acuerdos Recíprocos por el Agua. Geoforum 92, 134–143. https://doi.org/10.1016/j.geoforum.2018.04.001

Bremer, L.L., Nelson, S., Jackson, S., Izquierdo-Tort, S., Lansing, D., Shapiro-Garza, E., Echavarría, M., Upton, C., Asquith, N., Isyaku, U., Asiyanbi, A., He, J., Pascual, U., 2023. Embedding local values in Payments for Ecosystem Services for transformative change. Curr. Opin. Environ. Sustain. 64, 101354. https://doi.org/10.1016/j.cosust.2023.101354

Brunson, M.W., Huntsinger, L., 2008. Ranching As A Conservation Strategy: Can Old Ranchers Save The New West? Rangeland Ecol Manag 61, 137–147. https://doi.org/10.2111/07-063.1

Calle, A., 2020. Partnering with cattle ranchers for forest landscape restoration. Ambio 49, 593–604. https://doi.org/10.1007/s13280-019-01224-8

Celermajer, D., Schlosberg, D., Rickards, L., Stewart-Harawira, M., Thaler, M., Tschakert, P., Verlie, B., Winter, C., 2021. Multispecies justice: theories, challenges, and a research agenda for environmental politics. Environ Polit 30, 119–140. https://doi.org/10.1080/09644016.2020.1827608

Chandra, A., McNamara, K.E., Dargusch, P., 2017. The relevance of political ecology perspectives for smallholder Climate-Smart Agriculture: a review. J Political Ecol 24, 821–842. https://doi.org/10.2458/v24i1.20969

Chan, K.M., Gould, R.K., Pascual, U., 2018. Editorial overview: Relational values: what are they, and what's the fuss about? Curr Opin Env Sust 35, A1–A7. https://doi.org/10.1016/j.cosust.2018.11.003

Chao, S., Celermajer, D., 2023. Introduction to Multispecies Justice. Cultural Politics 19.

Chapman, M., Satterfield, T., Chan, K.M.A., 2019. When value conflicts are barriers: Can relational values help explain farmer participation in conservation incentive programs? Land Polic. 82, 464–475. https://doi.org/10.1016/j.landusepol.2018.11.017

Chapman, M., Satterfield, T., Wittman, H., Chan, K.M.A., 2020. A payment by any other name: Is Costa Rica's PES a payment for services or a support for stewards? World Dev 129, 104900. https://doi.org/10.1016/j.worlddev.2020.104900

Costanza, R., d'Arge, R., Groot, R. de, Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., Belt, M. van den, 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260. https://doi.org/10.1038/387253a0

Debucque, D.L., Murphy, S., Parent, M., Porciello, J., Smaller, C., 2020. Ceres2030: Sustainable Solutions to End Hunger. International Institute for Sustainable Development.

Dunlap, A., Sullivan, S., 2020. A faultline in neoliberal environmental governance scholarship? Or, why accumulation-by-alienation matters. Environ Plan E Nat Space 3, 552–579. https://doi.org/10.1177/2514848619874691

Eaton, W.M., Burnham, M., Robertson, T., Arbuckle, J.G., Brasier, K.J., Burbach, M.E., Church, S.P., Hart-Fredeluces, G., Jackson-Smith, D., Wildermuth, G., Canfield, K.N., Córdova, S.C., Chatelain, C.D., Fowler, L.B., Hendawy, M.M.Z. elAbdeen, Kirchhoff, C.J., Manheim, M.K., Martinez, R.O., Mook, A., Mullin, C.A., Murrah-Hanson, A.L., Onabola, C.O., Parker, L.E., Redd, E.A., Schelly, C., Schoon, M.L., Sigler, W.A., Smit, E., Huysen, T. van, Worosz, M.R., Eberly, C., Rogers, A., 2022. Advancing the scholarship and practice of stakeholder engagement in working landscapes: a co-produced research agenda. Socio-ecological Pract Res 4, 283–304. https://doi.org/10.1007/s42532-022-00132-8

Enquist, C.A., Jackson, S.T., Garfin, G.M., Davis, F.W., Gerber, L.R., Littell, J.A., Tank, J.L., Terando, A.J., Wall, T.U., Halpern, B., Hiers, J.K., Morelli, T.L., McNie, E., Stephenson, N.L., Williamson, M.A., Woodhouse, C.A., Yung, L., Brunson, M.W., Hall, K.R., Hallett, L.M., Lawson, D.M., Moritz, M.A., Nydick, K., Pairis, A., Ray, A.J., Regan, C., Safford, H.D., Schwartz, M.W., Shaw, M.R., 2017. Foundations of translational ecology. Front Ecol Environ 15, 541–550. https://doi.org/10.1002/fee.1733

Enqvist, J.P., West, S., Masterson, V.A., Haider, L.J., Svedin, U., Tengö, M., 2018. Stewardship as a boundary object for sustainability research: Linking care, knowledge and agency. Landscape Urban Plan 179, 17–37. https://doi.org/10.1016/j.landurbplan.2018.07.005

Ezzine-de-Blas, D., Corbera, E., Lapeyre, R., 2019. Payments for Environmental Services and Motivation Crowding: Towards a Conceptual Framework. Ecol Econ 156, 434–443. https://doi.org/10.1016/j.ecolecon.2018.07.026

Fletcher, R., Büscher, B., 2020. Conservation basic income: A non-market mechanism to support convivial conservation. Biol Conserv 244, 108520. https://doi.org/10.1016/j.biocon.2020.108520

Frietsch, M., Loos, J., Löhr, K., Sieber, S., Fischer, J., 2023. Future-proofing ecosystem restoration through enhancing adaptive capacity. Commun. Biol. 6, 377. https://doi.org/10.1038/s42003-023-04736-y

Galarza-Villamar, J.A., McCampbell, M., Agyekumhene, C., Asingizwe, D., Attoh, E.M.N.A.N., Damtew, E., Chepkwony, R., Cieslik, K., Munthali, N., Murindahabi, M.M., Mutavi, F., Nyamekye, A.B., Tafesse, S., Struik, P.C., Leeuwis, C., 2024. The role of connective interventions in the collective management of public-bad problems: Evidence from a socio-ecological system perspective. NJAS: Impact Agric. Life Sci. 96, 2293846. https://doi.org/10.1080/27685241.2023.2293846

Green, L., Schmook, B., Radel, C., Mardero, S., 2020. Living Smallholder Vulnerability: The Everyday Experience of Climate Change in Calakmul, Mexico. J Lat Am Geogr. https://doi.org/10.1353/lag.0.0129

Haenn, N., 2016. The Middle-Class Conservationist: Social Dramas, Blurred Identity Boundaries, and Their Environmental Consequences in Mexican Conservation. Curr Anthropol 57, 197–218. https://doi.org/10.1086/685728

Hecken, G.V., Merlet, P., Lindtner, M., Bastiaensen, J., 2019. Can Financial Incentives Change Farmers' Motivations? An Agrarian System Approach to Development Pathways at the Nicaraguan Agricultural Frontier. Ecol Econ 156, 519–529. https://doi.org/10.1016/j.ecolecon.2016.12.030

Himes, A., Muraca, B., 2018. Relational values: the key to pluralistic valuation of ecosystem services. Curr Opin Env Sust 35, 1–7. https://doi.org/10.1016/j.cosust.2018.09.005

Hines, S., 2022. Water for All: Community, Property, and Revolution in Modern Bolivia. University of California Press, Oakland, CA.

IPBES. 2022. Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Balvanera, P., Pascual, U., Christie, M., Baptiste, B., and González-Jiménez, D. (eds.). IPBES secretariat, Bonn, Germany. DOI: https://doi.org/10.5281/zenodo.6522522

Ishihara, H., 2018. Relational values from a cultural valuation perspective: how can sociology contribute to the evaluation of ecosystem services? Curr. Opin. Environ. Sustain. 35, 61–68. https://doi.org/10.1016/j.cosust.2018.10.016

Islam, N., Winkel, J., 2017. Climate Change and Social Inequality. https://doi.org/10.18356/2c62335d-en

Joslin, A., 2020. Translating Water Fund Payments for Ecosystem Services in the Ecuadorian Andes. Dev Change 51, 94–116. https://doi.org/10.1111/dech.12542

Kaiser, J., Haase, D., Krueger, T., 2021. Payments for ecosystem services: a review of definitions, the role of spatial scales, and critique. Ecol Soc 26. https://doi.org/10.5751/es-12307-260212

Kennedy, C.A., Brunson, M.W., 2007. Creating a Culture of Innovation in Ranching A study of outreach and cooperation in west-central Colorado. Rangelands 29, 35–40. https://doi.org/10.2111/1551-501x(2007)29[35:cacoii]2.0.co;2

Kerr, J., Vardhan, M., Jindal, R., 2013. Incentives, conditionality and collective action in payment for environmental services. Int J Commons 8, 595–616. https://doi.org/10.18352/ijc.438

Kimmerer, R.W., 2015. Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants. Milkweed Editions.

Krauss, J.E., 2021. Decolonizing, conviviality and convivial conservation: towards a convivial SDG 15, life on land? J Political Ecol 28. https://doi.org/10.2458/jpe.3008

LeRoy, S., Elias, E., 2022. Rangeland and Climate Adaptation. Come Rain or Shine.

Lliso, B., Pascual, U., Engel, S., Mariel, P., 2020. Payments for ecosystem services or collective stewardship of mother earth? Applying deliberative valuation in an indigenous community in Colombia. Ecol Econ 169, 106499. https://doi.org/10.1016/j.ecolecon.2019.106499

Loos, J., Benra, F., Berbés-Blázquez, M., Bremer, L.L., Chan, K.M.A., Egoh, B., Felipe-Lucia, M., Geneletti, D., Keeler, B., Locatelli, B., Loft, L., Schröter, B., Schröter, M., Winkler, K.J., 2023. An environmental justice perspective on ecosystem services. Ambio 52, 477–488. https://doi.org/10.1007/s13280-022-01812-1

Ma, Z., Bauchet, J., Steele, D., Godoy, R., Radel, C., Zanotti, L. 2017. Comparison of Direct Transfers for Human Capital Development and Environmental Conservation. World Development, Volume 99, Pages 498-517, ISSN 0305-750X. https://doi.org/10.1016/j.worlddev.2017.05.030.

Martin, L.J., 2022. Wild By Design: The Rise of Ecological Restoration. Harvard University Press, Cambridge, MA. https://doi.org/10.5822/978-1-61091-599-1

Massarella, K., Nygren, A., Fletcher, R., Büscher, B., Kiwango, W.A., Komi, S., Krauss, J.E., Mabele, M.B., McInturff, A., Sandroni, L.T., Alagona, P.S., Brockington, D., Coates, R., Duffy, R., Ferraz, K.M.P.M.B., Koot, S., Marchini, S., Percequillo, A.R., 2021. Transformation beyond conservation: how critical social science can contribute to a radical new agenda in biodiversity conservation. Curr Opin Env Sust 49, 79–87. https://doi.org/10.1016/j.cosust.2021.03.005

McElwee, P., Fernández-Llamazares, Á., Aumeeruddy-Thomas, Y., Babai, D., Bates, P., Galvin, K., Guèze, M., Liu, J., Molnár, Z., Ngo, H.T., Reyes-García, V., Chowdhury, R.R., Samakov, A., Shrestha, U.B., Díaz, S., Brondízio, E.S., 2020. Working with Indigenous and local knowledge (ILK) in large-scale ecological assessments: Reviewing the experience of the IPBES Global Assessment. J Appl Ecol 57, 1666–1676. https://doi.org/10.1111/1365-2664.13705

McWherter, B., Munger, W., Ma, Z., Radel, C., Zanotti, L., Bauchet, J., Godoy, R. Under review. The unexpected role of conditionality in promoting relational values: Evidence from a Bolivian incentive-based conservation program. World Development.

Messick, J.A., Serenari, C., 2023. Investigating how relational values influence landowner participation in an endangered species conservation program. J. Environ. Plan. Manag. ahead-of-print, 1–19. https://doi.org/10.1080/09640568.2023.2285728

Müller, R., Pistorius, T., Rohde, S., Gerold, G., Pacheco, P., 2013. Policy options to reduce deforestation based on a systematic analysis of drivers and agents in lowland Bolivia. Land Use Policy 30, 895–907. https://doi.org/10.1016/j.landusepol.2012.06.019

Muñoz-Piña, C., Guevara, A., Torres, J.M., Braña, J., 2008. Paying for the hydrological services of Mexico's forests: Analysis, negotiations and results. Ecol Econ 65, 725–736. https://doi.org/10.1016/j.ecolecon.2007.07.031

Muradian, R., Arsel, M., Pellegrini, L., Adaman, F., Aguilar, B., Agarwal, B., Corbera, E., Blas, D.E. de, Farley, J., Froger, G., Garcia-Frapolli, E., Gómez-Baggethun, E., Gowdy, J., Kosoy, N., Coq, J.F.L., Leroy, P., May, P., Méral, P., Mibielli, P., Norgaard, R., Ozkaynak, B., Pascual, U., Pengue, W., Perez, M., Pesche, D., Pirard, R., Ramos-Martin, J., Rival, L., Saenz, F., Hecken, G., Vatn, A., Vira, B., Urama, K., 2013. Payments for ecosystem services and the fatal attraction of win-win solutions. Conserv. Lett. 6, 274–279. https://doi.org/10.1111/j.1755-263x.2012.00309.x

Pagiola, S., Ramírez, E., Gobbi, J., Haan, C. de, Ibrahim, M., Murgueitio, E., Ruíz, J.P., 2007. Paying for the environmental services of silvopastoral practices in Nicaragua. Ecol Econ 64, 374–385. https://doi.org/10.1016/j.ecolecon.2007.04.014

Polanyi, K., 1944. The Great Transformation. Beacon Press, New York.

Provost, G.L., Schenk, N.V., Penone, C., Thiele, J., Westphal, C., Allan, E., Ayasse, M., Blüthgen, N., Boeddinghaus, R.S., Boesing, A.L., Bolliger, R., Busch, V., Fischer, M., Gossner, M.M., Hölzel, N., Jung, K., Kandeler, E., Klaus, V.H., Kleinebecker, T., Leimer, S., Marhan, S., Morris, K., Müller, S., Neff, F., Neyret, M., Oelmann, Y., Perović, D.J., Peter, S., Prati, D., Rillig, M.C., Saiz, H., Schäfer, D., Scherer-Lorenzen, M., Schloter, M., Schöning, I., Schrumpf, M., Steckel, J., Steffan-Dewenter, I., Tschapka, M., Vogt, J., Weiner, C., Weisser, W., Wells, K., Werner, M., Wilcke, W., Manning, P., 2023. The supply of multiple ecosystem services requires biodiversity across spatial scales. Nat. Ecol. Evol. 7, 236–249. https://doi.org/10.1038/s41559-022-01918-5

Reid, R.S., Fernández-Giménez, M.E., Wilmer, H., Pickering, T., Kassam, K.-A.S., Yasin, A., Porensky, L.M., Derner, J.D., Nkedianye, D., Jamsranjav, C., Jamiyansharav, K., Ulambayar, T., Oteros-Rozas, E., Ravera, F., Bulbulshoev, U., Kaziev, D.S., Knapp, C.N., 2021. Using Research to Support Transformative Impacts on Complex, "Wicked Problems" With Pastoral Peoples in Rangelands. Frontiers Sustain Food Syst 4, 600689. https://doi.org/10.3389/fsufs.2020.600689

Robinson, C.J., James, G., Whitehead, P.J., 2016. Negotiating Indigenous benefits from payment for ecosystem service (PES) schemes. Global Environ Change 38, 21–29. https://doi.org/10.1016/j.gloenvcha.2016.02.004

Roche, L.M., Saitone, T.L., Tate, K.W., 2021. Rangeland Ecosystem Service Markets: Panacea or Wicked Problem? Frontiers Sustain Food Syst 5, 554373. https://doi.org/10.3389/fsufs.2021.554373

Rodríguez-de-Francisco, J.C., Duarte-Abadía, B., Boelens, R., 2019. Payment for Ecosystem Services and the Water-Energy-Food Nexus: Securing Resource Flows for the Affluent? Water-sui 11, 1143. https://doi.org/10.3390/w11061143

Safford, H.D., Sawyer, S.C., Kocher, S.D., Hiers, J.K., Cross, M., 2017. Linking knowledge to action: the role of boundary spanners in translating ecology. Front Ecol Environ 15, 560–568. https://doi.org/10.1002/fee.1731

Saldaña, 2016. The coding manual for qualitative researchers. SAGE, Thousand Oaks, California, USA.

Sand, I. van de, 2012. Payments for Ecosystem Services in the Context of Adaptation to Climate Change. Ecol Soc 17. https://doi.org/10.5751/es-04561-170111

Sattler, C., Matzdorf, B., 2013. PES in a nutshell: From definitions and origins to PES in practice—Approaches, design process and innovative aspects. Ecosyst Serv 6, 2–11. https://doi.org/10.1016/j.ecoser.2013.09.009

Shapiro-Garza, E., 2013. Contesting Market-Based Conservation: Payments for Ecosystem Services as a Surface of Engagement for Rural Social Movements in Mexico. Hum Geogr 6, 134–150. https://doi.org/10.1177/194277861300600109

Shapiro-Garza, E., McElwee, P., Hecken, G.V., Corbera, E., 2020. Beyond Market Logics: Payments for Ecosystem Services as Alternative Development Practices in the Global South. Dev Change 51, 3–25. https://doi.org/10.1111/dech.12546

Siders, A.R., 2019. Adaptive capacity to climate change: A synthesis of concepts, methods, and findings in a fragmented field. Wiley Interdiscip Rev Clim Change 10. https://doi.org/10.1002/wcc.573

Skillington, T., 2020. Democracy, Biodiversity and More than Human Justice Imperatives: Institutional Responses to Crisis. Soc. Sci. 9, 166. https://doi.org/10.3390/socsci9090166

Smith, A.P., Vallury, S., Metcalf, E.C., 2023. Social dimensions of adaptation to climate change in rangelands: a systematic literature review. Clim. Chang. 176, 180. https://doi.org/10.1007/s10584-023-03648-4

Tavory, I., Timmermans, S., 2013. A Pragmatist Approach to Causality in Ethnography. Am J Sociol 119, 682–714. https://doi.org/10.1086/675891

Tengö, M., Hill, R., Malmer, P., Raymond, C.M., Spierenburg, M., Danielsen, F., Elmqvist, T., Folke, C., 2017. Weaving knowledge systems in IPBES, CBD and beyond—lessons learned for sustainability. Curr Opin Env Sust 26, 17–25. https://doi.org/10.1016/j.cosust.2016.12.005

Timmermans, S., Tavory, I., 2012. Theory Construction in Qualitative Research: From Grounded Theory to Abductive Analysis. Sociol Theor 30, 167–186. https://doi.org/10.1177/0735275112457914

Varghese, J., Crawford, S.S., 2021. A cultural framework for Indigenous, Local, and Science knowledge systems in ecology and natural resource management. Ecol Monogr 91. https://doi.org/10.1002/ecm.1431

Vatn, A., 2010. An institutional analysis of payments for environmental services. Ecol Econ 69, 1245–1252. https://doi.org/10.1016/j.ecolecon.2009.11.018

Vila-Henninger, L., Dupuy, C., Ingelgom, V.V., Caprioli, M., Teuber, F., Pennetreau, D., Bussi, M., Gall, C.L., 2022. Abductive Coding: Theory Building and Qualitative (Re)Analysis. Sociol Method Res 004912412110675. https://doi.org/10.1177/00491241211067508

Wertz-Kanounnikoff, S., Locatelli, B., Wunder, S., Brockhaus, M., 2011. Ecosystem-based adaptation to climate change: What scope for payments for environmental services? Clim Dev 3, 143–158. https://doi.org/10.1080/17565529.2011.582277

West, P., 2006. Conservation Is Our Government Now: The Politics of Ecology in Papua New Guinea. Duke University Press.

West, S., Haider, L.J., Masterson, V., Enqvist, J.P., Svedin, U., Tengö, M., 2018. Stewardship, care and relational values. Curr Opin Env Sust 35, 30–38. https://doi.org/10.1016/j.cosust.2018.10.008

White, A.C., Faulkner, J.W., Conner, D.S., Méndez, V.E., Niles, M.T., 2022. "How can you put a price on the environment?" Farmer perspectives on stewardship and payment for ecosystem services. J. Soil Water Conserv. 00041. https://doi.org/10.2489/jswc.2022.00041

Wilmer, H., Schulz, T., Fernández-Giménez, M.E., Derner, J.D., Porensky, L.M., Augustine, D.J., Ritten, J., Dwyer, A., Meade, R., 2021. Social learning lessons from collaborative adaptive rangeland management. Rangelands. https://doi.org/10.1016/j.rala.2021.02.002

Wunder, S., 2015. Revisiting the concept of payments for environmental services. Ecol Econ 117, 234–243. https://doi.org/10.1016/j.ecolecon.2014.08.016

CHAPTER 4

SUPPORTING RESTORATION AND CLIMATE ADAPTIVE CAPACITY AT WUDA OGWA (ARTICLE 3)

Abstract:

This case study from the Wuda Ogwa restoration project reflects on lessons learned from a transdisciplinary approach to braiding knowledge in support of a climate adaptive ecological restoration project led by the Northwestern Band of the Shoshone Nation. The goal of this paper is to summarize, synthesize, and analyze social and ecological data to support NWBSN members and other restoration partners making socially informed and climate-adapted restoration choices. Lessons learned from this case study contribute to building the ideas and practices of climate adapted ecological restoration. The knowledges included in this paper draw from published Shoshone history, ethnobotany, and contemporary video productions published by the NWBSN. The paper's ecological and social data sources include 1) climate risk modeling of culturally important plant species; 2) a study of existing vegetation communities; 3) water quality data from Battle Creek; 4) fish and wildlife monitoring; 5) modeling of potential beaver restoration areas; 6) site soil and biochar pilot testing; and 7) semi-structured interviews of neighboring landowners near the Wuda Ogwa site. The findings are that building adaptive capacity involves increasing both the ecological resilience of a site as well as the collaborative capacity of the land managers, partners, neighbors. This paper offers insight from the Wuda Ogwa restoration project into nine social-ecological

elements identified by the analysis of this paper as central to this project and similar efforts.

Introduction

The intersecting crises of climate change, biodiversity loss, and ecosystem degradation are galvanizing a global response consisting of science, policy, and grassroot collective action (IPBES, 2019; IPCC, 2023; USGCRP, 2023). The United Nations declared the years 2021-2030 as the Decade on Ecosystem Restoration and there are currently hundreds of documented major ecological restoration projects and thousands of local projects underway across the globe (Levinthal and Weller, 2023). A central challenge of this decade is building transdisciplinary understanding of how to conceptualize, design, and implement climate resilient restoration that addresses coupled social and ecological systems (Fischer et al., 2021; Simonson et al., 2021). A diverse range of scholars are calling for improving the capacity of restoration partnerships to braid Indigenous, local, and western-based scientific knowledge systems to support social and ecological healing (Chambers et al., 2021; Kadykalo et al., 2021; Mehltretter et al., 2024). This case study from the Wuda Ogwa restoration project reflects on lessons learned from a transdisciplinary approach to braiding knowledge in support of a climate adaptive ecological restoration project led by the Northwestern Band of the Shoshone Nation (NWBSN).[16] The Wuda Ogwa restoration project is located at the confluence of

[16] This paper is the result of six years of collaboration and relationship building among the main author, who is a non-native graduate student at Utah State University (USU), several members of the NWBSN, several other USU graduate students and faculty, and members of the companies BIOWEST and HAL. The main author is a descendant of

Battle Creek and the Bear River in what the Shoshone call Sihivigoi, or Willow Valley. This valley, named Cache Valley by settlers, is located in the present-day United States of America and encompasses both the states of Idaho and Utah.

Ecosystem restoration science has grown in the past three decades to include both ecological and social perspectives and is defined as the process of assisting the recovery of a degraded, damaged, or destroyed ecosystem to reflect values regarded as inherent in the ecosystem and to provide goods and services that people value (Martin, 2017). In addition to the intrinsic (regarded as inherent) and instrumental (means to a human end) values, relational values are increasingly recognized as significant motivators of ecological restoration (Wainaina et al., 2023). Relational values describe the relationships and responsibilities that exist between people and the more-than-human world as well as among people, often mediated through nature (Chan et al., 2018). In the face of the intersecting ecological crises, scholars are calling for new ways to relate to social and ecological systems to address the root causes and symptoms of these crises (Hernandez, 2022). Social movements, restoration practitioners, and scholars are actively exploring how to bring justice and relational values questions into navigating social-ecological system change while negotiating the plural values underpinning social structures and ecological conditions shaped by colonialism, capitalism, and climate change (Larsen, 2024; Yazzie, 2018).

Indigenous scholars and environmental justice movements have long pointed out that the causes of these social-ecological crises and associated impacts have

---

settlers who moved to Sihovigoi (Willow Valley) in the early 1990s and is not a member of the NWBSN. USU's Logan campus resides on the ancestral, traditional, and contemporary lands in the Sihivigoi of the Northwestern Band of the Shoshone Nation.

disproportionate negative impacts on historically marginalized groups. The 6th report from the Intergovernmental Panel on Climate Change (IPCC) recently recognized colonialism as a driver of not only the climate crisis but also increasing communities' vulnerability to it (IPCC, 2023). Despite an ongoing history of dispossession and marginalization, lands stewarded by Indigenous peoples contain 80% of the world's remaining biodiversity, and Indigenous knowledge and knowledge systems are critical to progressing towards a sustainable future for all (Recio and Hestad, 2022).

A key question considering growing Indigenous land reclamation and co-management activity is how to support ecological restoration on re-acquired Indigenous land that was previously under multi-generational settler-colonial land management. A growing number of restoration practitioners, ecologists, Indigenous scientists, and Indigenous land managers perceive opportunities for innovation when it comes to bringing together Indigenous knowledge and Western ecological science to advance restoration and stewardship (Chan et al., 2012; Itsiipootsikimskai et al., 2023; Kimmerer, 2015). In these transdisciplinary collaborations, it is important to avoid tokenizing Indigenous knowledge as "data" that is slotted into western scientific models (Latulippe and Klenk, 2020). There is also a need to recognize the sovereignty, rights and cultural protocols of Indigenous peoples. An interdisciplinary group of Indigenous scholars recently proposed a set of "CARE principles" to center collective benefit, authority to control, responsibility and ethics in collaborative ecological research (Jennings et al., 2023). By centering Indigenous knowledge, stories, and restoration goals, new attempts at co-produced research aim to support partnerships that create more equitable planning processes and outcomes relevant to conserving biodiversity and cultural diversity

(Hernandez, 2022). The challenge ahead is to move away from extractive, top-down research and towards more meaningfully collaborative research that better serves Indigenous stewardship goals of restoring land and human relationships. This article explores how the Wuda Ogwa restoration project, led by the Northwestern Band of the Shoshone Nation (NWBSN) and supported by an interdisciplinary team of ecological and social scientists, has approached restoring the ecosystem and improving relations in the Bear River watershed. Lessons learned from the knowledge braiding approach used to support the Wuda Ogwa restoration contribute insight to a growing literature on climate adaptive ecological restoration.

The goal of the Wuda Ogwa project is to restore the land to look and feel like pre-massacre conditions while supporting NWBSN members reconnecting with their land and sharing their story. The history of colonization and land expropriation led to the loss of Shoshone management of the Wuda Ogwa site, but knowledge and relations persist that reflect strong connections to the land (Parry 2019). Reciprocal biocultural restoration (Kimmerer 2015) deepens this connection and provides a framework for regenerating a landscape by braiding Shoshone knowledge and goals with ecological monitoring and modeling as well as engagement with the local knowledge of farmers and ranchers.

This paper presents a summary, synthesis, and analysis of the efforts to co-produce science and braid knowledge in support of the NWBSN's goals of healing the land, exercising sovereignty, sharing their story, and practicing adaptive management given the uncertainty of climate change. In dialogue with the seven principles of climate-adapted restoration (Simonson et al. 2021) as well as the six priorities for social-ecological restoration (Fischer et al. 2021), this paper contributes social and ecological insight from the Wuda Ogwa restoration project. The findings of this analysis can inform how other efforts to implement ecological restoration projects might engage both social and ecological contexts while braiding diverse knowledge sources to support climate resilient restoration.

Literature Review

Knowledge braiding, reciprocity, and relationships

Braiding different types of knowledge supports the ability of land stewards to achieve more robust and transformative collaborations geared to restore landscapes and human relationships (Reid et al., 2021; Satterfield et al., 2013). A growing number of case studies demonstrate how to practice knowledge braiding, particularly in the context of Indigenous-led restoration efforts (Marks-Block et al., 2021; McElwee et al., 2020; Pavlik et al., 2021; Reyes-García et al., 2019). There are ethical and practical reasons to bridge Indigenous and Western scientific ecological knowledge to manage land in ways that achieve conservation goals and support Indigenous sovereignty (Kassi et al., 2022; Wilcox et al., 2023). The ethical and justice issues revolve around addressing the colonial history of genocide, land expropriation, and marginalization (Estes and Dunbar-Ortiz, 2020). Recognizing Indigenous history and relationships to land is part of a larger process of healing from the trauma of colonization (Parry, 2018). The practical reasons are that Indigenous knowledge about ecological processes like fire, food webs, and multispecies relationships is increasingly recognized as holding critical insight for ecological restoration practitioners working to heal people and landscapes from the legacy of colonial and capitalist land management paradigms (Chesnais et al., 2024; Marks-Block and Tripp, 2021).

Indigenous scholars point out the need to bring ideas and practices of reciprocity, relationship and culture into ecological restoration. Potawatomi botanist, author, and professor Robin Wall Kimmerer, describes a need for, "the mutually reinforcing restoration of land and culture such that repair of ecosystem services contributes to cultural revitalization, and renewal of culture promotes restoration of ecological integrity" (Kimmerer, 2011). In her keynote address to the Society of Ecological Restoration (SER), Kimmerer called for a biocultural approach to restoration that emphasizes the science and practice of restoring ecosystems, as well as human and cultural relationships to place, such that cultures are strengthened and revitalized alongside the lands with which they are inextricably linked (2021). In *Braiding Sweetgrass*, Kimmerer writes, "Like other mindful practices, ecological restoration can be viewed as an act of reciprocity in which humans exercise their caregiving responsibility for the ecosystems that sustain them. We restore the land, and the land restores us" (Kimmerer, 2015).

The Potawatomi climate justice scholar Kyle Whyte describes the concept of "renewing relatives" as a decolonizing trajectory of self-determined planning for climate change. In his view, renewing Indigenous knowledge involves renewing individual and collective relationships with both humans and non-humans, and thus restoring reciprocity among the relatives. While this involves restoring persistent relationships that are part of long-standing Indigenous heritages, it also involves creating new relationships that support Indigenous peoples' mobilizing to address climate change (Whyte, 2017).

Advances in climate adaptation in the context of ecological restoration

The concept of climate adaptation planning emerged over three decades ago with the 1988 formation of the United Nations Intergovernmental Panel on Climate Change (Hubs, 2023). Early climate adaptation efforts emphasized bringing stakeholders to the table to identify options for and make commitments to mitigating and adapting to climate change impacts. Criticism of early climate adaptation planning cautioned against neglecting social drivers of climate and cross-scale interactions (Ford et al., 2018). Contemporary climate adaptation research is both calling for and recognizing the difficulty of working across social and ecological disciplines while centering the practical needs of the users of climate adaptation science (Wilmer et al., 2024). A new generation of climate adaptation planning emphasizes scenario planning and the co-production of knowledge involving scientists, local communities, and stakeholders (Iwaniec et al., 2020). Scenario planning is a structured process of identifying a set of "potential future conditions" by considering a wide range of uncertainty in the variables used to inform planning (Miller et al., 2022). Current climate adaptation literature recommends that co-production of knowledge should occur throughout the planning process (Chambers et al., 2022; Klenk et al., 2017). This includes framing the problems and/or generating questions, interpreting results, and braiding western science with local and Indigenous knowledge, practices, institutions, and governance arrangements. Another contemporary goal is to decolonize climate adaptation scholarship and praxis (Bronen and Cochran, 2021; Whyte, 2017). This approach calls for acknowledgement of colonial and neo-colonial injustices driving Indigenous peoples' climate vulnerability, taking seriously Indigenous knowledge and relational ontologies, and promoting climate adaptation strategies that engage Indigenous capacities and aspirations for self-determination and cultural continuity (Johnson et al., 2022). A core question in this decolonizing trajectory is how to braid different types of knowledge in ways that engage climate change adaptation planning as a strategic opportunity for Tribes to retain cultural practices, return traditional management practices to the land, and enhance successful collaborations between different kinds of land managers to address climate change (Norgaard, 2018). A related concept that was developed to support these collaborations is the idea of "collaborative capacity", which identifies capacities that enable a partnership to "develop, support, and implement collective, inclusive, equitable, and scalable impacts, including the ability to collaborate, to influence others, and to share leadership" (Baxter and Land, 2023).

Ecologists and conservation scientists are working to articulate a generalizable framework to support successful ecological restoration in the era of climate change. Scholars have identified a need to better understand how to make restoration both a social and ecological endeavor (Fischer et al., 2021). Fischer and colleges outline a set of priorities for this endeavor that draw from resilience principles such a navigating complexity as well as engaging the relational values that motivate diverse partnerships. Recent scholarship also emphasizes that building the adaptive capacity of coupled social-ecological systems requires attention to social learning, transforming systems, creative flexibility in decision making, and addressing socio-political power structures to makes them attuned and responsive to the needs of stakeholders, rights holders, and caregivers (Frietsch et al., 2023; St-Laurent et al., 2021). Fischer and colleagues (2021) call for new research in two areas of need: 1) *post hoc* cross-sectional assessments of socio-ecological restoration projects and 2) transdisciplinary ‘living labs’ that accompany restoration projects as they unfold.

This paper addresses these needs by synthesizing Fischer and colleagues’ priorities for social-ecological restoration along with Simonson and colleagues’ principles of climate-adapted ecological restoration. By analyzing these principles and priorities in the context of the Wuda Ogwa restoration project, it contributes a case study to the field of transdisciplinary climate adaptation science.

The first principle of climate-adapted ecological restoration is considering climate change uncertainties when setting restoration objectives (Simonson et al., 2021). The second is selecting sites based on understanding projected changes to climate and managing connectivity. The third is accounting for future distribution and fitness when choosing target species and ecosystems. The fourth is reestablishing and managing key ecosystem interactions and micro-climatic niches. The fifth is identifying and mitigating site-level climate change risks. The sixth is aligning the project with long-term policies and seeking synergies across multiples objectives. The seventh is designing monitoring frameworks that enable adaptive management of the restoration trajectory. These seven principles of climate adapted restoration focus on an ecological foundation and would benefit from a more transdisciplinary coupling of social and ecological systems. The authors also note that there is scant evidence of climate change resilient restoration in practice.

Reflecting on these principles and priorities in the context of the Wuda Ogwa project provides a case study on integrating social and ecological insight from an on-the-ground restoration project led by the NWBSN.

Project Background

History

In 2018, the NWBSN purchased the site of the Bear River Massacre. This traditional Shoshone winter camp is located in present-day southeastern Idaho. After more than 150 years, the NWBSN have acquired the land along the Bear River where, in 1863, more than 400 Shoshone were massacred by settlers and volunteers led by the US Army (Parry, 2019). The NWBSN intends to make the site of one of North America's most egregious massacres of Indigenous people into a cultural and interpretive center where Shoshone tribal educators can share the Tribe's history and restore the ecosystem that existed at the site prior to the massacre. The name of the Tribe's project is Wuda Ogwa, which is the Shoshone translation for Bear River. The site was referred to by settlers as "The Battle of Bear River" or "The Bear River Massacre Site." The challenge faced by the Wuda Ogwa restoration is to restore a culturally meaningful landscape that supports reverence, resilience, and regeneration in light of more than 155 years of land-use change and a changing climate.

After the massacre, Shoshone survivors continued to inhabit the area near the Bear River. In 1863, the United States (US) government and several Shoshone bands signed the Treaties of Fort Bridger and Box Elder (Parry, 2019). After the treaty signing, government officials attempted to move the Shoshone to the newly founded Fort Hall Indian Reservation in Idaho. While some moved north, many stayed in Utah, and in August 1875, over 600 Northwestern Shoshones were baptized into the Mormon Church. A permanent settlement named Washakie was established in the 1880s by Northwestern

Shoshone and Mormon leaders four miles south of Portage, Utah. On April 29, 1987, the NWBSN became a federally recognized tribe after years of Shoshone advocacy.

In the mid-nineties, the US National Park Service conducted a special resource study and environmental assessment of the Bear River Massacre Site (Spude, 1995). This study considered options for the massacre site that included designation as a County Historical Site, a State Historic Site, National Historic Site, and National Historic Reserve. While the study did consult leadership from four Shoshone Bands, the assessment is an example of government research conducted in a 'top-down' rather than genuinely collaborative manner. In the study, there is clear documentation of Shoshone activism and desire to reclaim the land and tell their story. Yet a Shoshone-led alternative is barely considered and is dismissed as unrealistic.

The goal of the NWBSN to reclaim their ancestral land and tell their story began to succeed after more than a century and a half of endurance and perseverance. On March 24, 2003, the Trust for Public Land's Tribal Lands Program and the American West Heritage Center purchased twenty-six acres of the site and donated it back to the NWBSN. In 2018, the tribe purchased roughly 350 additional acres and began their process of restoring the land. This process entailed reaching out for consultation with scientists at Utah State University, local restoration contractors BIOWEST, Inc., and the water engineering firm Hansen, Allen, Luce, Inc. for technical assistance. In 2021, the NWBSN, Trout Unlimited, and researchers from USU began a three-year project funded by the Wildlife Conservation Society (WCS) to braid together Indigenous, local, and scientific knowledge in order to support climate adapted ecological restoration at Wuda Ogwa.

Starting in 2021, crews with the Utah Conservation Corp began removing Russian Olive trees at the site. The next year, volunteers began planting willows and cottonwoods to begin the restoration of the site's riparian habitat. While removing invasive species and planting native ones is an important start, the experience with spring floods in 2023 showed why a transformation of the hydrological conditions is needed as well. Spring floods after record snowpack in 2022-2023 caused major damage at Wuda Ogwa's bridges and water infrastructure. Floods washed away many plantings and covered others with thick mud and debris. While these spring floods are a natural part of the site's hydrology, the flood flows moving through Battle Creek's simplified channel demonstrated vulnerabilities of the site's physical infrastructure and degraded geomorphology.

In the summer of 2023, the NWBSN hosted the Wuda Ogwa Stewardship program, which brought tribal youth and elders together on the land to share knowledge and culture about the site. Participants in the program also traveled to nearby ecological restoration sites to learn about the experiences of scientists and ranchers who are working to restore beaver activity in neighboring watersheds. In the summer of 2024, the NWBSN and the Sageland Collaborative installed the first Beaver Dam Analogs (BDAs) to begin implementing restoration techniques that aim to improve the ecosystem function of the Battle Creek riparian corridor, floodplains, and hyporheic zones.

Wuda Ogwa restoration project goals and intentions

The NWBSN's broad goals for the Wuda Ogwa project are to restore the land to look and feel like pre-massacre conditions while ensuring that the land is resilient to climate change. When the Trust for Public Land donation was completed in 2003, then NWBSN Tribal Chairwoman Gwen Davis was quoted as saying, “We’ve waited many years for this to happen, our dreams have become a reality today.” The meaning of having the land back was and is still profound. NWBSN Executive Director Bruce Parry described how, “This is sacred land to us. It is the burial ground of our ancestors and it is deeply satisfying to have it protected.”[17]

In the video documentary “Restoring Sacred Ground,” produced by the NWBSN about the Wuda Ogwa restoration, Vice-Chairman of Tribal Council and Wuda Ogwa Project Manager Brad Parry spoke about the NWBSN’s motivations for restoration: “What is binding us together is that connection to land, to place. We belong to it more than we own it. We want the earth to rebuild itself, but we need to give it a push in the right way” (NWBSN, 2024). High Country News (HCN) journalist Brooke Larsen conducted another interview with Vice-Chairman Parry, in which he spoke about the transformative potential of the restoration project:

> “For thousands of years, this wasn’t a massacre site,” Brad Parry told restoration volunteers at a planting day. The area — now known as Preston, Idaho, just 10 miles north of the Utah border — was a gathering place where the Northwestern Band lived, celebrated, performed the Warm Dance and connected with other bands of the Shoshone. “By inviting you all out and doing this, we want to recapture that,” Parry said. “We want to make this a place to come again.” (Larsen, 2024)

Former Chairman of NWBSN Tribal Council and historian Darren Parry spoke about the right approach for scientists who are collaborating with Indigenous people:

> You have to go slow to go fast, it’s about taking the time to build those relationships. You can’t do that over a phone call or one meeting. This traditional knowledge is so important and vital and I want researchers to engage with tribes in a way that isn’t a one off then they’re gone. If you

[17] Chairwoman Davis and Executive Director Parry are quoted from the NWBSN history website: https://www.nwbshoshone.com/history/.

> engage with a tribe, it's a long-term commitment. Once you gain the trust of elders, then you can go fast and the magic happens. They need to know you're into it for the right reason and the relationship is ongoing (NWBSN, 2024)

As part of the HCN article, Larsen also spoke with NWBSN member and anthropologist Jason Brough about the Tribe's desire to build a cultural and interpretive center. Brough talked about the Tribe's intention to make the center Indigenous-designed, -run. and -interpreted: "We don't want to be just a museum," Brough said. "We want our perspectives told, even if it's difficult for people to hear." Also speaking with Larsen, Shoshone knowledge keeper Rios Pacheco said, "You don't even need a center to be healed. Right now, you're healing people with the land."

The Wuda Ogwa Restoration Project: Summary, Synthesis, and Analysis

The goal of this paper is to summarize, synthesize, and analyze social and ecological data to support NWBSN members and other restoration partners making socially informed and climate-adapted restoration choices. The goal of knowledge braiding is to help build a shared sense of meaning. Shared transdisciplinary meaning embraces a pluralistic epistemology that considers the existence of multiple ways of knowing and being (Rigolot, 2020). The university team recognized that a shared sense of meaning is only possible through diverse groups of people spending time with each other and learning in-person from each other. While an academic paper can help inform this conversation and social learning, it is not a substitute. The analysis in this paper is grounded in Indigenous research methods that emphasize relationships, respect, relevance, reciprocity, and responsibility (McGregor et al., 2018). Respecting and engaging multiple sources of knowledge is enabled by our relationships and responsibilities that center around co-producing actionable research that supports the NWBSN's goals for the Wuda Ogwa restoration project.

The Shoshone knowledge included in this paper draws from published Shoshone history (Parry 2019), ethnobotany (Pacheco, 2020), and contemporary video productions published by the NWBSN (2024). Data sovereignty protocols are detailed in Appendix 1. The paper's ecological and social data sources include 1) climate risk modeling of culturally important plant species; 2) a vegetation and wetland delineation study that maps the site's existing vegetation communities; 3) a watershed assessment of Battle Creek, the Bear River, and Great Salt Lake; 4) wildlife studies that include bird surveys, camera trapping, and fish surveys; 5) spatial modeling of local potential beaver restoration areas; 6) site soil and biochar pilot testing; and 7) semi-structured interviews of neighboring landowners near the Wuda Ogwa site. These data were collected or compiled by different individual or group partners on the project and their contributions are detailed in the next section. My role in the project was to help coordinate data collection as well as analyze and synthesize the findings.

Analysis for this paper is organized around the contributions and limitations of the plural knowledges and disciplinary lenses. Analysis is also structured to highlight the challenges and opportunities illuminated by the different lenses. All research is grounded in the guidance of Tribal staff and elders in the context of partnership with the Wuda Ogwa restoration project. The discussion following the analysis section aims to identify how insights from Wuda Ogwa might offer generalizable insight about knowledge braiding and climate-adapted ecological restoration.

Summary of the processes and contributions the knowledge sources

When the Wuda Ogwa site was purchased in 2018, then NWBSN Tribal Council Chairman Darren Parry approached the USU College of Natural Resources to ask if it would be possible to ecologically restore the site to pre-massacre conditions. Parry described the limitations of Shoshone knowledge as being part of the historical dispossession and exclusion from the land. He also described how elders still took their families to the site to teach about their people and their ongoing relationship to the land (Parry, personal communication). Shoshone oral and written history is a critical part of braiding knowledge because this intergenerational knowledge describes the site uses, characteristics, and history. This is especially important given that Shoshone history was ignored and marginalized during the settler-colonial and modern era (Parry 2019).

After initial consultation with USU researchers, a larger group formed that consisted of social and ecological scientists from USU, restoration contractors from BIOWEST Inc. and Allred Restoration, engineers from Hansen, Allen, and Luce, Inc, and partners like Trout Unlimited and the Wildlife Conservation Society. This group has collaboratively worked with the leadership of the NWBSN to co-produce research to support the restoration efforts. The contributions of the ecologists were to gather site-specific environmental data such as current vegetation community composition, presence of fish and wildlife, water quality and hydrological measurements, and soil health. A transdisciplinary team worked to braid Shoshone plant knowledge from elders' publications (Pacheco, 2022; Parry, 2019) with historical records of local plant community composition (Hull and Hull, 1974) to produce a climate change risk assessment for these culturally important plants (Figure 8) (Koutzoukis et al., accepted).

The initial ecological and water quality data helped quantify the extent to which site conditions were degraded by land-use practices on surrounding farms, ranches, and water management systems.

The social drivers of these ecological conditions inspired the inclusion of social scientists, who worked to understand the perceptions and motivations of the people living and working around the Wuda Ogwa site. Social scientists brought insight into coupled socio-ecological systems and methods for qualitative data gathering. Two rounds of semi-structured qualitative interviews (n=21) with 25 neighboring landowners (some interviews were with married couples) were conducted by two USU graduate students between 2020 (Stocker, 2021) and 2024 (Woodbury, 2024). Purposive and snowball sampling engaged participants who owned land or were part of land-owning families in the Battle Creek and Bear River watersheds. Interviews were transcribed and coded for thematic patterns (Saldaña, 2016). Coding was both inductive where themes, codes and categories emerged from the data and deductive, particularly looking for themes related to opportunity and barriers to collaboration, relational values, as well as mental models of how the local social, agricultural, ecological systems functioned (Walpole et al., 2020).

Challenges and opportunities from the ecological analysis

Wuda Ogwa is located around the confluence of the Bear River and Battle Creek. Battle Creek is a 19,685 acres watershed and 16.27-mile-long tributary of the Bear River. Battle Creek is currently listed as Impaired by the Idaho Department of Environmental Quality. The identified issues are abnormal flow, degraded habitat, turbid water quality, as well as nitrogen and phosphorus pollution.

An initial goal articulated by NWBSN leadership was to restore a native trout habitat at Wuda Ogwa. While initial channel restoration designs included removing fish passage barriers like irrigation diversions, more consideration was needed to evaluate the potential tradeoff to the identified refugia. Fish sampling found the presence of a native fish refugia in Battle Creek. Fish sampling in Beaver Creek was conducted by Ron Rogers of BIOWEST, Inc. in August of 2021. The sample found an assemblage of native fish including Mountain Sucker *Catostomus platyrhynchus,* Utah Chub *Gila atraria,* Speckled Dace *Rhinichthys osculus,* and Longnose Dace *R. cataractae.* Surveys did not detect invasive predatory species like carp in a reach section above an irrigation diversion on lower Battle Creek. Removing fish passage barriers downstream could expose this refugia to invasive predators like carp.

Another challenge to fish restoration is the high levels of sediment in Battle Creek. The water quality challenges were quantified by water sampling for turbidity levels on Battle Creek. Sampling was conducted in 2021 led by Ryan Dillingham of BIOWEST, Inc. and included sampling conducted by Native students in USU's Native American Summer Mentorship Program.[18] The water turbidity map in Figure 7 shows increasing levels of Nephelometric Turbidity Units (NTUs) in Battle Creek. Sampling found 8.27 NTUs at Treasureton Reservoir, an increase to 123.76 as Battle Creek enters the Wuda Ogwa site, and a peak at 154.33 near the confluence with the Bear River. For reference, cool water aquatic communities such as trout fisheries are considered by the Environmental Protection Agency to have limits around 10 NTUs.

---

[18] Native American Summer Mentorship Program: https://www.usu.edu/nacc/mesas//nasmp/

The Battle Creek turbidity data shows the challenge presented by current degraded water quality to NWBSN objectives of restoring Bonneville Cutthroat Trout habitat. Measuring NTUs identified areas that are contributing to sediment and turbidity issues. Understanding the drivers of water quality issues became a necessary part of a baseline assessment in addition to developing plans to improve riparian habitat. Qualitative interviews helped contextualize and understand local knowledge about the issue and where opportunities for collaboration may exist. This qualitative data is included in the next section that summarizes interviews with landowners in the Battle Creek watershed.

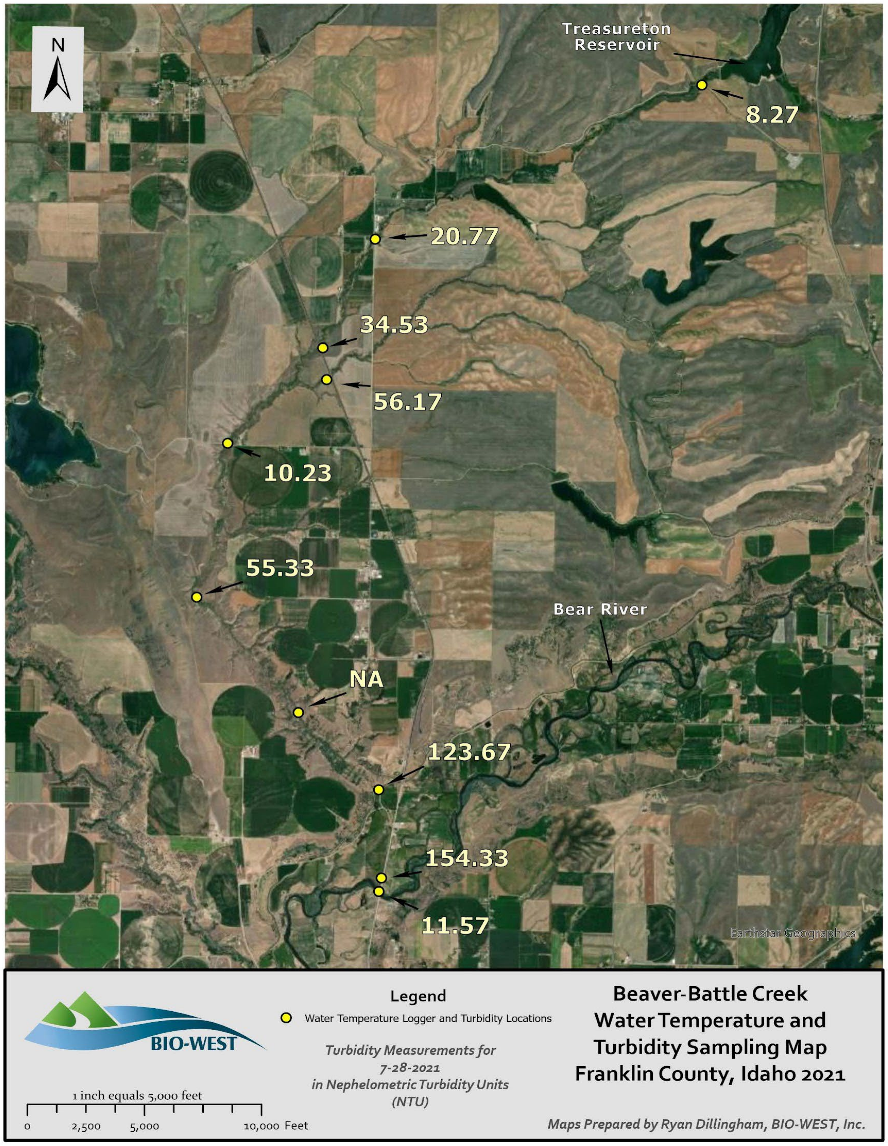

Figure 7: Battle Creek turbidity dataset. This map of Battle Creek shows the reach between Treasureton Reservoir in the upper right corner and the confluence with the Bear River in the map's bottom center. Each yellow dot represents a water sampling location and the numbers measure Nephelometric Turbidity Units (NTU). The main finding of this water monitoring is that turbidity measured in NTUs increases from the top to the bottom of the reach. This finding reflects the soil erosion and watershed conditions in Battle Creek and helps identify where restoration actions might be planned to reduce sediment runoff.

The opportunity for NWBSN watershed stewardship is both in improving water quality and restoring the natural hydrology of Battle Creek. The natural hydrology of Battle Creek refers to water flows that support the geomorphology and ecology of the stream. The potential flows include low flow, high flow pulses, small floods and large floods. All these environmental flow components help support different ecological functions. Project engineers at Hansen, Allen, and Luce Inc. estimate that average flows are between 10-15 cubic feet per second (CFS) and high flow events exceed 75 CFS. The estimated annual water volume moving through Wuda Ogwa is 10,857 Acre Feet (Parry and Andrew, 2023). Redesigning and transforming water infrastructure on the site like culverts, bridges, and irrigation diversions can help address the adaptive capacity of the site to absorb the potentially increasing frequency and intensity of floods and droughts associated with climate change. Transforming the Battle Creek channel from its currently incised and simplified geomorphology into a braided and sinuous path creates habitat for native riparian species like cottonwood and willow trees. Improving riparian habitat with a multi-strata tree canopy also creates more shaded aquatic habitat, potentially lowering stream temperatures to support a native trout populations. Structural complexity in the stream along with beaver activity could also help trap and settle sediment and turbidity. More complex geomorphic features help slow, sink, and spread water on the site, which may help improve water retention during drought periods and absorb pulse flows to mitigate flood impacts.

Another ecological challenge is the removal of invasive Russian Olive, *Elaeagnus angustifolia*. Russian Olive is an introduced invasive and its removal from Wuda Ogwa is desired by the NWBSN in order to make room to reestablish native willows and cottonwoods that have cultural significance and play a role in the history of the site. At Wuda Ogwa, two pilot tests in 2021 and 2022 used mobile biochar kilns to pyrolize the removed Russian Olive biomass using methods developed by the Utah Biomass Resources Group (McAvoy, 2023). Around the world, scientists are adapting the Indigenous practice of biochar production as a way to sequester carbon and enhance soil fertility (Roberts et al., 2010). A challenge identified by an initial pilot test at Wuda Ogwa was that Russian Olive biochar had a high pH of 9.34, and there was concern that if applied at a larger scale, this biochar could negatively affect the site's soil health, which is already slightly alkaline (pH 7.6-7.8). Second pilot tests showed the biochar mixed with site soil and cattle and horse manure in equal ratios by volume increased carbon content and reduced biochar pH levels (Figures 8 and 9). While these kilns may provide a way to process biomass from removed Russian Olive trees, more research is needed to identify the impact of this biochar on soil health and the establishment of desired native plant species. The opportunity to ameliorate biochar within healthy soil parameters could mean rebuilding the soil carbon content of Wuda Ogwa soils, which may help it retain moisture and become more drought resilient.

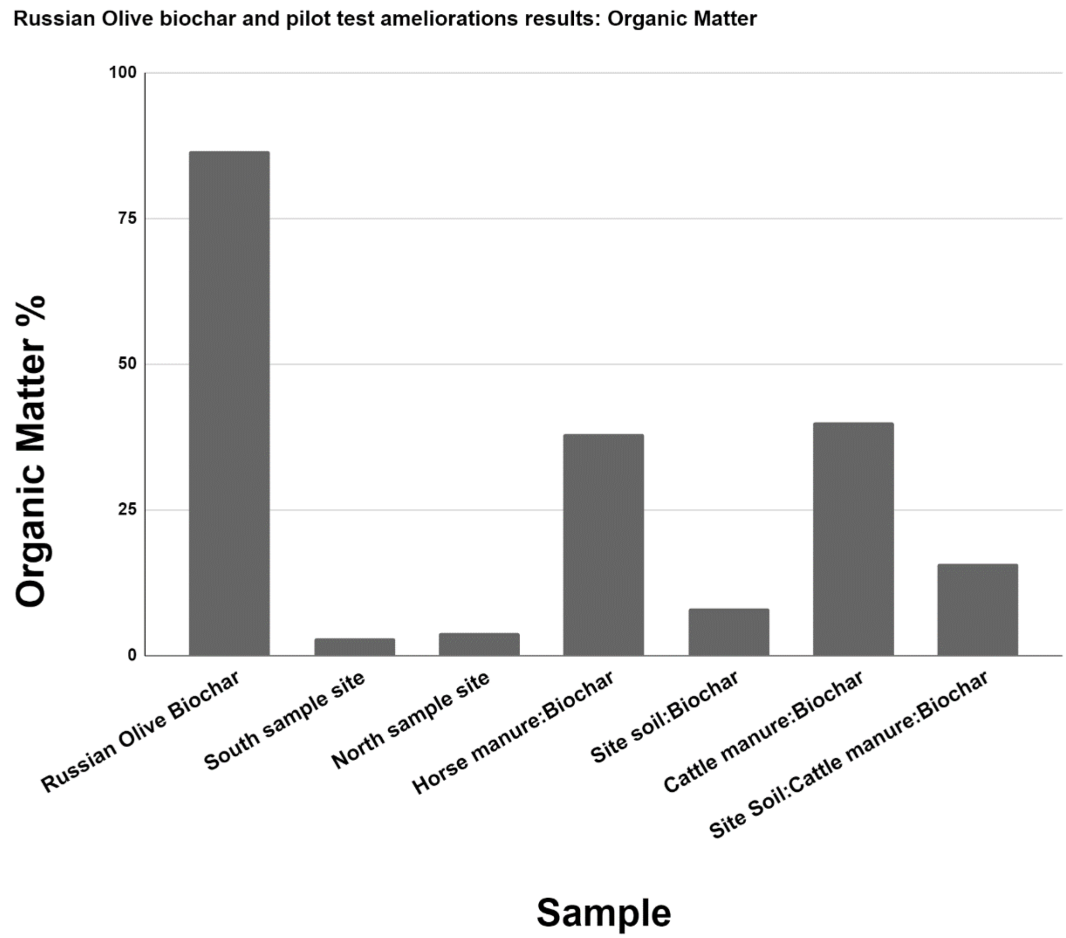

Figure 8: Russian Olive (RO) biochar organic matter levels compared to control site soil samples and four test RO amelioration combinations. Test samples show increasingly levels of organic matter compared the control samples. This increase in organic matter is a desired outcome of using biochar as a soil amendment because it potentially sequesters carbon materials in the soil and increases the water holding capacity of the soil.

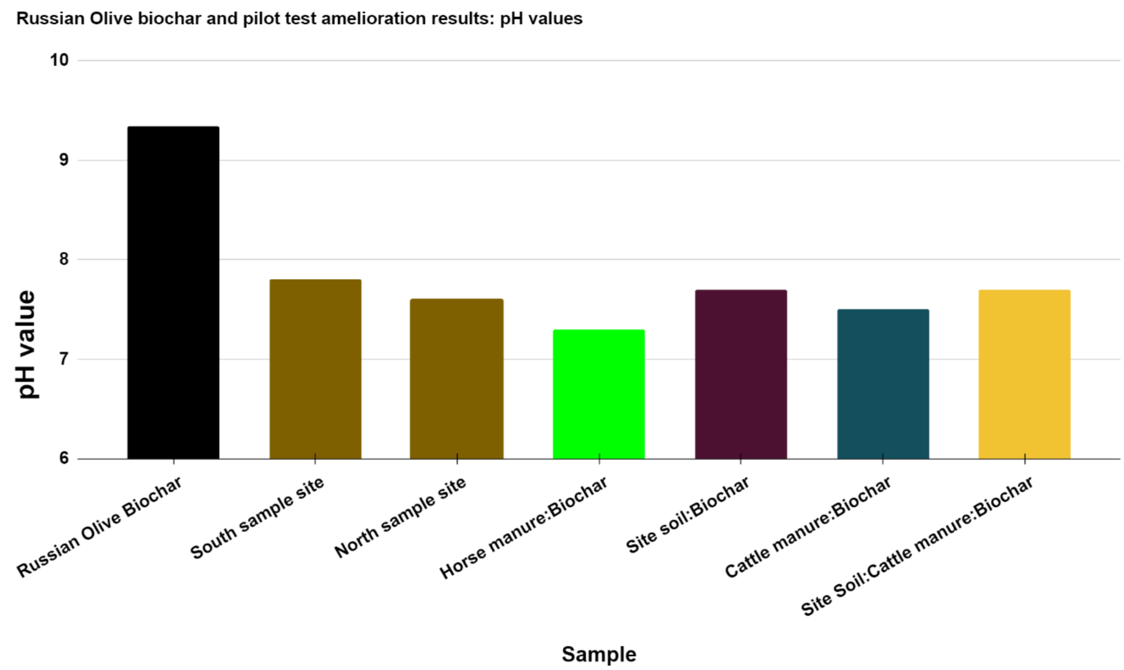

Figure 9: RO biochar pH levels (black) compared to site sample soils (brown) and four RO amelioration combinations (green, purple, blue and yellow). Results from the test combinations show pH levels that are similar or lower than the control soil samples. This more neutral pH is a desired outcome of the tests because the ameliorations appear to reduce the alkalinity of the RO biochar.

A third ecological challenge is understanding climate risks to culturally important species at the restoration site. A team of USU researchers including the author consulted with NWBSN elders and several publications to identify culturally important plant species and then used downscaled climate models to analyze climate risks to these native species (Koutzoukis et al., 2024; Pacheco, 2022; Parry, 2019). Under current conditions, most species have medium and high suitability at Wuda Owga (Figure 10). The species expected to see no change in suitability between historic and future conditions, with suitability staying high or medium, are four forbs (common milkweed "San-Ah-Koo"[19] [*Asclepias speciosa*], common yarrow "Patontsia" [*Achillea millefolium*], field mint "Pakwana" [*Mentha arvensis*], sego lily "Sikoo" [*Calochortus nuttallii*]), one grass (Great Basin wild rye, [*Leymus cinerius*]), and one shrub (Wyoming big sagebrush "Poho-pin" [*Artemisia tridentata* ssp. wyomingensis]). The model results showing a resilient suitability of Milkweed were identified as an opportunity by elders and NWBSN leadership because the species supports monarch butterflies and pollinator habitat.

Climate modeling found increasing suitability between historic and SSP5-8.5 scenarios[20] for three grasses (Indian ricegrass, needle and thread, sand dropseed) and five tree and shrub species (coyote willow, Fremont cottonwood, peachleaf willow, skunkbush sumac, Utah serviceberry). We found decreasing suitability for two forbs (arrowleaf balsamroot, yampah); four grass and grass-like species (cattail [*Typha latifolia*], horsetail "Sebu" [*Equisetum hyemale*], bluebunch wheatgrass, thickspike wheatgrass); and five shrubs and trees (grey alder, aspen [*Populus tremuloides*], chokecherry, narrowleaf cottonwood [*Populus angustifolia*], and Wood's rose). Bluebunch wheatgrass, chokecherry, Indian ricegrass, needle and thread, sand dropseed, coyote willow, Fremont cottonwood, peachleaf willow, and skunkbush sumac stayed in the same suitability class under both emissions scenarios (SSP2-4.5, SSP5-8.5; Table 1). For the species with different suitability classes between emissions scenarios (arrowleaf

---

[19] These plant names include common names, Shoshone names in quotes when available, and binomial nomenclature in italics.
[20] Shared Socioeconomic Pathways (SSPs) refer to climate models that quantify greenhouse gas levels, changes in population, economic growth, education, urbanization, and the rate of technological development that would affect future climate change (Riahi et al., 2017). SSP2-4.5 is a medium climate change scenario and SSP5-8.5 is a high climate change scenario.

balsamroot, yampah, cattail, thickspike wheatgrass, grey alder, aspen, narrowleaf cottonwood, Wood's rose, and Utah serviceberry [*Amelanchier utahensis*]) suitability was always lower under SSP5-8.5 than SSP2-4.5. Utah serviceberry is the exception to this pattern, with medium suitability under SSP2-4.5 and high suitability under SSP5-8.5.

A challenge to emerge from the climate risk modeling research is a larger question of how project managers and partners select plant varieties and planting techniques to mitigate risk and design for ecological resilience. While co-produced research found risks and opportunities in the modeling for different native species, there is still a need for a long-term adaptive management that provides a structured opportunity for project managers and partners to continue to braid Indigenous, local, and Western scientific knowledge in a way to inform a practical land management application of the findings from this modeling. A component of this challenge is the difficulty of translating model outputs into relevant and succinct recommendations that project partners can engage with in their restoration designs.

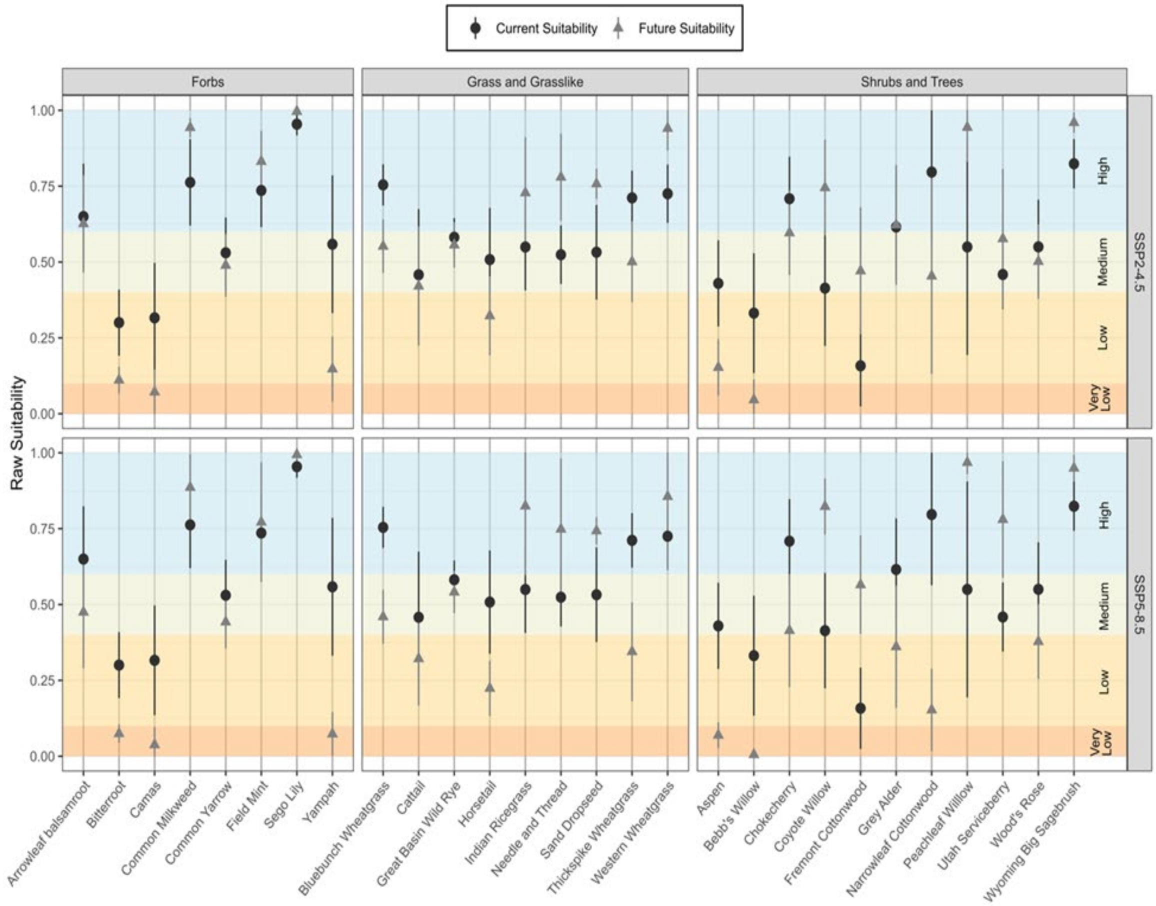

Figure 10: Climate risk analysis using Species Distribution Models (Koutzoukis et al, 2024). Culturally important species are located on the bottom of the X axis. The two bars show historic (1970-2000) and future (2061-2080) suitability under medium (SSP2-4.5) and high (SSP5-8.5) climate change scenarios within Cache and Malad Valleys ecoregion. Points indicate means, and error bars indicate 95% confidence intervals for all pixels in the Cache and Malad Valleys EPA Level IV Ecoregion. Suitability classes are as follows: < 0.1 very low suitability, 0.1-0.4 low suitability, 0.4-0.6 medium suitability, > 0.6 high suitability.

An opportunity identified by USU and BIOWEST's ecological monitoring is that there are small populations of beaver, *Castor canadensis,* already living in the restoration area of Battle Creek. In fact, the traditional Shoshone name for Battle Creek is Beaver Creek. Active beaver dams were observed in an initial site survey in 2018, and ongoing beaver activity was documented through annual drone surveys and wildlife camera trap monitoring. Restoration efforts could expand and support beaver activity by constructing Process Based Restoration structures like Beaver Dam Analogues (BDAs) to regenerate structurally complex riparian habitat and potentially trap some of the sediment (Scamardo et al., under review).

Modeling of beaver habitat on Battle Creek using the Beaver Restoration Analysis Tool, or BRAT model (Macfarlane et al., 2017), found widespread opportunity for beaver restoration (Figure 11). The BRAT model predicts where and at what densities beaver dams can be built and the results identify target areas for conservation and restoration. The construction of BDAs and enabling beaver activity facilitates a suite of hydrologic, geomorphic, and ecological feedbacks that increase stream complexity and channel–floodplain connectivity that improves aquatic and riparian habitat. Renewing a relationship with beaver is a restoration strategy that is increasingly used successfully across North America (Skidmore and Wheaton, 2022). However, the opportunity to support beaver activity as a strategy for watershed restoration is compounded by challenges in beaver management identified by the social science team.

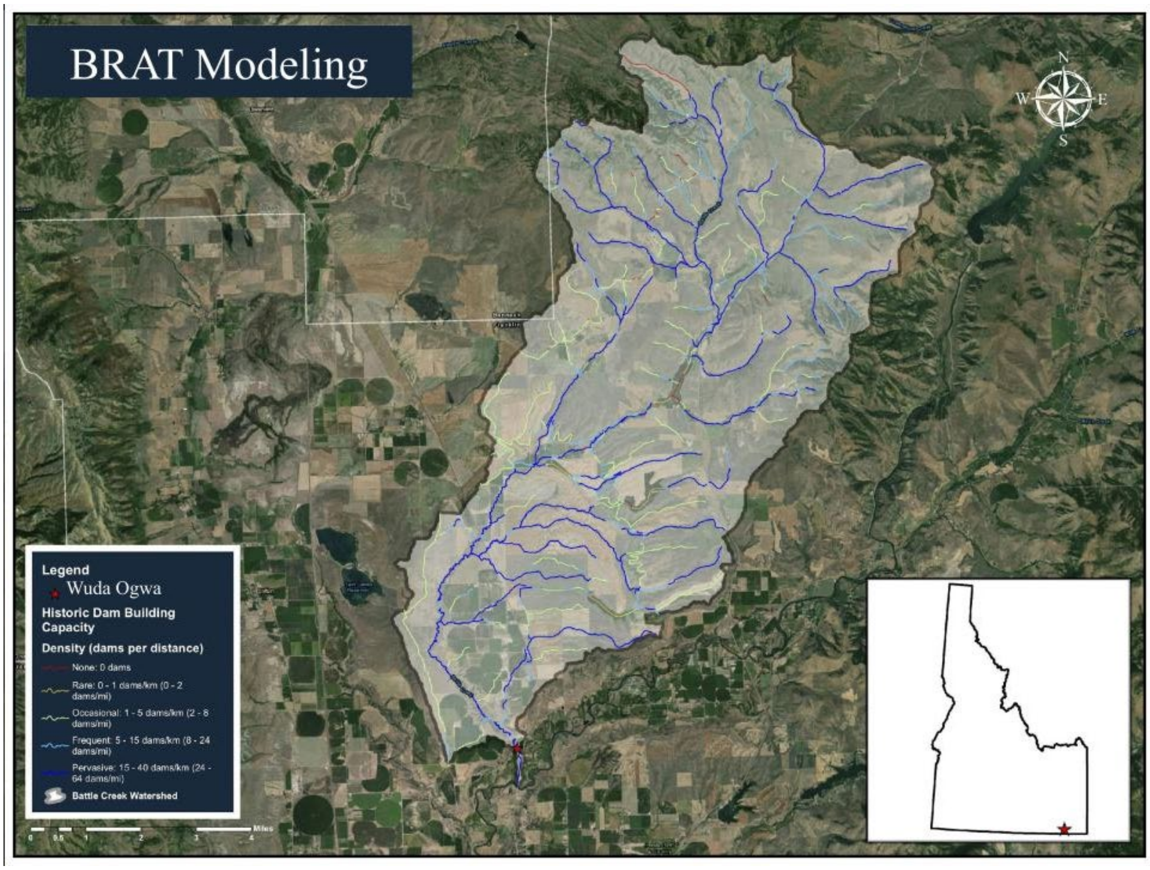

Figure 11: Beaver Restoration Analysis Tool (BRAT) modeling of Battle Creek watershed (light shaded area of map). BRAT modeling of beaver habitat on Battle Creek found widespread opportunity for beaver restoration (blue sections of the watershed). Battle Creek enters the Wuda Ogwa site at the red star at the bottom of the watershed. Map created by Kyle Todechenee (2020).

Challenges and opportunities from the social science analysis

The Battle Creek and Bear River watersheds are managed by a mosaic of owners whose land management practices influence stream conditions downstream at the Wuda Ogwa site. Working together across this landscape of working farms and ranchers to care for and improve watershed conditions represents a key restoration challenge. Twenty-one semi-structured interviews were conducted with Battle Creek and Bear River landowners by USU graduate students (Stocker, 2021; Woodbury, 2024). These interviews asked about participants' relational values and local knowledge of the landscape and watershed. The social science team's interviews with neighboring farmers and ranchers showed that there is interest in caring for and stewarding the watershed—a clear opportunity. They also found concern about several water and land management issues at a local and regional scale. Battle Creek is tributary of the Bear River, which is part of a larger three-state management system that includes Wyoming, Idaho, and Utah. The Bear River is the largest tributary to the Great Salt Lake (GSL), and there is increasing downstream public and political attention on upstream land management practices due to the current water crisis at the GSL (Larsen, 2024).

A major finding from interviews conducted by Woodbury (2024) is that livelihood is a key relational value for ranchers and farmers in the Battle Creek and Bear River watersheds. Woodbury's findings show that agricultural livelihoods are embedded in various social contexts, impacting identity, community, and other values associated with the ability to make major changes. The interviews with farmers and ranchers found evidence that they are paying close attention to regional water issues associated with the GSL crisis and local land management issues related to the Wuda Ogwa project. Many people value their independence and autonomy and many also expressed deep relational values to Battle Creek and the surrounding area:

> Well, my father was a farmer, and rancher, and so everything we had, everything we did was associated with the land that we have for the farm... that's where I really developed a bond, or whatever you want to call it with, with land. With the…property that it's almost…sacred. The rights and the responsibilities you have." (Participant 4)

> Well, I [was]… taught to just respect things and, and then just hard work. I think that hard work, working outside gives you … that respect that if you

> don't do good work…good things don't happen out there. So yeah, it's kind of my upbringing… you always want to leave it better than you found it and or try to fix anything you think is wrong with it. And that includes for human use, and or animal use. (Participant 7*)*

Neighboring landowners expressed a strong value around transparency, noting a desire to be informed of restoration actions that might impact their operation or change their way of life. Examples included increasing numbers of visitors in the area, loss of water rights, and flooding nearby houses and irrigation infrastructure due to beaver activity. One interview found an example of local distrust in scientists and government coming from past land management mistakes. The example was the introduction of the Russian Olive tree by the National Resource Conservation Service (NRCS) as a bank-stabilizer in the early twentieth century, which has resulted in current struggles with the management of the invasive species. A central finding from the social science team is that achieving ecological restoration objectives is best supported by active communication among landowners along Battle Creek about the Wuda Ogwa restoration plans as well as organizing opportunities to collaborate on upstream restoration activities.

Neighboring farmers and ranchers were generally supportive of the Wuda Ogwa project; however, interviews showed variance in mental models of how the ecosystem functions. Several shared their perception that Battle Creek has always been a “muddy little creek” and that it is a waste of resources to try restore it. An ecological issue identified by several interviewees is that the soil types in the watershed are very erodible and alkaline. In regard to beaver management, interviews suggested that landowners are cautiously supportive of beaver but “in the right place.” There is a long history of settlers perceiving beaver as a nuisance. One interviewee said about beaver: “We love em, we shoot em,” referring to when beaver block water infrastructure in the upper watershed.

People were more supportive of beaver existing lower in the Battle Creek watershed near the Wuda Ogwa site, where there was less risk of upstream culvert and road damage. Other interviewees expressed that beaver are useful higher in the mountains, where they can store water and improve forage quality. Neighbors' perceptions of the restoration project also reflected their views on land ownership.

> But, you know, at the end of the day, they [NWBSN] own the land, and as long as it's legal what they're doing… I can be a little upset about it, but … I'll defend their right to do what they want on their land and as much as I would hope they would defend my right to do what I would like on my land as well. (Participant 12)

These findings show some of the challenges with adaptively managing an ecosystem that sits across spaces with different ownership: people have different mental models of how the ecosystem works and there are different interests based on livelihoods. Braiding together these different local, Indigenous, and scientific knowledges requires long-term commitment to building relationships, trust, and the capacity to communicate and collaborate.

The interview data show there are several opportunities for collaboration between the NWBSN and neighboring landowners. One area for this potential collaboration is in establishing native plants to replace the Russian Olive (Stocker 2021). Some interviewees also communicated potential interest in restoring riparian areas as well as building check dams and wetlands to address water quality:

> The biggest issue is, from what I can see, is the concerns about the Bear River and that water going into the Bear River without having some kind of treatment going through a wetland or something like that to leach out some of that silt…We could easily do it up on my property by building dams or steps up through there, or we could just stop it a little bit here and then go up another 150 yards or something, put another little step dam in and, and we could do that kind of thing to keep it from erodin', and maybe trap enough of the water that we could get some vegetation growing in

> there. But that's the only way I could think that you could change the quality of it. (Participant 1)

In summary, a challenge identified in both the social and ecological research is that addressing underlying drivers of Battle Creek restoration requires managing an ecosystem that sits across a landscape ownership mosaic. Nonetheless, the social research identified an opportunity--the desire to collaborate and improve watershed stewardship. A main challenge to collaboration on shared restoration efforts across the Battle Creek ecosystem is concern about a negative impact on livelihoods. An implication is that watershed restoration efforts may be more successful if they ensure that agricultural livelihoods are not impacted, or are compensated with economic or social incentives. Other strategies could include cost-sharing approaches like sharing resources and volunteers to remove invasive species and plants native ones, build BDAs and rock detention structures (Norman et al., 2022), install beaver coexistence technology like pond levelers and relocate problem beavers. The interviews also showed that landowners shared a common sentiment of wanting to know what is happening and valuing transparency and communication. Ongoing sharing of ecological data and stories about the condition of the watershed and the Wuda Ogwa restoration efforts could address the desire for transparency and help align mental models about ecological health of the watershed.

Discussion

Dilemmas and questions that have emerged from the project to date

The dilemmas and questions that emerged from this initial knowledge braiding approach are both unique to a place and illustrative of broader complexities and trade-offs encountered in working lands conservation amidst climate change uncertainties. In Fischer et al.'s (2021) paper, a priority for climate adapted ecological restoration is to support people as stewards who navigate complexity. Collaborative co-produced research can play a role in helping restoration project teams navigate social and ecological complexity by helping to braid together plural knowledges and perspectives about a site and its many contexts. The summary, synthesis, and analysis presented in this article show how Wuda Ogwa is embedded in a complex landscape, watershed, and land ownership mosaic. There are diverse Indigenous, local, and scientific knowledges about the site, watershed, and landscape that are important to consider when planning management choices. The following examples show how a knowledge braiding approach can address some of these dilemmas and questions.

Ecological and social research on Battle Creek identified several dilemmas that are reflective of Simonson et al.'s s second principle of understanding and managing connectivity. One is related to the presence of several native fish refugia that BIOWEST scientists discovered upstream from Wuda Ogwa. While initial restoration ideas included removing fish passage barriers like irrigation diversions to support native Cutthroat migration, more ecological consideration is now needed to evaluate the potential tradeoff to the identified refugia. The risk is that in connecting the upstream reaches, downstream invasive carnivores could impact the refugia population. As the locations of the refugia are upstream from Wuda Ogwa, the dilemma for developing a strategy for caring for these refugia is related to working across the land ownership mosaic as well as designing water infrastructure at the Wuda Ogwa site.

Another dilemma on Battle Creek is how to address the water quality issue. Should the NWBSN try to acquire additional acreage of riparian habitat to add to the Wuda Ogwa project? Are there riparian easements and conservation incentive systems that restoration partners could mobilize to improve water quality and riparian habitat on upstream lands? Navigating these coupled social-and ecological questions is a challenge that is likely to find resonance in many restoration projects on working landscapes.

Fischer and colleagues (2021) suggest that relational values can bridge gaps between actors. The Shoshone knowledge and local knowledge that is shared in this article both show deep and unique relational values that encompass responsibilities and connections to caring for and stewarding the landscape. Bridging between agricultural livelihoods and Indigenous connections to ancestors and place is a large and difficult gap to bridge, especially in the context of settler-colonial violence and historical marginalization. Reciprocal recognition of relational values may contribute to bridging this gap and build collaborative capacity to navigate ecological restoration in an era of climate change. The knowledge braiding approach proposed by Kimmerer (2015) helps this bridging because it recognizes that each strand of plural knowledge is unique yet also considers how this knowledge is shaped by power structures and histories.

Another dilemma relates to the project's experimental use of biochar kilns to process removed Russian Olive. While these kilns provide a way to process biomass from removed Russian Olive trees into a soil amendment, more research is needed to identify the impact of this biochar on long-term soil health and the establishment of desired native plant species. Although biochar is a compelling Indigenous technique that sequesters carbon and potentially increases soil resilience to drought, local experimentation is needed to understand if it is appropriate for the Russian Olive feedstock and particular, in this case alkaline, soil conditions. The second pilot test had positive initial results and the project needs multi-year monitoring to verify the outcomes. The approach used in this co-produced research was to try small and iterative experimentation that could provide actionable results to inform management decisions. For example, the next step could try biochar production at a slightly larger scale and use more replicated treatment and control plots to achieve more robust results about this technique's ability to sequester carbon and improve soil health. This outcome illustrates the need for long-term research partnerships to co-produce and implement adaptive monitoring and restoration strategies.

A third dilemma emerged from the climate change risk modeling of culturally important species. Our modeling identified climate change risks to riparian species like Narrowleaf Cottonwood and Bebb's Willow. Cottonwoods and willows are both culturally significant to the Shoshone and play a major role in the oral history of the site. Restoring climate resilient populations of these riparian tree species is a clear way to meet the NWBSN's goal of making the site look and feel like pre-massacre conditions and understanding how to make these species resilient in the face of climate change risks is a major priority. Addressing these dilemmas requires transforming the site ecology and hydrology through active interventions (such restoring creek complexity and sinuosity) and ongoing management (like using water rights to irrigate restoration areas or organizing collective action around beaver management). These complex challenges reflect how principles for climate adapted ecological restoration are strengthened by an understanding of coupled social-ecological systems. While restoring native species has always been a main part of restoration ecology, a transdisciplinary knowledge braiding approach that includes climate modeling co-produces evidence that highlights the need to transform site conditions to increase ecological resiliency to climate risks.

The dilemma is how to restore at-risk native species when the land has been significantly altered by introduced species and human-induced changes in the functioning of site hydrology so that it is no longer suitable for those native species? A potential climate adapted ecological restoration approach is using a suit of actions that restore key ecological and hydrological processes. In this case, these actions include supporting beaver activity, installing BDAs, and building upland rock retention structures in addition to creating new meandering creek channels and wetland ponds (Norman et al., 2022). This approach is supported by multiple strands of the evidence braid from the BRAT model, drone and camera trap modeling, local rancher knowledge, and Shoshone oral history. Ongoing adaptive monitoring of restoration trajectories will be needed to assess how designs are able to cope with future flood and drought events. Beaver dams and beaver dam analogs can also act as a reservoir for surrounding vegetation, offsetting the negative effects of seasonal and longer-term drought (Jordan and Fairfax, 2022; Skidmore and Wheaton, 2022). While our models show some climate risks (and potentially opportunities) to native species, how will project managers and partners evaluate plant varieties and planting techniques to mitigate risk and continue designing for ecological resilience? The implication here is a similar need to build capacity for ongoing adaptive management and monitoring that can account for climate change pathway uncertainties and risks.

Renewing relations with a species like beaver is a challenge because of long-held settler mental models of the species as a nuisance. Interviews by both Stocker (2021) and Woobury (2024) showed diverse local mental models and ways of relating to beaver. Some ranchers perceive that beavers bring significant ecological and hydrological value to the landscapes that they manage. The ecological and social evidence suggests that strengthening relationships with neighboring landowners and key non-human species is a promising way to address larger drivers of ecosystem degradation across the landscape. Transforming relationships and mental models of beaver activity may be a pathway to build the ecological and hydrological resilience of the Battle Creek watershed. One potential way to do this is to build the collaborative capacity of the landowners along the watershed. For example, if Wuda Ogwa partners helped to build capacity to trap and relocate problem beavers, then it might address landowners' legitimate concerns while reducing the amount of lethal removal. Similarly, partners could help build adaptive beaver infrastructure like pond leveling devices and culvert protective fences along the watershed to reduce risks to livelihoods. A collaborative approach that recognizes livelihoods and plural relational values could help shift attitudes towards beavers. This is another area where long-term co-produced social-ecological research might help refine working lands conservation strategies.

Reflections on climate-adapted ecological restoration

The Wuga Ogwa project presents an opportunity to reflect on the seven principles of restoration design and implementation to support climate-adapted ecological restoration that was introduced in the literature review (Simonson et al 2021). The first principle in climate-adaptive restoration is to consider climate change risks and uncertainties when setting restoration objectives. Broad scale climate risks and uncertainties are identified in large interdisciplinary reports like the Fifth National Climate Assessment and the IPCC report. In the Intermountain West region where Wuda Ogwa is located, drought and increasing aridity are threatening water resources by increasing variability of snowpack, surface water, and groundwater (USGCRP, 2023). High temperatures have intensified droughts and there is a high likelihood of a more arid future. At the same time, the region is experiencing more intense precipitation events that increase risk of flooding.

Central climate uncertainties for Wuda Ogwa revolve around how a warming climate will affect hydrology at the site. Historically, the site was nurtured by snowmelt that flowed into the Bear River and Battle Creek. Now that both watersheds are extensively dammed, how will warming temperate affect water delivery? If there is more rain than snow, will that rain come in increasingly variable events? The historically high 2023 spring flood that destroyed bridges and culverts while washing away hundreds of restoration plantings is a recent example of the need to consider climate risks. However, there is uncertainty in the climate modeling between the different greenhouse gas emission scenarios known as Shared Socioeconomic Pathways (SSPs). It is hard to predict which climate change pathway Wuda Ogwa will experience. This uncertainly drives home the need to keep assessing climate change conditions as restoration continues and develop adaptive capacity to adjust to future climate and site hydrology.

Downscaled climate risk models like the one braided into this paper provide a way to consider risks and uncertainties. However, it remains a challenge to translate these models into restoration designs and management strategies. This challenge is both social and biophysical in that successfully getting leaders, managers, and neighbors to engage with climate adaptation planning is quite difficult when there are more immediate pressing issues. One takeaway from the experience of knowledge braiding in this case is to present risk models and climate projections as part of an array of information streams that inform decision making. It takes time and intention to consider future climate risks and building adaptive capacity is a mid- to long-term proposition.

Simonson and colleagues' (2021) second principle is to select sites based on projected changes to climate and ecological connectivity. This topic is where ecological thinking needs to consider the cultural and spiritual connections that Indigenous people have to sacred and cultural sites. Even if a site has degradation issues and is considered ecologically vulnerable, how should ecologists relate to the fact that people still hold plural and relational values that motivate collective action? Wuda Ogwa is an example of how the Shoshone's history with the site is motivating restoration efforts because of the Tribe's cultural, historical and ecological relations to the site. Even though there are climate risks of droughts and floods at the site, there are ecological restoration actions that can heal the site's biodiverse habitat and eco-hydrological functions. The ecological connection of Wuda Ogwa to the larger Bear River and Great Salt Lake ecosystems is another motivation of wide public interest in the project. This interest has motivated hundreds of volunteers who have helped with restoration and monitoring work. The high level of connectivity both socially and ecologically means that Wuda Ogwa is a highly valuable site for ecological restoration despite degraded water quality conditions and climate risks like droughts and floods.

The third principle is to account for future distribution and fitness when choosing the target species or ecosystems. The knowledge-braiding approach in this paper addresses this by compiling a list of culturally important species and analyzing their potential distribution based on two climate scenarios (Koutzoudkis et al, 2024). What was unique about our knowledge-braiding approach is that we centered Shoshone knowledge and objectives. Recognizing and honoring Shoshone knowledge created opportunity to reimagine the site's ecology even after settler-colonialism has significantly altered the hydrology and species composition. By identifying downscaled, place-based, species-specific risks, this knowledge-braiding approach offers evidence that mangers can use to build the adaptive capacity of the site. Even though the modeling data show risks to plants like cottonwoods and willows, Shoshone knowledge and cultural connection to the plants make a stronger strand in the braid in the sense that their restoration will be prioritized despite the modeling data.

The fourth principle is re-establishing critical ecosystem interactions and microclimatic niches. This principle is being addressed by restoration actions that create structural complexity in riparian habitat. By slowing, sinking, and spreading water thorough the historical floodplain, restoration managers are attempting to create multiple microclimatic niches that offer lower-temperature refugia. Local knowledge gathered through interviews provides evidence that this fourth principle should also consider the social dimensions of organizing restoration across ownership boundaries, particularly in working landscapes such as Battle Creek. These ecosystem interactions and microclimatic niches are embedded in social systems and understanding these social dynamics allows for more comprehensive and coupled socio-ecological restoration designs and implementation strategies. An example of this is the need to work across land ownership boundaries to address water quality and riparian habitat along Battle Creek. Understanding how to engage local relational values as a bridge to potentially collaborate on cross-boundary riparian restoration upstream of Wuda Ogwa is an example of how a knowledge braiding approach can increase the robustness of this fourth principle.

The fifth principle is to identify and mitigate site-level climate change risks. Some of these risks have already come to pass, such as the destructive flooding experienced in 2023. Designing infrastructure like culverts, road, and irrigation systems should consider that flood zones may change along with the magnitude and frequency of fluvial and pluvial events.

The sixth principle is to align projects with long term policies, seeking synergies across multiple objectives. Historically, long term land management policies in the United State have not respected Indigenous knowledge or considered local knowledge as relevant to science-based decisions. The NWBSN’s activism both at Wuda Ogwa and the Great Salt Lake is playing a critical role in changing the story that is being told about the larger GSL ecosystem. By making the watershed cultural connection through media events and storytelling, Shoshone leaders have created a connection between Wuda Ogwa in rural southeastern Idaho and a growing constituency in the urban Wasatch Front. This activism has mobilized large volunteer events at Wuda Ogwa as well as increased recognition from state agency staff and political leaders. For example, hundreds of people from all over the region joined the NWBSN for a tree planting day in 2023 and multiple state officials have recognized the important role the Tribe is playing in stewarding water to ensure that the Bear River and GSL are healthy.

Recognizing the synergy between the Shoshone's multiple objectives also has important implications for understanding the values that are motivating people to engage in restoration, conservation, and climate adaptation work. For example, for over 150 years, Shoshone members worked to tell their story and gain recognition for their people. Recognizing this agency and intergenerational persistence is a powerful story that shows how connection to place and culture motivates care and stewardship. The Shoshone knowledge of relating to the Great Salt Lake as more than human kin carries profound implications for responding to the current water crises. Former Tribal Council Chairman Darry Parry often tells the story of how his Grandmother, Mae Timbimboo Parry, referred to the lake as "Grandmother Water." In this perspective, stewarding the lake and the watershed is part of renewing our relationships to more-than-human kin by protecting and caring for their long-term well-being. This Indigenous knowledge and their relational values have demonstrated considerable power to bring people together to find synergies across multiple objectives.

The seventh principle is to design a monitoring framework that enables adaptive management of the ecosystem trajectory. Current examples of putting this principle into practice include the installation of climate and streamflow gauging stations at Wuda Ogwa. Collecting detailed baseline data in the current phase will allow for more robust adaptive management in the future to evaluate the ecosystem trajectory. Monitoring frameworks also require thinking about people and governance. A knowledge-braiding framework based on co-produced science emphasizes how restoration monitoring should continually include and engage the people who have the ability to influence the site's ecological trajectory. For example, organizing co-monitoring with Shoshone managers and neighboring landowners could help all involved understand each other's mental models about the drivers and issues of the local ecosystem. In the summer of 2023, the Wuda Ogwa Stewardship program brought Shoshone elders and youth out to a neighboring ranch where beaver restoration is ongoing. The conversations about how to monitor beaver activity showed compelling mutual interest in stewarding the health of the watershed and in building relationships across boundaries.

Implications for the field of climate adaptation, ecological restoration, and collaborative co-produced research

Building adaptive capacity involves increasing both the ecological resilience of a site as well as the collaborative capacity of the land managers and partners. Adaptation approaches address three ecological areas of action: resistance, resilience, and transformation (St-Laurent et al., 2021). Resistance actions are designed to maintain current or historical structures and functions. Examples at Wuda Ogwa include identifying existing native vegetation and wildlife habitat on the site. From a historical and socio-cultural perspective, Shoshone activism and land reclamation resists the cultural erasure of settler-colonialism. Restoration at Wuda Ogwa affirms ongoing Shoshone relationships to land, culture, and more-than-human kinships.

Resilience actions are designed to improve the capacity of a system to return to desired past or current structures and functions following a disturbance. One example is removing invasive plant species (e.g., Russian Olive) while planting native species (e.g., willow, cottonwood, and milkweed) that support wildlife, fish, and pollinators. Another example is riparian restoration that restores the historical riverscape's capacity to absorb and rebound from both floods and droughts. A final example is site-specific climate and watershed monitoring (e.g., installation of a weather station at Wuda Ogwa) to understand if conditions are pushing against a climactic threshold.

Transformational actions are designed to allow or drive a transition towards new structures and functions. The NWBSN's strategy for Wuda Ogwa's restoration intends to transform the site from an ecologically simplified, degraded, drought and flood vulnerable state to a more ecologically complex condition with greater resilience to increasingly variable precipitation and temperatures. For example, channel simplification and incision will be addressed with Process-Based Restoration, Beaver Dam Analogues, Post Assisted log structures, and "living with beaver infrastructure" like culvert exclusion devices. These transformative actions build ecological resilience by slowing, sinking and spreading water across the land while restoring species identified as important to NWBSN culture. While the presence of modern infrastructure like highways, powerlines, and irrigation canals means that there is little ability to completely restore the site to pre-massacre conditions, having agency over the care and responsibility of the site is deeply meaningful to the NWBSN as evidenced in their annual commemoration ceremony, recent Wuda Ogwa film, publications, and interviews with the media.

Transformational actions intertwine across ecology and culture. At a 2023 volunteer tree planting events, Wuda Ogwa Project Manager Brad Parry spoke of culturally transforming the site, “By inviting you all out and doing this...We want to make this a place to come again.” What this cultural and ecological transformation means is healing the land and our human relations from colonialism while renewing our relationships to each other and the more-than-human world. Cultural Specialist Patty Timbimboo-Madsen describes this dynamic well: “Relationships are building and I’m thankful for that. Partners bring us all together because we’re all working and learning from each other. That knowledge that they have, that we give them, they learn to see us as human beings and not just Indians” (NWBSN, 2024). Her words speak to the need for settler-scientists to transform our understandings and relationships to prioritize respect, humility, and reciprocity. These descriptions of ecological, cultural, and interpersonal transformation have important lessons for the growing field of collaborative capacity. This capacity is defined as developing, supporting, and implementing collective, inclusive, equitable, and scalable impacts, including the ability to collaborate, to influence others, and to share leadership (Baxter and Land, 2023). A knowledge-braiding approach can help build ecological resilience and collaborative capacity by bringing together critical and plural ways of knowing to ecological restoration and climate change adaptation planning. This paper has argued that there is a need for transdisciplinary knowledge braiding that can help address complex socio-ecological restoration projects. A key insight from this case study is the centrality of long-term, placed-based relationships in enabling meaningful knowledge braiding.

Knowledge braiding is an important concept because it emphasizes the unique and plural qualities of knowing the world. Robin Wall Kimmerer (2015) emphasizes how braiding both sweetgrass and knowledge can bring us into reciprocal relationship with each other. The Wuda Ogwa case study show an example of how knowledge braiding can play a role in self-determined planning for climate change. Restoration efforts at Wuda Ogwa shows how renewing Shoshone knowledge involves healing and renewing relationships with both humans and more-than-human kin. While this involves restoring persist relationships that are part of long-standing heritage such as origin stories and surviving terrible trauma, it also involves creating new relationships that support mobilization to address climate change and ecological degradation. Shoshone knowledge and values about reciprocally relating to the more-than-human world are a critically important framework for relating to the larger watershed issues that connect Wuda Ogwa to the Bear River and Great Salt Lake. Wuda Ogwa will contribute an estimated 10,857 annual acre feet to the Great Salt Lake, or around 2% of the 471,000 annual acre-feet of water that is needed to stabilize lake levels (Steed, 2024). While the quantitative contribution is very small, the qualitative contribution is huge because the Wuda Ogwa restoration project emotionally connects many different people to history, place, and the watersheds that connects us. These relational values are spreading through Shoshone stories, activism, and the shared restoration work at Wuda Ogwa.

Reflecting on the seven principles of climate-adapted restoration (Simonson et al. 2021) as well as the six priorities for social-ecological restoration (Fischer et al. 2021), this paper offers insight from the Wuda Ogwa restoration project into nine social-ecological elements identified by the analysis of this paper as central to this project and similar efforts (Figure 12). These elements are 1) Understanding livelihoods and working lands; 2) Braiding multiple knowledges; 3) Building social relationships; 4) Cultivating cross-boundary collaborations; 5) Growing capacity to navigate change; 6) Facilitating dialogue about potential climate futures; 7) Exploring the provision of conservation economic incentives; 8) Engaging plural values and motivations; 9) Supporting boundary spanning organizations and personnel. Comparing these nine elements to the experiences of other similar ecological restoration projects will help build a base of evidence as to what enables climate adapted ecological restoration in working landscapes.

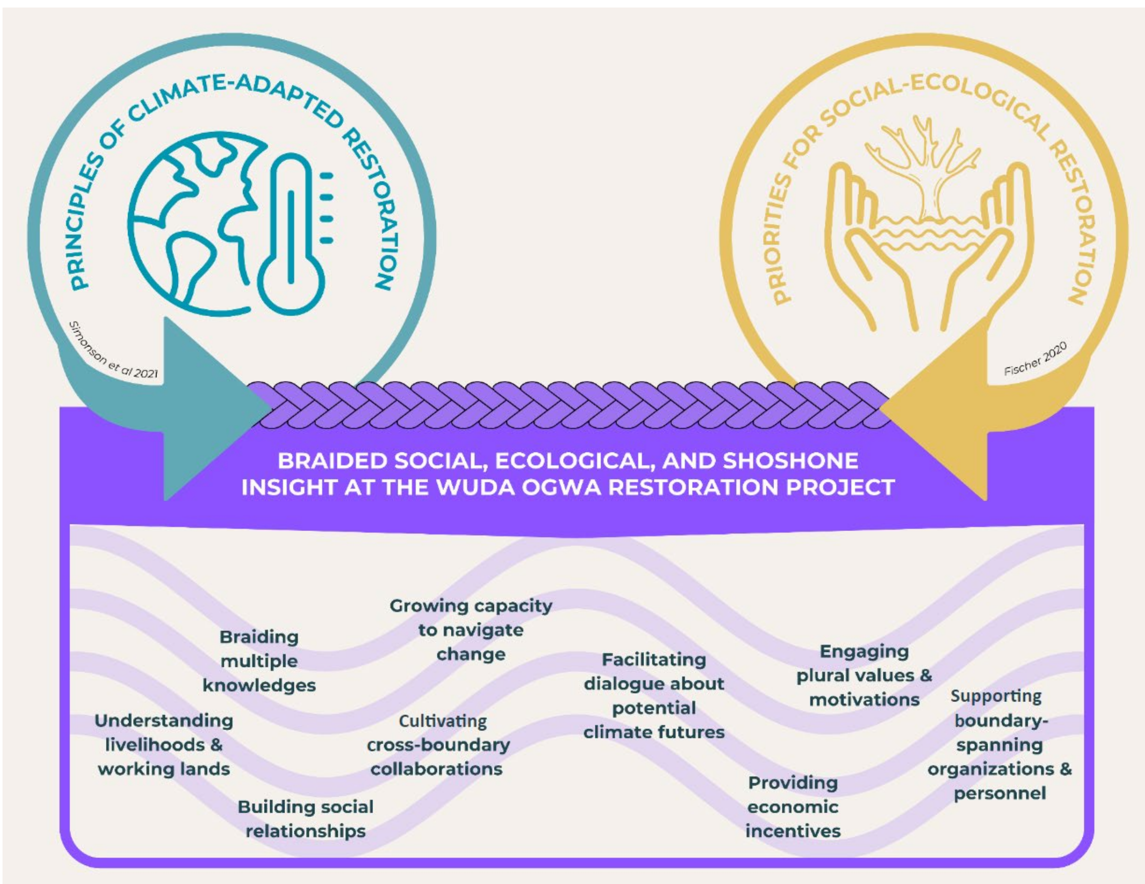

Figure 12: Key socio-ecological elements of a knowledge braiding approach to climate adapted ecological restoration. These nine elements reflect lessons learned from the Wuda Ogwa restoration project.

Conclusion

The Wuda Ogwa project supports the cultural identity of the NWBSN by creating a place of healing where the Tribe brings people together to heal from historical trauma, strengthen their relationships to a part of their traditional territory, collaborate with partners who believe in their vision for this place, and teach others about their culture, history and resilience. Ecologically restoring this site includes aesthetic, spiritual, knowledge, social identity, and educational benefits. The significant value associated with the Tribe telling their stories of persistence and resilience joins a wider conversation involving Indigenous communities in the Intermountain West and across the world work to the restoration and “re-storyation” of historic sites where settler narratives have previously marginalized Indigenous narratives (Nabhan 1991; Kimmerer 2017). Around the world, there is a need to continue listening to Indigenous perspectives about how to approach co-management, ecological restoration, and climate adaptation.

The Shoshone people have always used stories to advocate for a connection to land as pedagogy (Parry 2019). For example, consider Mae Timbimboo’s story of relating to the Great Salt Lake as Grandmother Water and how that relationship, rather than ownership, might guide future water management decisions. The current era is experiencing a resurgence of Indigenous activism, scholarship, and land management practices. There are important discussions needed on how to ethically and responsibly bring Indigenous knowledge into academia, as a way of legitimizing the knowledge of Indigenous peoples. Part of these discussions are advanced by attention to the CARE principles of collective benefit, authority to control, responsibility, and ethics in collaborative ecological research (Jennings et al., 2023). By grounding this co-produced research in ongoing relationship and dialogs with NWBSN leadership, this article strives to embody the CARE principles by articulating data sovereignty protocols (Appendix 2) and ensuring co-produced research products benefit and are relevant to the Wuda Ogwa project goals.

This paper presents a summary, synthesis, and analysis of the efforts to co-produce science and braid knowledge in support of the NWBSN's goals of healing the land, exercising sovereignty, sharing their story, and practicing adaptive management given the uncertainty of climate change. It works to show the value of braiding knowledge for co-producing climate-adapted ecological restoration and how this project's insights can inform global restoration efforts by including transdisciplinary social and ecological research. Amidst a changing climate and a decade of ecosystem restoration, there is an opportunity to collectively dismantle settler-colonialism, care for human and more-than-human kin, and actively nurture plural ways of knowing and relating to land.

References

Baxter, J., Land, S., 2023. What does collaborative capacity make possible? Prevailing perspectives on the relationship between collaborative capacity and landscape stewardship outcomes. California Landscape Stewardship Network.

Bronen, R., Cochran, P., 2021. Decolonize climate adaptation research. Science 372, 1245–1245. https://doi.org/10.1126/science.abi9127

Chambers, J.M., Wyborn, C., Klenk, N.L., Ryan, M., Serban, A., Bennett, N.J., Brennan, R., Charli-Joseph, L., Fernández-Giménez, M.E., Galvin, K.A., Goldstein, B.E., Haller, T., Hill, R., Munera, C., Nel, J.L., Österblom, H., Reid, R.S., Riechers, M., Spierenburg, M., Tengö, M., Bennett, E., Brandeis, A., Chatterton, P., Cockburn, J.J., Cvitanovic, C., Dumrongrojwatthana, P., Durán, A.P., Gerber, J.-D., Green, J.M.H., Gruby, R., Guerrero, A.M., Horcea-Milcu, A.-I., Montana, J., Steyaert, P., Zaehringer, J.G., Bednarek, A.T., Curran, K., Fada, S.J., Hutton, J., Leimona, B., Pickering, T., Rondeau, R., 2022. Co-productive agility and four collaborative pathways to sustainability transformations. Glob. Environ. Chang. 72, 102422. https://doi.org/10.1016/j.gloenvcha.2021.102422

Chambers, J.M., Wyborn, C., Ryan, M.E., Reid, R.S., Riechers, M., Serban, A., Bennett, N.J., Cvitanovic, C., Fernández-Giménez, M.E., Galvin, K.A., Goldstein, B.E., Klenk, N.L., Tengö, M., Brennan, R., Cockburn, J.J., Hill, R., Munera, C., Nel, J.L., Österblom, H., Bednarek, A.T., Bennett, E.M., Brandeis, A., Charli-Joseph, L., Chatterton, P., Curran, K., Dumrongrojwatthana, P., Durán, A.P., Fada, S.J., Gerber, J.-D., Green, J.M.H., Guerrero, A.M., Haller, T., Horcea-Milcu, A.-I., Leimona, B., Montana, J., Rondeau, R., Spierenburg, M., Steyaert, P., Zaehringer, J.G., Gruby, R., Hutton, J., Pickering, T., 2021. Six modes of co-production for sustainability. Nat Sustain 4, 983–996. https://doi.org/10.1038/s41893-021-00755-x

Chan, K.M.A., Guerry, A.D., Balvanera, P., Klain, S., Satterfield, T., Basurto, X., Bostrom, A., Chuenpagdee, R., Gould, R., Halpern, B.S., Hannahs, N., Levine, J., Norton, B., Ruckelshaus, M., Russell, R., Tam, J., Woodside, U., 2012. Where are Cultural and Social in Ecosystem Services? A Framework for Constructive Engagement. Bioscience 62, 744–756. https://doi.org/10.1525/bio.2012.62.8.7

Chan, K.M., Gould, R.K., Pascual, U., 2018. Editorial overview: Relational values: what are they, and what's the fuss about? Curr Opin Env Sust 35, A1–A7. https://doi.org/10.1016/j.cosust.2018.11.003

Chesnais, A.K., Brewer, J.P., Whyte, K.P., Saposhnik, R.S., Johnson, M.K., 2024. Reform Federal Policies to Enable Native American Regenerative Agriculture. Issues Sci. Technol. 40, 50–54. https://doi.org/10.58875/yqyw4711

Estes, N., Dunbar-Ortiz, R., 2020. Examining the Wreckage. Mon Rev 1–7. https://doi.org/10.14452/mr-072-03-2020-07_1

Fischer, J., Riechers, M., Loos, J., Martin-Lopez, B., Temperton, V.M., 2021. Making the UN Decade on Ecosystem Restoration a Social-Ecological Endeavour. Trends in Ecology and Evolution. Vol 36, 20–28. https://doi.org/10.1016/j.tree.2020.08.018

Ford, J.D., Pearce, T., McDowell, G., Berrang-Ford, L., Sayles, J.S., Belfer, E., 2018. Vulnerability and its discontents: the past, present, and future of climate change vulnerability research. Climatic Change 151, 189–203. https://doi.org/10.1007/s10584-018-2304-1

Frietsch, M., Loos, J., Löhr, K., Sieber, S., Fischer, J., 2023. Future-proofing ecosystem restoration through enhancing adaptive capacity. Commun. Biol. 6, 377. https://doi.org/10.1038/s42003-023-04736-y

Hernandez, J., 2022. Fresh Banana Leaves: Healing Indigenous Landscapes through Indigenous Science. North Atlantic Books.

Hubs, U.C., 2023. Vulnerability Assessment [WWW Document]. URL https://www.climatehubs.usda.gov/actions-and-resources/vulnerability-assessment

Hull, Hull, M.K., 1974. Pre-settlement Vegetation of Cache Valley, Utah and Idaho. Journal of Range Management 27, 27–29.

IPBES, 2019. Global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany. https://doi.org/10.5281/zenodo.3831673

IPCC, 2023. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland.

Itsiipootsikimskai, Atwood, S.B., Rider, A. (State of B.L.F., Provost, A. (Many V.M., Maffie, J., Brunson, M.W., Moccasin, M. (Berry C.P.W., Head, N.P. (Chief B.M.B., Frandy, T., 2023. Níksókowaawák as Axiom: The Indispensability of Comprehensive Relational Animacy in Blackfoot Ways of Knowing, Being, and Doing. Soc. Nat. Resour. ahead-of-print, 1–22. https://doi.org/10.1080/08941920.2023.2180696

Iwaniec, D.M., Cook, E.M., Davidson, M.J., Berbés-Blázquez, M., Georgescu, M., Krayenhoff, E.S., Middel, A., Sampson, D.A., Grimm, N.B., 2020. The co-production of sustainable future scenarios. Landscape Urban Plan 197, 103744. https://doi.org/10.1016/j.landurbplan.2020.103744

Jennings, L., Anderson, T., Martinez, A., Sterling, R., Chavez, D.D., Garba, I., Hudson, M., Garrison, N.A., Carroll, S.R., 2023. Applying the ‘CARE Principles for

Indigenous Data Governance' to ecology and biodiversity research. Nat. Ecol. Evol. 7, 1547–1551. https://doi.org/10.1038/s41559-023-02161-2

Johnson, D.E., Parsons, M., Fisher, K., 2022. Indigenous climate change adaptation: New directions for emerging scholarship. Environ Plan E Nat Space 5, 1541–1578. https://doi.org/10.1177/25148486211022450

Jordan, C.E., Fairfax, E., 2022. Beaver: The North American freshwater climate action plan. Wiley Interdiscip Rev Water. https://doi.org/10.1002/wat2.1592

Kadykalo AN, Cooke SJ, Young N. The role of western-based scientific, Indigenous and local knowledge in wildlife management and conservation. *People Nat*. 2021; 3: 610–626.

Kassi, N., Humphries, M.M., Dub, M., Dragon, J., Olivier, N., Bowser, K., Berry, M., 2022. Braiding Knowledges: The Canadian Mountain Network Experience. Mt Res Dev 42, P1–P6. https://doi.org/10.1659/mrd.2022.00026

Kimmerer, R., 2011. Human Dimensions of Ecological Restoration, Integrating Science, Nature, and Culture 257–276. https://doi.org/10.5822/978-1-61091-039-2_18

Kimmerer, R.W., 2015. Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants. Milkweed Editions.

Kimmerer, R.W. 2017. The Covenant of Reciprocity. In The Wiley Blackwell Companion to Religion and Ecology, J. Hart (Ed.). https://doi.org/10.1002/9781118465523.ch26

Klenk, N., Fiume, A., Meehan, K., Gibbes, C., 2017. Local knowledge in climate adaptation research: moving knowledge frameworks from extraction to co-production. Wiley Interdiscip Rev Clim Change 8. https://doi.org/10.1002/wcc.475

Koutzoukis, S., Munger, W., Capito, L., Parry, D., Parry, B., Klain, S.C., Brunson, M., Huntly, N., Taylor, T., 2024. Collaborative Knowledge Braiding for Restoration: Assessing Climate Change Risks and Adaptation Options at Wuda Ogwa in Southeastern Idaho, United States. Restoration Ecology.

Larsen, B., 2024. The Northwestern Shoshone are restoring the Bear River Massacre site. High Country News.

Latulippe, N., Klenk, N., 2020. Making room and moving over: knowledge co-production, Indigenous knowledge sovereignty and the politics of global environmental change decision-making. Curr Opin Env Sust 42, 7–14. https://doi.org/10.1016/j.cosust.2019.10.010

Levinthal, R., Weller, R., 2023. Mega-eco projects: a global assessment of large-scale ecological restoration initiatives. Socio-Ecol. Pr. Res. 5, 341–361. https://doi.org/10.1007/s42532-023-00157-7

Macfarlane, W.W., Wheaton, J.M., Bouwes, N., Jensen, M.L., Gilbert, J.T., Hough-Snee, N., Shivik, J.A., 2017. Modeling the capacity of riverscapes to support beaver dams. Connectivity in Geomorphology from Binghamton 2016 277, 72–99. https://doi.org/10.1016/j.geomorph.2015.11.019

Marks-Block, T., Lake, F.K., Bird, R.B., Curran, L.M., 2021. Revitalized Karuk and Yurok cultural burning to enhance California hazelnut for basketweaving in northwestern California, USA. Fire Ecol 17, 6. https://doi.org/10.1186/s42408-021-00092-6

Marks-Block, T., Tripp, W., 2021. Facilitating Prescribed Fire in Northern California through Indigenous Governance and Interagency Partnerships. Fire 4, 37. https://doi.org/10.3390/fire4030037

Martin, D.M., 2017. Ecological restoration should be redefined for the twenty-first century. Restor. Ecol. 25, 668–673. https://doi.org/10.1111/rec.12554

McAvoy, D.J., 2023. Big Box Biochar Kiln Operation and Best Practices. J. Vis. Exp. https://doi.org/10.3791/65362

McElwee, P., Fernández-Llamazares, Á., Aumeeruddy-Thomas, Y., Babai, D., Bates, P., Galvin, K., Guèze, M., Liu, J., Molnár, Z., Ngo, H.T., Reyes-García, V., Chowdhury, R.R., Samakov, A., Shrestha, U.B., Díaz, S., Brondízio, E.S., 2020. Working with Indigenous and local knowledge (ILK) in large-scale ecological assessments: Reviewing the experience of the IPBES Global Assessment. J Appl Ecol 57, 1666–1676. https://doi.org/10.1111/1365-2664.13705

McGregor, D., Restoule, J., Johnston, R., 2018. Indigenous Research: Theories, Practices, and Relationships. Canadian Scholars Press.

Mehltretter, S., Bradford, A., Longboat, S., Luby, B., 2024. In a Good Way: Braiding Indigenous and Western Knowledge Systems to Understand and Restore Freshwater Systems. Water 16, 934. https://doi.org/10.3390/w16070934

Miller, B.W., Schuurman, G.W., Symstad, A.J., Runyon, A.N., Robb, B.C., 2022. Conservation under uncertainty: Innovations in participatory climate change scenario planning from U.S. national parks. Conservation Sci Pract 4. https://doi.org/10.1111/csp2.12633

Nabhan, G. P. 1991. Restoring and Re-storying the Landscape. *Ecological Restoration*, **9**, 1, 3–4.

Norgaard, 2018. Salmon and Acorns Feed Our People. Rutgers University Press.

Norman, L.M., Lal, R., Wohl, E., Fairfax, E., Gellis, A.C., Pollock, M.M., 2022. Natural infrastructure in dryland streams (NIDS) can establish regenerative wetland sinks that reverse desertification and strengthen climate resilience. Sci Total Environ 849, 157738. https://doi.org/10.1016/j.scitotenv.2022.157738

NWBSN, 2024. Restoring Sacred Ground. Centerstar.

Pacheco, R., 2022. Shoshone Plants: Coloring Book and Guide. Northwestern Band of the Shoshone Nation and Utah State University.

Parry, B., Andrew, B., 2023. Bear River (Wuda Ogwa) Massacre Site Ecological Restoration.

Parry, D., 2019. The Bear River Massacre: A Shoshone History. Common Consent Press.

Pavlik, B.M., Louderback, L.A., Vernon, K.B., Yaworsky, P.M., Wilson, C., Clifford, A., Codding, B.F., 2021. Plant species richness at archaeological sites suggests ecological legacy of Indigenous subsistence on the Colorado Plateau. Proc National Acad Sci 118. https://doi.org/10.1073/pnas.2025047118

Recio, E., Hestad, D., 2022. Indigenous Peoples: Defending an Environment for All. International Institute for Sustainable Development.

Reid, A.J., Eckert, L.E., Lane, J., Young, N., Hinch, S.G., Darimont, C.T., Cooke, S.J., Ban, N.C., Marshall, A., 2021. "Two-Eyed Seeing": An Indigenous framework to transform fisheries research and management. Fish Fish 22, 243–261. https://doi.org/10.1111/faf.12516

Reyes-García, V., Fernández-Llamazares, Á., McElwee, P., Molnár, Z., Öllerer, K., Wilson, S.J., Brondizio, E.S., 2019. The contributions of Indigenous Peoples and local communities to ecological restoration. Restor Ecol 27, 3–8. https://doi.org/10.1111/rec.12894

Rigolot, C., 2020. Transdisciplinarity as a discipline and a way of being: complementarities and creative tensions. Humanit. Soc. Sci. Commun. 7, 100. https://doi.org/10.1057/s41599-020-00598-5

Roberts, K.G., Gloy, B.A., Joseph, S., Scott, N.R., Lehmann, J., 2010. Life Cycle Assessment of Biochar Systems: Estimating the Energetic, Economic, and Climate Change Potential. Environ. Sci. Technol. 44, 827–833. https://doi.org/10.1021/es902266r

Saldaña, 2016. The coding manual for qualitative researchers. SAGE, Thousand Oaks, California, USA.

Satterfield, T., Gregory, R., Klain, S., Roberts, M., Chan, K.M., 2013. Culture, intangibles and metrics in environmental management. J Environ Manage 117, 103–114. https://doi.org/10.1016/j.jenvman.2012.11.033

Scamardo, J., Munger, W., Loria, K., Nauman, B., Wang, J., Leopold, S., Heggli, A., Huntly, N., Baker, M., Meadow, A.M., under review. Lessons Learned: Trends in the Outcomes, Practice, and Law of Low Tech Process-Based Restoration in Western Rangelands. Rangeland Ecology and Management.

Simonson, W.D., Miller, E., Jones, A., García-Rangel, S., Thornton, H., McOwen, C., 2021. Enhancing climate change resilience of ecological restoration — A framework for action. Perspect. Ecol. Conserv. 19, 300–310. https://doi.org/10.1016/j.pecon.2021.05.002

Skidmore, P., Wheaton, J., 2022. Riverscapes as natural infrastructure: Meeting challenges of climate adaptation and ecosystem restoration. Anthropocene 38, 100334. https://doi.org/10.1016/j.ancene.2022.100334

Spude, C.H., 1995. Special Resource Study and Environmental Assessment of the Bear River Massacre Site. United States Department of the Interior-National Park Service, Denver, Colorado.

Steed, B., 2024. The Great Salt Lake Strategic Plan.

St-Laurent, G.P., Oakes, L.E., Cross, M., Hagerman, S., 2021. R–R–T (resistance–resilience–transformation) typology reveals differential conservation approaches across ecosystems and time. Commun. Biol. 4, 39. https://doi.org/10.1038/s42003-020-01556-2

Stocker, C., 2021. Characterizing Relational Values to Inform Message-Framing at the Boa Ogoi Historical Site. MSc thesis. Utah State University. Logan, Utah.

USGCRP, 2023. Fifth National Climate Assessment. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/nca5.2023

Wainaina, P., Minang, P.A., Muthee, K., 2023. Relational values within landscape restoration: a review. Curr. Opin. Environ. Sustain. 64, 101335. https://doi.org/10.1016/j.cosust.2023.101335

Walpole, E.H., Toman, E., Stidham, M. *et al.* The science and practice of ecological restoration: a mental models analysis of restoration practitioners. *Environ Syst Decis* **40**, 588–604 (2020). https://doi.org/10.1007/s10669-020-09768-x

Whyte, K.P., 2017. “Indigenous Peoples, Climate Justice, and Decolonial Philosophy.”

Wilcox, A.A.E., Provencher, J.F., Henri, D.A., Alexander, S.M., Taylor, J.J., Cooke, S.J., Thomas, P.J., Johnson, L.R., 2023. Braiding Indigenous knowledge systems and Western-based sciences in the Alberta oil sands region: A systematic review. Facets 8, 1–32. https://doi.org/10.1139/facets-2022-0052

Wilmer, H., Ferguson, D.B., Dinan, M., Thacker, E., Adler, P.B., Walsh, K.B., Bradford, J.B., Brunson, M., Derner, J.D., Elias, E., Felton, A., Gray, C.A., Greene, C., McClaran, M.P., Shriver, R.K., Stephenson, M., Suding, K.N., 2024. Resilience Is Not Enough: Toward a More Meaningful Rangeland Adaptation Science. Rangel. Ecol. Manag. 95, 56–67. https://doi.org/10.1016/j.rama.2024.04.003

Woodbury, S., 2024. The desert will blossom: LDS relational values and multispecies justice in the Intermountain West. MSc thesis. Utah State University. Logan, Utah.

Yazzie, M., 2018. Decolonizing Development in Diné Bikeyah. Environment and Society, Indigenous Resurgence, Decolonization, and Movements for Environmental Justice 19.

CHAPTER 5

DISSERTATION CONCLUSION

"Stewardship means acting responsibly to serve the needs of a community"

— National Congress of American Indians, 2009.

The articles in this dissertation are connected by the idea that working together on working landscapes requires building collaborations able to co-produce science, braid together plural knowledge, and build incentive structures that support intergenerational stewardship. These collaborations are strengthened by attention to relational values that emphasize humility, agility, persistence, and a shared understanding of place-based context. This idea is described in a conceptual diagram in Figure 13.

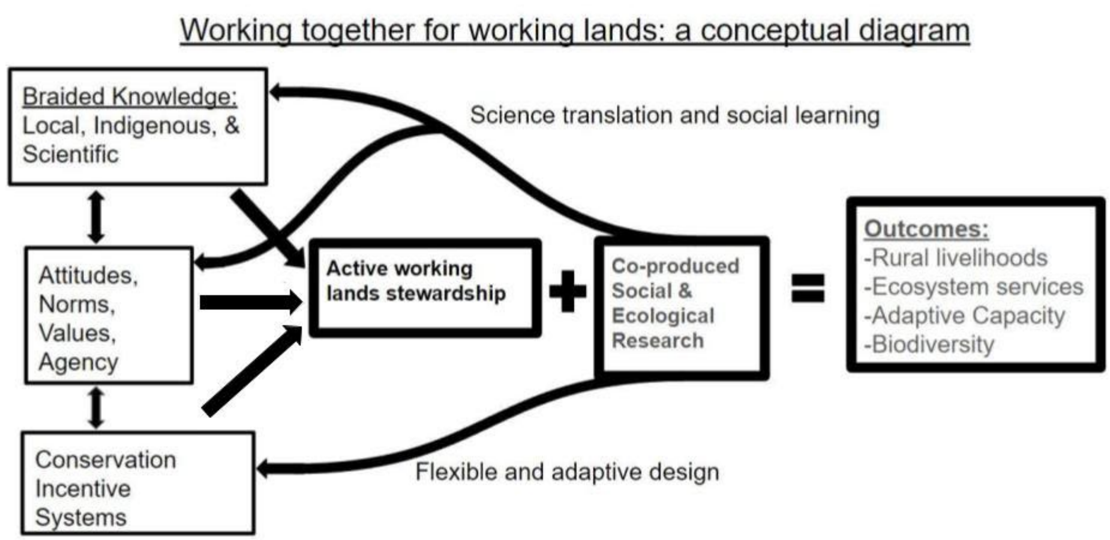

Figure 13: Working together for working lands conceptual diagram

This dissertation explored two strategies that may better support working together on working lands: conservation incentive programs and knowledge braiding. Article one explores the interaction between grazing livelihoods and participation in the Watershared conservation incentive program in Bolivia. Article two explores how Watershared field staff facilitate participation in ways that enable a relational approach to care-based stewardship. Article three explores how relationships and a knowledge braiding approach can support Shoshone stewardship of the Wuda Ogwa restoration site in the US West. When considered as whole, these articles show how working landscapes is a concept that is evolving to include diverse stewardship motivations as well as the need for plural ways of knowing and relating to the working land and human communities whose lives are braided together with the well-being of the land, water, and more-than-human kin.

While this work is slow and often challenging, this dissertation provides evidence that it is indeed possible to improve the ecosystems of working landscapes while improving rural livelihoods. Findings from this dissertation show the need for a collaborative and relational disposition amongst working lands researchers. Effectively and ethically working across boundaries requires humility, agility, persistence, understanding of context, and a commitment to reciprocity. Building adaptive capacity by braiding knowledge is possible and there is a need to gather a wider evidence base to strengthen the theoretical and pedagogical potential of these ideas.

In Adrienne Maree Brown's book, *Emergent Strategy: Shaping Change, Changing Worlds,* she argues that imagination is one of the spoils of colonization (Brown, 2017). The question of who gets to imagine the future for a given geography is a core political question with enormous implications. Reclaiming the capacity to imagine a future in the era of climate change and strengthening the collaborative capacity to imagine and act together is a need that bridges ecology, justice, and politics. Three of Brown's principles of emergent strategies reflect the findings in this dissertation including: 1) Change is constant; 2) Move at the speed of trust. Focus on critical connections more than critical mass — build resilience by building relationships; and 3) What you pay attention to grows (Brown, 2017).

As case studies and methods to support transdisciplinary collaborations continue to grow and evolve, the next steps will entail building an evidence base of how to theorize, situate, and facilitate these processes to support resiliency and transformation on working landscapes.

References

Brown, A., 2017. Emergent strategy. AK Press, Edinburgh, Scotland.

Appendices

Appendix A. Interview Instruments for Watershared Participants and Non-participants

Entrevista semiestructurado - Guía del participante

- Follow script for informed consent
- Test audio-recording device
- Confirm permission for audio recording and start recording

Municipality:
Community:
Interviewer:
Date of interview:
Time of interview:
Code of interviewee:

Sección 1. Tú, tu sustento y tu comunidad	
(Asegúrese de descifrar individual vs HH / familia en las entrevistas)	
	Para comenzar, me gustaría hacerle algunas Rápidos sobre usted y su familia y lo que hace.
1.	¿Cuánto tiempo hace vivido aquí?
Getting to know participant: • Crops • Cattle • Time in community	• Para empezar, ¿me contaría tu experiencia viviendo en esa comunidad? ¿Como fue tú tiempo aquí? • Afuera de usted, con quien más conforma de su familia en hogar ¿De dónde viven ellos? ¿Aquí? • ¿Podrías contarme un poco sobre lo que hace? (p. ej., cultivar, criar animales, trabajar en una ciudad cercana, etc.)? • ¿Podría decirme más que hace su familia para ganarse? • ¿Podrías hablarme de un día normal en tu vida? ¿Qué haces desde la mañana hasta la tarde? ¿Eso cambia de temporada en temporada? • ¿Que son los raíces culturas de tu familia?, (por ejemplo mi abuelo era alemán y por su música, cultura, idioma yo identifico como alemán)
2.	¿Tiene cultivos? ¿Qué tipo de cultivos cultivas?
If Crops not mentioned: • Do they plant?	• ¿Cosecha las plantas para el alimento en tu hogar, las vendes para el efectivo, o ambos?

• Types • Where do they plant • What do they plant	• ¿Qué cultivos te gustaría cultivar más? • ¿Dónde cultivas, es la tierra que tiene (esta compartido, en tierra indiviso, aquillado)?
3.	¿Crías animales domesticados en algún lugar o guardas animales en tu casa? ¿Qué animales tienes?
If animals not mentioned: • *Have them?* • *Types?* • *Consume/sell?* • *Where do they keep them?* • *Wildlife problems?*	• Pollo, cerdo, ganado, alpaca, ¿algo más? *Si el ganado es pronto ¿Cuántos ganados tienes? ¿Qué tipos?* *Si es ganado, solicite: ¿El ganado son de a usted o a alguien más en su hogar?* • ¿Consume sus propios animales? (por ejemplo, huevos, leche, piel, etc.)? • ¿Vende sus propios animales (por ejemplo, huevos, leche, piel, etc.)? • ¿Dónde crías tu ganado? ¿Es esto en la tierra que tiene? ¿Se comparte con tu familia? ¿Si no se alquila? • ¿Tienes algunos conflictos o interacciones con animales silvestres?
4. Type of land owned	¿Podría contarnos un poco más sobre la tierra que tiene en general? ¿Hay bosque o quebradas? ¿Qué tipo de árboles están en eso?
5.	Recuerda cuando llegaste aquí por la primera vez, ¿cómo decidiste donde construir tu casa, plantar tus cultivos, colocar tu ganado?
How decided where to build, plant, &keep animals	• ¿Hablaste sobre estas decisiones en su hogar o solo no más? ¿Hablas con su pareja? ¿Cómo fue esa conversación? • ¿Hablaste con sus vecinos u otros amigos o alguien en su comunidad ante que hizo esas decisiones? ?
6.	¿Trabaja usted o los miembros de su familia en algún lugar afuera de su propiedad
Work outside HH; • Types of Jobs • Who does them • Far or close to HH • Why	• ¿Qué tipo de trabajo hacen usted o los miembros de su hogar? • A dónde van ustedes / los miembros de su hogar a buscar trabajo? • Por qué ustedes / los miembros de su hogar eligen este tipo de trabajo? • Si es posible, ¿querría trabajar más o menos lejos de su tierra? • ¿Es difícil o fácil encontrar trabajo fuera de su tierra? • ¿Qué tipo de trabajo te gustaría ver hacer a sus hijos? ¿Quiere que trabajen en su propia tierra algún día? ¿O quieres que trabajen en la ciudad o en algún otro lugar?

¡Gracias por compartir eso conmigo!

Sección 2. Individual: Participación actual en ARA.

A continuación, me gustaría hacerle algunas preguntas sobre un programa en su área llamado Acuerdos Recíprocos De Agua (ARA) .

(Explico lo que el programa es en otras palabras, si es necesario [Proyecto de Natura, Proyecto de incentivas con Natura, etc.])

7.	¿Puedes decirme lo que sabes sobre ARA?
Do they know of ARA/how?	• ¿Has oído hablar de este programa? • ¿Cómo has oído hablar de ARA?
8.	¿Fuiste a la reunión donde explican el programa ARA?
How was the offering meeting; • Experiences? • Well explained?	• SÍ: ¿Podría hablarme sobre de esa reunión? (lo que hablaron, etc.) • SÍ: ¿Cómo te sentiste de la presentación? • SÍ: ¿Qué te pareció la presentación? • ¿si la respuesta es SI: ¿Usted entendió todo que explico? ¿Sentiste que entendiste cómo funcionaba bien?
9.	¿Cuáles crees que son los principales objetivos de ARA? ¿Cómo piensas en esas metas?
• ARA objectives • think it helps environment/ livelihood?	• ¿Crees que ARA se propone proteger los bosques? ¿Cree que está funcionando ahora? ¿Cómo es eso? • ¿Crees que ARA se propone mejorar la calidad del agua? ¿Cree que está funcionando ahora? ¿Cómo es eso?
10. Participant?	¿Está usted un participante en el programa ahora o ha participado en el programa en el pasado?
Le voy a hacer algunas preguntas sobre sus experiencias con el programa ARA hasta ahora.	
11.	¿Podría decirme porque tomar la decisión a participar en al programa?
Decision to participate:	• Hay otros factores / consideraciones en los que pensó cuando decidió participar con el programa ARA?

• Didn't want to/couldn't? • Something in the contract? • Feel it would impact; land/community? • Would they join if it was offered again?	• ¿Piensa que el programa crearía cambios en su agua o tierra? ¿Estaba motivado por los incentivos? • ¿Pensaste que participar en el programa afectaría a tu comunidad?
12.	¿Cómo tomo la decisión para participar en ARA?
Decision to join – included spouse/HH/neighbor/ community? Importance of spouse in decision	• ¿Hablaste sobre la decisión con su pareja? ¿Como fue esa conversación? ¿Y tomaste la ultimo decisión con ellos? ¿Converso la decisión con otros miembros del hogar? ¿Comento la decisión con otras personas en su comunidad (miembros que no son miembros del hogar)? • ¿Qué tan importante la opinión de su pareja en la decisión a participar in ARA?
13.	¿Me puede contar un poco sobre el contrato que firmó para participar en ARA?
Details of the contract	• ¿Cuánto duró? • ¿Qué parcela de tierra firmó en el programa? (Características de la parcela: presencia de arroyo, pluviometría típica, riego, vegetación, pendiente, altitud, ¿otros?)
14.	¿Cómo tomo la decisión a cuál de tus parcelas a poner en conservación?
Decision on which land top put in	
15.	¿Qué esperabas del programa cuando empezó? ¿Cómo se han cumplido tus expectativas hasta ahora?
Expectations of program & were they met?	• ¿Podría decirme más sobre qué expectativas tuyas no se cumplieron? • ¿Por qué no se han cumplido estas expectativas? ¿Por qué crees que esto sucedió?
16.	¿Puedes decirme las cosas que están prohibida en su contrato?
What is not permitted in the contract? • Provisions reasonable?	• ¿Crees que estas prohibida son razonables? ¿Por qué o por qué no? • ¿Siente que estas prohibiciones son las mismas para todos los que participan en un ARA?

• Same for everyone? • Know anyone who had to payback their incentives • What if you were falsely accused of failing to meet contract req.? • Who maintains contract reqs.? • Problems maintaining contract? • Problems with Natura?	• ¿Qué crees que paso si hagas algo prohibido en su contrato? ¿Hay alguna vez oído hablar de alguien que no cumple con las provisiones y que paso? • (Condicional) Si Natura dice que no cumpliste per que usted sabe que ha cumplido, ¿Qué harías? • ¿Cuál de las provisiones ha completado? ¿Quién en su hogar es responsable de cumplir con estas provisiones? ¿Quién hace el trabajo que es necesario para mantener estas provisiones? • ¿Cómo se ve ese trabajo? ¿Podrías darme un ejemplo? • ¿Podría decirme sobre algún problema que haya tenido que cumplir prohibiciones y mantener los provisiones? • ¿Cuál de las provisiones estaba la más difícil a cumplir o mantener? ¿Por qué - qué pasó? ¿Cuáles son algunos de los desafíos? • ¿Tuviste algún problema con Natura? ¿Esto ha afectado tu contrato de alguna manera?
17. If had C before and are in UC now; notice difference in contracts?	(Para comunidades con experiencias pasadas con ARA condicional): ¿Tenía un contrato antes de este? • Si es así, ¿hubo alguna diferencia en lo que este contrato que tiene ahora haga en comparación con el contrato anterior? ¿Qué piensa sobre de esas diferencias?
Gracias, yo sé que hablaste con nuestro equipo el año pasado, pero nos gustaría hablar con usted más sobre los incentivos que eligió como parte de su participación en ARA	
18.	¿Qué tipo de incentivos eligió?
19.	¿Podría decirme sobre su decisión de elegir (incentivo)?
• Why pick X incentive? • Expectations for self/land/etc.?	• ¿Cuáles eran tus planes para usar ____? • ¿Sintió que tendría algún impacto en su tierra o medio de vida? • ¿Sientes que tus expectativas se han cumplido?
20.	¿El incentivo que conseguiste, puedes obtener eso afuera de ARA o sin participar?

• Could you get X incentive outside of ARA? • Have you? • If not, why?	*Rápido SÍ*: ¿Has comprado el artículo en el pasado? Si no: ¿Qué le impidió comprar este incentivo en el pasado? *Rápido NO:* ¿por qué no? *(*Explorar *la capacidad, razones económicas, logísticas, de interés)*
¡Bueno! A continuación, nos gustaría hablarle más sobre sus incentivos específicos, usted dijo que eligió ______ ¿correcto?	
S i las cajas de abejas entrevistado mencionó, entonces pregunto: ¿Cómo ha sido su experiencia con las cajas de abejas?	

• Experience with bee boxes previously?
• If no – received training?
• Have they used it? Still using it?
• Needed additional materials?
• Who manages it?
• What do they do with the honey/products?
• Have they found it useful?
	a. ¿Ha tenido experiencia previa con el uso de cajas de abejas?
	b. Si la respuesta es NO: ¿Recibió capacitación sobre su uso?
	    a. ¿Usaste la caja de abejas? ¿Todavía lo estás usando? ¿Si no, porque no?
	c. ¿Hubo materiales adicionales que necesitaba para comenzar? ¿Cómo los obtuviste?
	d. ¿Quién ha estado manejando la caja de abejas?
	e. ¿Se cosecha de miel o hacer cualquier producto de la miel?
	f. ¿Qué hiciste con la miel o los productos de miel?
	g. Si se menciona la venta, ¿quién vendió la miel?
	    a. En general, ¿cree que la caja de las abejas fue útil o no para su hogar? ¿Cómo es eso?
	¿Qué te parece la variedad de árbol que elegiste? ¿Has tenido experiencias con esos? ¿Son injertadas?
	¿Recibió capacitación sobre el mantenimiento o cuidado de ellos?

Si los árboles frutales entrevistado mencionó, haga las siguientes Rápidos: ¿Cómo ha sido su experiencia con sus árboles frutales?	
	a) ¿Qué te parece la variedad de árbol que elegiste? ¿Has tenido experiencias con esos? ¿Son injertadas?

<table>
<tr>
<td>

- Experience with fruit trees previously?
- If no – received training?
- What varieties?
- Needed extra materials?
- Planted them?
- How's it going?
- Collected/sold fruit

</td>
<td>

i. ¿Recibió capacitación sobre el mantenimiento o cuidado de ellos?
ii. ¿Hubo materiales adicionales que necesitabas para comenzar?
b) ¿Plantaste los árboles frutales? ¿Están los árboles frutales todavía vivos? ¿Si no, porque no?
c) ¿Quién ha estado manejando los árboles frutales?
d) ¿Cosechaste alguna fruta?
e) ¿Qué hiciste con las frutas?
f) Si se menciona la venta, ¿quién vendió las frutas?

</td>
</tr>
<tr>
<td colspan="2">

<u>Si el entrevistado mencionó alambre de espino, politubo o tanque de agua, haga las siguientes preguntas:</u> <u>¿Cómo ha sido su experiencia con X?</u>

</td>
</tr>
<tr>
<td>

- Experience with X?
- Received training?
- Used it? How?
- Needed extra materials?
- Who put it up/maintains it?

</td>
<td>

¿Recibió alguna capacitación o ayuda con los incentivos?
i. ¿Hubo materiales adicionales que necesitó para usarlos?
ii. b) ¿Para qué usaste el alambre/ politubo / tanque de agua?
Si se mencionó la construcción de una cerca, pregunte: ¿la cerca todavía está funcionando? *Si no*, ¿por qué no?
a. d) Si se mencionó la construcción de politubos de agua o tanques de agua, pregunte: ¿Están las politubos de agua o los tanques de agua todavía en uso? ¿Si no, porque no?

</td>
</tr>
<tr>
<td colspan="2">

<u>Si el entrevistado mencionó pasto, como la siguiente Rápido:</u> ¿Cómo ha sido su experiencia al sembrar semillas de pasto?

</td>
</tr>
<tr>
<td>

- Experiences with planting forage seed?
- Received training?
- Needed extra tools?
- Is it still good?

</td>
<td>

¿Recibió algún tipo de asistencia o capacitación en la siembra de semillas de pasto?
¿Hubo herramientas o materiales adicionales que necesitó para plantarlos?
¿Podría decirme sobre su decisión sobre dónde plantarlos y por qué?
¿Me podría comentar su proceso para plantar las semillas?
¿El pasto en el que los plantaste sigue funcionando?

</td>
</tr>
</table>

Hemos hablado sobre las provisiones de sus contratos y los incentivos que recibió por ellos.	
21.	Al pensar en todo eso, ¿cree que el trabajo que realizó para mantener sus provisiones fue igual al que recibió de los incentivos que recibió de ARA?
Is work put in equal to benefit of program? OR worth it"?	Pregunto si NO: ¿Podría decirme lo que cree que sería igual? Pregunta si NO: ¿Siente que Natura escucharía si usted / la comunidad pidiera X? Pregunta si SI: ¿Podrías pensar en algo que lo haga diferente?
22.	¿Hay cambios de responsabilidades entre usted y su familia desde que firmó un contrato de ARA?
Changes in HH • What does it look like? • Change who does what in HH? • Change decisions in HH with spouse? • General changes	• ¿Me contarías un poco más sobre lo que ha cambiado? • ¿Hay algún nuevo trabajo debido a los contratos de ARA? ¿Para su pareja, hijos, familia extendida? • ¿Puedes contarnos los detalles de esto? • ¿Ha cambiado algo acerca de cómo se toman las decisiones en su hogar en general? ¿Cómo es eso?
23.	¿Participación en ARA ha cambiado su relación con los miembros de su familia, o la dinámica de su hogar? ¿Cómo es eso?
Conflicts in the change?	• ¿Ha habido algún conflicto? con tu pareja?
24. Changes relations with community?	¿Participación en ARA ha cambiado su relación con otros miembros de la comunidad, o entre su hogar y otras familias de su comunidad?
25.	¿Cómo ha cambiado como realizo su trabajo/ o actividad de trabajo como resultado de su participación en ARA?
Change in work due to ARA-	• ¿Había cambios en sus prácticas agrícolas debido las prohibiciones del contrato de ARA?

• In Ag work? • Cattle?	• Había cambios en su manejo del ganado por la causa de la prohibiciones del contrato de ARA?
26.	¿Qué piensas de esos cambios? ¿Han sido justos? ¿injusto?
Thoughts on changes? Is it just?	• ¿Podría decirme más sobre cómo han sido justos o injustos? *si INJUSTO: En su opinión, ¿cómo podría mejorarse esto?*
27.	En general, ¿se siente mejor o peor como resultado de su participación en ARA?
Feel better or worse about your participation in ARA	• ¿Podría compartir conmigo de qué manera se siente mejor / peor? *Indicación: (indague cómo han percibido los efectos de los medios de vida, el ganado, la agricultura, etc.)*
Sección 3. Comunidad: Participación actual en ARA.	
A continuación, me gustaría hacerle algunas Rápidos sobre su comunidad. Para empezar, ¿podrías decirme primero?	
28.	¿A quién consideras parte de tu comunidad? / Se relaciona más con sus vecinos más cerca o con toda la comunidad
How is community defined	• ¿Personas que viven en tu pueblo / ciudad? • ¿Otros agricultores en tu pueblo / ciudad?
29.	¿Conoces a otros que se han participado en ARA?
Know someone else who participates in ARA? Why did they? Did anything change for them? Did it influence your participation?	• ¿Por qué crees que se participó? • ¿Piense que algo cambio en su forma de vida por su participación ¿Podrías contarme un poco más sobre de eso? • ¿Influyó eso en tu decisión de participar o no? ¿Cómo es eso?
30.	¿Conoce a alguien que no participo, pero deseaba que podría haber participo?
Know someone who doesn't participate?	• ¿Qué crees que les impidió hacerlo?
31.	¿Piensa usted que toda la gente en la comunidad tiene la oportunidad a participar in ARA si quiere?

Do you think everyone has the same opportunity to participate? Motives? Thoughts?	• ¿Cuáles son algunos de los motivos por los miembros de la comunidad no pudieron participar? ¿Cómo se sienten al respecto? • ¿Cómo te sientes sobre eso? ¿Es justo o injusto, desde su perspectiva? ¿Por qué?
32.	En general, ¿cuáles son los efectos de ARA en su comunidad?
Impacts of ARA on the community? Benefits? Challenges? Are the changes just?	• ¿Qué beneficios has visto? • ¿Qué desafíos ha traído ARA a su comunidad? • ¿Cómo te sientes sobre eso? ¿Es justo o injusto, desde su perspectiva? ¿Por qué?
33.	¿Ha habido algún problema nuevo en su comunidad desde que comenzó ARA?
Any new problems in the community? Are they b/c of ARA? How could you resolve these problems?	• ¿Sientes que esos problemas se han debido a ARA? • ¿Puedes decirme más sobre lo que pasó? • ¿Qué ha hecho la comunidad para resolver los problemas? • ¿Me puede decir cómo cree que pueden resolverse estos problemas? • ¿Anticipa más problemas o conflictos en el futuro? Si es así, ¿qué crees que podría pasar? ¿Por qué?
34.	¿Ha cambiado la relación entre las personas en su comunidad desde que comenzó ARA, o ha cambiado la dinámica de la comunidad?
Have relationships within the community changed/dynamics? How do you feel about these changes? Just/in just.	• ¿Sientes que estos cambios se deben a que ARA esté presente en la comunidad? • ¿Podría decirme más sobre los cambios? ¿Por qué crees que ocurrieron estos cambios? • ¿Cómo te sientes sobre eso? ¿Es justo o injusto, desde su perspectiva? ¿Por qué?
35.	¿Ha cambiado la relación entre su comunidad y otras comunidades desde que comenzó ARA?
Anything changed between your	• ¿Podría decirme más sobre los cambios? ¿Por qué crees que ocurrieron estos cambios?

community and other communities How do you feel about that?	• ¿Cómo te sientes sobre eso? ¿Es justo o injusto, desde su perspectiva? ¿Por qué?
Sección 4. Percepciones sobre el medio ambiente y las ONG.	
36.	¿Podría contarme sus experiencias con Natura (la ONG que administra ARA)?
Personal experiences with Natura. Past/Present	• ¿Los conocías antes? • ¿Cuáles fueron tus pensamientos cuando presentaron el proyecto?
37.	¿Podría describir una interacción y que haya tenido con Natura?
Describe interaction with Natura Were they open/honest/respectful Has participating in ARA changed that relationship?	• ¿Qué piensas de esas interacciones? • ¿Te trataron con respeto? • Fueron abiertos/honestos al comunicarse con usted? • <u>*Pregunte si el entrevistado fue / es un participante:*</u> ¿Han cambiado tus interacciones con Natura desde que te iniciar programa? • <u>*Pregunte si el entrevistado fue / es un participante:*</u> ¿Alguien de Natura ha ido a visitarte a ti ya tu tierra? ¿Qué hicieron?
38.	¿Siente que ha habido algún cambio en los bosques y el agua a su alrededor, o cambios con la vida silvestre, ya que ARA estaba en su área?
Been change in forest or water since ARA started What changes have you noticed?	• ¿Sientes que esos cambios están directamente relacionados con ARA? • ¿Podrías contarme algunos de esos cambios que has notado? ¿Qué piensas de estos cambios? ¿Una cosa buena? ¿Un problema para ti? ¿Realmente no me importa?
39. Have any other comments/ideas	¿Tiene alguna otra idea sobre ARA ahora que desea que contarme? ¿Alguna otra idea sobre las necesidades de conservación de su comunidad?

Conclusion & Thank You

- Thank you again for taking the time to talk with us and share your thoughts.
- Hand them a copy of the Letter of Information, which includes all your contact information (if did not hand them this before started interview)
- Ask if they have any questions and make sure everything was clear
- Remind them everything is confidential
- Remind them where to find the results and/or contacts
    - Ask for contact info if they want to be given a summary of the results
- Stop recording
- Thank you again and goodbye

Record any observations, thoughts, feelings and/or reactions about the interview (from the interviewer's perspective) if any.

Entrevista semiestructurado - Guía del NON participante

- Follow script for informed consent
- Test audio-recording device
- Confirm permission for audio recording and start recording

Municipality:
Community:
Interviewer:
Date of interview:
Time of interview:

Sección 1. Tú, tu sustento y tu comunidad	
(Asegúrese de descifrar individual vs HH / familia en las entrevistas)	
	Para comenzar, me gustaría hacerle algunas Rápidos sobre usted y su familia y lo que hace.
40.	¿Cuánto tiempo hace vivido aquí?
Getting to know participant: • Crops • Cattle • Time in community	• Para empezar, ¿me contaría tu experiencia viviendo en esa comunidad? ¿Como fue tú tiempo aquí? • Afuera de usted, con quien más conforma de su familia en hogar ¿De dónde viven ellos? ¿Aquí? • ¿Podrías contarme un poco sobre lo que hace? (p. ej., cultivar, criar animales, trabajar en una ciudad cercana, etc.)? • ¿Podría decirme más que hace su familia para ganarse? • ¿Podrías hablarme de un día normal en tu vida? ¿Qué haces desde la mañana hasta la tarde? ¿Eso cambia de temporada en temporada? • ¿Que son los raíces culturas de tu familia?, (por ejemplo mi abuelo era alemán y por su música, cultura, idioma yo identifico como alemán)
41.	¿Tiene cultivos? ¿Qué tipo de cultivos cultivas?
If Crops not mentioned: • Do they plant? • Types • Where do they plant • What do they plant	• ¿Cosecha las plantas para el alimento en tu hogar, las vendes para el efectivo, o ambos? • ¿Qué cultivos te gustaría cultivar más? • ¿Dónde cultivas, es la tierra que tiene (esta compartido, en tierra indiviso, aquillado)?
42.	¿Crías animales domesticados en algún lugar o guardas animales en tu casa? ¿Qué animales tienes?
	• Pollo, cerdo, ganado, alpaca, ¿algo más?

If animals not mentioned: • *Have them?* • *Types?* • *Consume/sell?* • *Where do they keep them?* • *Wildlife problems?*	*Si el ganado es pronto ¿Cuántos ganados tienes? ¿Qué tipos?* *Si es ganado, solicite: ¿El ganado son de a usted o a alguien más en su hogar?* • ¿Consume sus propios animales? (por ejemplo, huevos, leche, piel, etc.)? • ¿Vende sus propios animales (por ejemplo, huevos, leche, piel, etc.)? • ¿Dónde crías tu ganado? ¿Es esto en la tierra que tiene? ¿Se comparte con tu familia? ¿Si no se alquila? • ¿Tienes algunos conflictos o interacciones con animales silvestres?
43.	¿Podría contarnos un poco más sobre la tierra que tiene en general? ¿Hay bosque o quebradas? ¿Qué tipo de árboles están en eso?
Type of land owned	
44.	Recuerda cuando llegaste aquí por la primera vez, ¿cómo decidiste donde construir tu casa, plantar tus cultivos, colocar tu ganado?
How decided where to build, plant, &keep animals	• ¿Hablaste sobre estas decisiones en su hogar o solo no más? ¿Hablas con su pareja? ¿Cómo fue esa conversación? • ¿Hablaste con sus vecinos u otros amigos o alguien en su comunidad ante que hizo esas decisiones? ?
45.	¿Trabaja usted o los miembros de su familia en algún lugar afuera de su propiedad
Work outside HH; • Types of Jobs • Who does them • Far or close to HH • Why	• ¿Qué tipo de trabajo hacen usted o los miembros de su hogar? • A dónde van ustedes / los miembros de su hogar a buscar trabajo? • Por qué ustedes / los miembros de su hogar eligen este tipo de trabajo? • Si es posible, ¿querría trabajar más o menos lejos de su tierra? • ¿Es difícil o fácil encontrar trabajo fuera de su tierra? • ¿Qué tipo de trabajo te gustaría ver hacer a sus hijos? ¿Quiere que trabajen en su propia tierra algún día? ¿O quieres que trabajen en la ciudad o en algún otro lugar?
Sección 2. Individual: Participación actual en ARA.	
A continuación, me gustaría hacerle algunas preguntas sobre un programa en su área llamado Acuerdos Recíprocos De Agua (ARA) .	
(Explico *lo que el programa es en otras palabras, si es necesario [Proyecto de Natura, Proyecto de incentivas con Natura, etc.])*	

46.	¿Puedes decirme lo que sabes sobre ARA?
Do they know of ARA/how?	• Has oído hablar de este programa? • Cómo has oído hablar de ARA?
47.	¿Fuiste a la reunión donde explican el programa ARA?
How was the offering meeting; • Experiences? • Well explained?	• SÍ: ¿Podría hablarme sobre de esa reunión? (lo que hablaron, etc.) • SÍ: ¿Cómo te sentiste de la presentación? • SÍ: ¿Qué te pareció la presentación? • ¿si la respuesta es SI: ¿Usted entendió todo que explico? ¿Sentiste que entendiste cómo funcionaba bien?
48.	¿Cuáles crees que son los principales objetivos de ARA? ¿Cómo piensas en esas metas?
• ARA objectives • think it helps environment/ livlihood?	• Crees que ARA se propone proteger los bosques? ¿Cree que está funcionando ahora? ¿Cómo es eso? • Crees que ARA se propone mejorar la calidad del agua? ¿Cree que está funcionando ahora? ¿Cómo es eso?
49.	¿Esta usted un participante en el programa ahora o ha participado en el programa en el pasado?
Participant?	
<u>Si el entrevistado</u> <u>no es un PARTICIPAN</u> <u>t en el programa o ha</u> <u>Nunca ha</u> <u>participado en el programa en el pasado, por ejemplo:</u>	
Voy a hacerle un par de Rápidos acerca de por qué s que no participó en ARA.	
50.	¿Podría decirme sobre por qué decidió no participar en el programa?
Decision to not participate: • Didn't want to/couldn't? • Something in the contract? • Feel it would impact; land/community? • Would they join if it was offered again?	• ¿Es porque no querías? • ¿Es porque no pude? • ¿Hay algo en el contrato que no lo convenció que no participar ¿Qué? ¿Por qué? • ¿Hay otros factores / consideraciones en los que pensó al tomar su decisión sobre ARA? • ¿Sientes que ARA tendrá algún impacto en la tierra / agua? • ¿Cuáles fueron tus pensamientos sobre los incentivos que ofrecieron? • En su opinión, ¿cree que ARA tendrá algún impacto en su comunidad? • Si la Fundación Natura Bolivia vuelve a ofrecer el programa nuevamente en su comunidad, ¿consideraría participar en al programa?
51.	¿Cómo hizo la decisión e a participar en ARA?

Decision to not join – included spouse/HH/neighbor/ community? Importance of spouse in decision	• ¿Hablaste con su pareja sobre esa decisión? Que dijo ello/a? • ¿Tomaste esa decisión solo? ¿Con su pareja? ¿Comento la decisión con otros miembros del hogar? ¿Comento su decisión con otras personas en su comunidad (miembros que no son miembros del hogar)?

Sección 3. Comunidad: Participación actual en ARA.

A continuación, me gustaría hacerle algunas Rápidos sobre su comunidad. Para empezar, ¿podrías decirme primero?

52.	¿A quién consideras parte de tu comunidad? / Se relaciona más con sus vecinos más cerca o con toda la comunidad
How is community defined	• ¿Personas que viven en tu pueblo / ciudad? • ¿Otros agricultores en tu pueblo / ciudad?
53.	¿Conoces a otros que se han participado en ARA?
Know someone else who participates in ARA? Why did they? Did anything change for them? Did it influence your participation?	• ¿Por qué crees que se participó? • ¿Piense que algo cambio en su forma de vida por su participación ¿Podrías contarme un poco más sobre de eso? • ¿Influyó eso en tu decisión de participar o no? ¿Cómo es eso?
54.	¿Conoce a alguien que no participo, pero deseaba que podría haber participo?
Know someone who doesn't participate?	• ¿Qué crees que les impidió hacerlo?
55.	¿Piensa usted que toda la gente en la comunidad tiene la oportunidad a participar in ARA si quiere?
Do you think everyone has the same opportunity to participate? Motives? Thoughts?	• ¿Cuáles son algunos de los motivos por los miembros de la comunidad no pudieron participar? ¿Cómo <u>se</u> sienten al respecto? • ¿Cómo te sientes sobre eso? ¿Es justo o injusto, desde su perspectiva? ¿Por qué?

56.	En general, ¿cuáles son los efectos de ARA en su comunidad?
Impacts of ARA on the community? Benefits? Challenges? Are the changes just?	• ¿Qué beneficios has visto? • ¿Qué desafíos ha traído ARA a su comunidad? • ¿Cómo te sientes sobre eso? ¿Es justo o injusto, desde su perspectiva? ¿Por qué?
57.	¿Ha habido algún problema nuevo en su comunidad desde que comenzó ARA?
Any new problems in the community? Are they b/c of ARA? How could you resolve these problems?	• ¿Sientes que esos problemas se han debido a ARA? • ¿Puedes decirme más sobre lo que pasó? • ¿Qué ha hecho la comunidad para resolver los problemas? • ¿Me puede decir cómo cree que pueden resolverse estos problemas? • ¿Anticipa más problemas o conflictos en el futuro? Si es así, ¿qué crees que podría pasar? ¿Por qué?
58.	¿Ha cambiado la relación entre las personas en su comunidad desde que comenzó ARA, o ha cambiado la dinámica de la comunidad?
Have relationships within the community changed/dynamics? How do you feel about these changes? Just/in just.	• ¿Sientes que estos cambios se deben a que ARA esté presente en la comunidad? • ¿Podría decirme más sobre los cambios? ¿Por qué crees que ocurrieron estos cambios? • ¿Cómo te sientes sobre eso? ¿Es justo o injusto, desde su perspectiva? ¿Por qué?
59.	¿Ha cambiado la relación entre su comunidad y otras comunidades desde que comenzó ARA?
Anything changed between your community and other communities How do you feel about that?	• ¿Podría decirme más sobre los cambios? ¿Por qué crees que ocurrieron estos cambios? • ¿Cómo te sientes sobre eso? ¿Es justo o injusto, desde su perspectiva? ¿Por qué?
Sección 4. Percepciones sobre el medio ambiente y las ONG.	

60.	¿Podría contarme sus experiencias con Natura (la ONG que administra ARA)?
Personal experiences with Natura. Past/Present	• ¿Los conocías antes? • ¿Cuáles fueron tus pensamientos cuando presentaron el proyecto?
61.	¿Podría describir una interacción y que haya tenido con Natura?
Describe interaction with Natura Were they open/honest/respectful Has participating in ARA changed that relationship?	• ¿Qué piensas de esas interacciones? • ¿Te trataron con respeto? • Fueron abiertos/honestos al comunicarse con usted? • *Pregunte si el entrevistado fue / es un participante:* ¿Han cambiado tus interacciones con Natura desde que te iniciar programa? • *Pregunte si el entrevistado fue / es un participante:* ¿Alguien de Natura ha ido a visitarte a ti ya tu tierra? ¿Qué hicieron?
62.	¿Siente que ha habido algún cambio en los bosques y el agua a su alrededor, o cambios con la vida silvestre, ya que ARA estaba en su área?
Been change in forest or water since ARA started What changes have you noticed?	• ¿Sientes que esos cambios están directamente relacionados con ARA? • ¿Podrías contarme algunos de esos cambios que has notado? ¿Qué piensas de estos cambios? ¿Una cosa buena? ¿Un problema para ti? ¿Realmente no me importa?
63. Have any other comments/ideas	¿Tiene alguna otra idea sobre ARA ahora que desea que contarme? ¿Alguna otra idea sobre las necesidades de conservación de su comunidad?

Conclusion & Thank You

- Thank you again for taking the time to talk with us and share your thoughts.
- Hand them a copy of the Letter of Information, which includes all your contact information (if did not hand them this before start interview)
- Ask if they have any questions and make sure everything was clear
- Remind them everything is confidential
- Remind them where to find the results and/or contacts

    - Ask for contact info if they want to be given a summary of the results
- Stop recording
- Thank you again and goodbye

Record any observations, thoughts, feelings and/or reactions about the interview (from the interviewer's perspective) if any.

Appendix B. Data Sovereignty Protocols

A data sovereignty protocol outlines how data produced in collaborative science projects will be stored, shared, and published (Walter and Suina, 2019). The CARE Principles of data sovereignty call for Indigenous collective benefit, authority to control data, responsibility and ethics (Jennings et al., 2023). The objective of this data sovereignty protocol is to clarify how knowledge co-produced by Wuda Ogwa partners has a clear pathway to benefit and be managed by NWBSN leadership. Ecological data gathered by USU researchers are managed in conjunction with BIOWEST, Inc., under the leadership of the NWBSN. Climate model analysis code is available on the Hydroshare data platform. Landowner interview data are managed by USU researchers under IRB Protocol #12860, *Mobilizing local knowledge of watershed health.* A de-identified summary and analysis of interviews will be provided to Wuda Ogwa project leadership. Indigenous knowledge is owned and managed by NWBSN and by elders who have chosen to publish their knowledge. This draft data sovereignty protocol is a work in progress that will grow and evolve with consultation and discussion with project partners.

References

Jennings, L., Anderson, T., Martinez, A., Sterling, R., Chavez, D.D., Garba, I., Hudson, M., Garrison, N.A., Carroll, S.R., 2023. Applying the 'CARE Principles for Indigenous Data Governance' to ecology and biodiversity research. Nat. Ecol. Evol. 7, 1547–1551. https://doi.org/10.1038/s41559-023-02161-2

Walter, M., Suina, M., 2019. Indigenous data, indigenous methodologies and indigenous data sovereignty. Int J Soc Res Method 22, 233–243. https://doi.org/10.1080/13645579.2018.1531228

CURRICULUM VITAE

William Wesley Munger

CAREER OBJECTIVE:

The overarching career objective is to engage in collaborative and co-produced science that builds the capacity and creativity of working lands stewards. A linked objective is to continue to build my skills and knowledge as a rangeland manger. The main area of interest are 1) Developing co-produced rangeland research and management; 2) Implementing and evaluating ecological restoration; 3) Innovating climate adaptation strategies and technologies; and 4) Creating wildlife and livestock coexistence strategies.

EDUCATION:

BA in Anthropology, 2011. Reed College.
Thesis: Social War in the Salad Bowl: On Gangs and the Domestic Application of Counterinsurgency.

PhD in Environment and Society.
S.J. and Jessie E. Quinney College of Natural Resources at Utah State University, Department of Environment and Society.

EXPERIENCE:

<u>Postdoctoral researcher (Current)</u>
USDA-Agricultural Research Service. US Sheep Experimental Station.

<u>Ecological Restoration Coordinator (2019-2024)</u>
Wuda Ogwa Restoration Project.

<u>Range Rider</u>
Logan Canyon Grazing Association (2023)
The Nature Conservancy, Dugout Ranch and Canyonlands Research Center (2021-2023)

<u>Instructor</u>
Utah State University (2022-2024)

<u>Ranch Manager</u>
Dark Mountain Range Operations (2018-Current)