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Conserving the Greater Sage-Grouse: A Social-Ecological Systems Case Study from the California-Nevada Region

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ABSTRACT

The Endangered Species Act (ESA) continues to serve as one of the most powerful and contested federal legislative mandates for conservation. In the midst of heated debates, researchers, policy makers, and conservation practitioners champion the importance of cooperative conservation and social-ecological systems approaches, which forge partnerships at multiple levels and scales to address complex ecosystem challenges. However, few real-world examples exist to demonstrate how multifaceted collaborations among stakeholders who share a common goal of conserving at-risk species may be nested within a systems framework to achieve social and ecological goals. Here, we present a case study of Greater Sage-grouse *(Centrocercus urophasianus)* conservation efforts in the "Bi-State" region of California and Nevada, United States. Using key-informant interviews, we explored dimensions and drivers of this landscape-scale conservation effort. Three themes emerged from the interviews, including 1) ESA action was transformed into opportunity for system-wide conservation; 2) a diverse, locally based partnership anchored collaboration and engagement across multiple levels and scales; and 3) best-available science combined with local knowledge led to "certainty of effectiveness and implementation"—the criteria used by the US Fish and Wildlife Service to evaluate conservation efforts when making listing decisions. Ultimately, collaborative conservation through multistakeholder engagement at various levels and scales led to proactive planning and implementation of conservation measures and precluded the need for an ESA listing of the Bi-State population of Greater Sage-grouse. This article presents a potent example of how a systems approach integrating policy, management, and learning can be used to successfully overcome the conflict-laden and "wicked" challenges that surround at-risk species conservation.

Introduction

Preventing the extinction of at-risk species through diverse stakeholder engagement is an urgent societal priority (Wilson et al., 2011; Sawchuk et al., 2015). Escalating pressures related to species protection and biodiversity conservation are complicated by social and ecological change due to rapid human population growth (Cincotta et al., 2000), land use change (Vitousek et al., 1997; Haines-Young, 2009), increasing food demands (Phalan et al., 2011), and climate change (Young et al., 2006). Scholars and practitioners alike have long called for collaborative approaches to achieve balance or determine acceptable trade-offs between diverse human interests and ecosystem health (Berkes, 2004). More recent calls for social-ecological systems (SES) approaches to conservation have been criticized as too abstract for real-world application (Brand and Jax, 2007; Brunson, 2012). This case study provides a tangible example of how SES principles were implemented by diverse stakeholders to achieve system-wide conservation for an at-risk species.

Endangered Species Act of 1973

At the center of this discourse is the Endangered Species Act (ESA), which continues to serve as one of the most powerful federal statutes guarding against species loss in the United States (Eisner et al., 1995; Scott et al., 2005). The ESA was passed in 1973 in the United States Senate (92-0) and House of Representatives (355-4) with broad bipartisan support (Schwartz, 2008). Its purpose was to provide, "a program for the conservation … of endangered species and threatened species" and the, "ecosystems upon which (these) species depend" (16 U.S.C. sec. 1531[b]). However, 40 years later, tension and turbulence over its purpose and effectiveness have fragmented support (Cheever, 1996) despite quantitative findings that listing has enhanced species' recoveries (Taylor et al., 2005).

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Three key criticisms of the ESA have been posed: 1) It focuses on the survival of individual species, in lieu of the overall functionality of systems (Benson, 2012); 2) it is often used as an "emergency room" approach to biodiversity protection for species on the brink of extinction, focusing attention on the listing decision rather than preventative and/or holistic conservation (Salzman and Thompson, 2010:282); and 3) few species have been delisted with the list-protect-recover-delist approach necessary for long-term species recovery (Scott et al., 2005). As a result, the ESA is frequently targeted for legislative modification or repeal (Bean, 2006).

When species' existence are threatened or endangered in the United States, the ESA imposes federal protections if other approaches have not succeeded. Two important questions have emerged as paramount to the future of biodiversity conservation in this context. First, can focal or umbrella species conservation help define the spatial, compositional, and functional attributes of a landscape and associated threats, with system-wide conservation or restoration measures rather than one-species-at-a-time protection (Lambeck, 1997; Simberloff, 1998; Roberge and Angelstam, 2004)? Second, can systems approaches be employed to better meld regulatory (i.e., "top-down") with collaborative and voluntary (i.e., "bottom-up") tools to achieve conservation goals (Berkes et al., 2003; Ostrom, 2009)? In rangeland systems, these strategies would require engaging a broad set of stakeholders who are committed to working together over longer periods of time to bridge contested divides through multiscalar partnerships to adaptively address restoration and management challenges (Bestelmeyer and Briske, 2012).

Systems Theory to Guide Conservation

Theoretical frameworks to guide conservation have called for ecosystem-centric and collaborative or cooperative approaches to conservation. Ecosystem approaches seek best-available scientific understanding of biophysical system dynamics to inform management actions that might achieve desired conservation outcomes (Koontz and Bodine, 2008; Boyd et al., 2014). Cooperative conservation, which emerged as a new paradigm in the 1990s and 2000s, sought to engage diverse sets of public and private partners in collaborative approaches to natural resource management. Core to cooperative conservation is the belief that solutions to environmental problems must consider social, political, and economic dimensions along with ecosystem dynamics (Klinger et al., 2007). As such, its proponents advocate for widening the decision-making space to include an array of partners working together to sustain landscapes and communities. There is no single model of cooperative conservation; efforts vary in the range of focal issues and concerns, scale and complexity of geography, types of public and private partners engaged, and methods of collaboration (McKinney and Johnson, 2009). The conservation approach is partner-centric, wherein diverse individuals work hand-in-hand, representing various interests, values, and skillsets, and providing a range of technical and funding resources. Projects address biological and social dimensions and require a coproduced investment in the conservation outcome (Neudecker et al., 2011). National recognition of the need for cooperative conservation resulted in formal adoption of the approach in US federal policy in 2004 (CEQ, 2005).

Success in improving process and outcomes through implementation of cooperative conservation in the context of the ESA have led some to advocate for it as an alternative to regulatory species listing and recovery efforts (Schwartz, 2008). Others have pointed to cooperative conservation as a vehicle to motivate long-term and lasting species recovery. For example, Scott et al. (2010:95) suggest conservationists have experienced "only the tip of the iceberg" when considering the escalation in the number of species that face extinction due to anthropogenic threats and depend on conservation interventions for survival. To address these challenges, these authors propose a cooperative conservation approach: incorporate a broader level of participation among federal and state agencies, private landowners, and nongovernmental organizations to build new partnerships; expand the range of policy and management options; empower the private sector; and prioritize species and systems for management (Scott et al., 2010). Others have stressed the path forward must involve expanding the regulatory focus of the ESA to empower local, adaptive, and ecologically based management, and by so doing enlarging the discussion to a wider set of stakeholders necessary to solve complex ecosystem problems (Boyd et al., 2014).

More recently, there have been calls for SES approaches to conservation that fully consider the interrelationships among human and biophysical system dimensions while embracing cooperative conservation principles (Bestelmeyer and Briske, 2012; Brunson, 2012; Virapongse et al., 2016). SES approaches seek to enhance system resilience or the capacity to endure disturbance while retaining critical system structures, processes, and feedbacks (Adger et al., 2005). While promising, SES approaches have been criticized as too abstract or theoretical to adequately inform practical rangeland management (Anderies et al., 2004; Brand and Jax, 2007). Even SES proponents recognize the "grand challenges" for such resilience-based approaches to environmental management (Bestelmeyer and Briske, 2012:656). For example, multiscalar system relationships are complex; it can be difficult to construct robust models of social and ecological dynamics, let alone understand how they can be influenced (Cumming et al., 2005); stakeholders are numerous, holding diverse and often competing interests; engaging them in meaningful ways that reduce conflict takes thoughtful and consistent effort (Leach, 2006); data are not often available at the temporal or spatial scale necessary to inform decisions (Bestelmeyer and Briske, 2012; Virapongse et al., 2016); and institutional support is often limited or unwilling to support adaptive governance approaches (Lemieux et al., 2014).

To inform SES conservation efforts, examples of practical solutions to these complex challenges are needed. SES approaches to conservation are touted as a fruitful means for addressing the decline of species and the systems on which they depend, yet examples of successful SES applications are lacking (Brunson, 2012). Especially absent are tangible descriptions of how local actors have employed SES principles to achieve system-wide planning and adaptive management for at-risk species. A resilience perspective requires management to be adaptive with a shift from the focus on "optimization" of solving environmental problems toward a conservation planning process that incorporates learning back into conservation design (Benson, 2012:28). Is it possible that SES approaches can help address critiques of the ESA (e.g., reactive instead of proactive, single species focus instead of system wide, and little focus on meaningful recovery) while building the adaptive capacity of the system for a more preventative conservation strategy? Evaluations of real-world attempts to employ SES approaches are needed to advance conservation theory and management guidance for natural resources in general and for at-risk species in particular.

Case Study of SES Conservation

In this article, we present a case study of conservation of the Bi-State Distinct Population Segment of Greater Sage-grouse *(Centrocercus urophasianus),* hereafter the "Bi-State sage-grouse," on the border of California and Nevada, United States. Bi-State sage-grouse are allopatrically isolated and genetically distinct (Oyler-McCance et al., 2005, 2014), occur along the southwestern edge of the species' range, and have been petitioned and reviewed for ESA protections on multiple occasions since 2002 (Table 1). A primary threat facing Bi-State sage-grouse has been identified as the encroachment of pinyon *(Pinus monophylla, Pinus edulis)* and juniper *(Juniperus osteosperma, Juniperus californica, Juniperus grandis),* hereafter "pinyon-juniper," into sagebrush ecosystems. This area of California and Nevada encompasses a complex ownership mosaic (Fig. 1) representative of many other landscape-scale initiatives in the West where conservation is

Table 1
Series of Endangered Species Act (ESA) petitions, findings, court settlements, and decisions by the US Fish and Wildlife Service (FWS) related to the Bi-State sage-grouse.

Yr	Action
2002	Petition made to emergency list the Mono Basin area population of sage-grouse as an endangered distinct population segment (DPS)
2002	FWS finding that petition did not present substantial scientific or commercial information to warrant listing
2005	Petition made to list the Mono Basin area population of sage-grouse as an endangered or threatened DPS
2006	FWS finding that 2002/2005 petitions did not present substantial scientific or commercial information to warrant a listing
2007	Complaint filed by the petitioners challenging the 2006 finding
2008	Settlement agreement between the FWS and petitioners
2010	FWS determination that the Bi-State DPS is precluded for listing and placed on the candidate species list
2011	FWS filed multiyear work plan as part of proposed settlement agreement for 251 species
2013	FWS determination that the Bi-State DPS is proposed listed as threatened under the ESA, with a 4(d) rule with critical habitat
2015	FWS decision that the Bi-State DPS is not warranted for listing under the ESA

multijurisdictional and affects a broad spectrum of social and ecological goals held by multiple stakeholders (McKinney et al., 2010).

Although not explicitly intended by stakeholders, this conservation effort effectively and creatively implemented SES principles for environmental management to conserve an at-risk species and the sagebrush ecosystem on which it depends. A diverse set of public and private interests worked at different levels and scales to successfully address the US Fish and Wildlife Service's (FWS) criteria for demonstrating "certainty of effectiveness and implementation" (FWS, 2015), precluding the need to list the species under the ESA. Perhaps more remarkably, stakeholders transformed the threat imposed by the ESA into a collective commitment toward locally led, system-wide conservation. This potent case study presents an example of an SES approach to at-risk species conservation and offers new insights into the relationships, structures, and interactions that can exist at multiple levels and scales. Ultimately, the effort demonstrates how SES theory can be applied to meet the "wicked" and complex challenges of species conservation (Allen and Gould, 1986:22; Boyd et al., 2014).

We organized this paper into four major sections. First, we present the Bi-State sage-grouse story in the context of the ESA, describing the history, landscape, process, and partnership actions as important background for this multistakeholder case study. Second, we describe our methodology and the themes that emerged on the basis of the experiences of stakeholders engaged in the effort. Specifically, we present interview results from key informants who helped us identify the main elements that enabled stakeholders to agree on, invest in, and implement sage-grouse habitat improvements. Third, we present a discussion of how this real-world case study can inform future SES approaches to conservation in the context of the ESA. Finally, we discuss management implications with an eye toward increasing interest and investment in linking social and ecological perspectives to advance biodiversity conservation and resilience-based rangeland conservation. We believe the Bi-State sage-grouse effort is a compelling case study for those interested in conservation in the context of the ESA, and it provides an example of how to transform theoretical, academic, and political conservation debates into real solutions that address the "adaptive challenges" of the future (Heifetz and Linksy, 2002:14).

Bi-State Sage-Grouse Story

Study Context

The story of the Bi-State sage-grouse is set along the border of California and Nevada at the interface of the Sierra Nevada Mountains to the west and the Great Basin to the east. Land ownership is composed of Bureau of Land Management (BLM); US Forest Service (USFS); Department of Defense (DOD); and private, state, county, and tribal lands, with the majority of habitat (91%) located on public lands (EOC, 2014; see Fig. 1). The geographic boundaries were defined by local knowledge of sage-grouse distribution (DOI-FWS, 2013) and span across 1.8 million ha of land (EOC, 2014). Elevation ranges from 1 386 to 4 344 m, with numerous rugged mountain ranges intermixed with broad valleys.

Floristically, this landscape represents sagebrush communities similar to those found in other areas of the Great Basin, which is dominated by multiple species of big (*Artemisia tridentata* spp.) and low (*A. arbuscular*) sagebrush species. Native bunchgrasses and perennial forbs comprise the understory vegetation, while invasive annual grass, namely cheatgrass *(Bromus tectorum),* increasingly common throughout much of the western United States, is less abundant. Pinyon-juniper woodlands are relatively common at elevations of 1 850 − 3 000 m. Similar to sage-grouse populations elsewhere (Connelly et al., 2004; Knick et al., 2013), Bi-State sage-grouse require contiguous areas of sagebrush to accommodate seasonal movements and fulfill habitat requirements across phenological stages (i.e., breeding, nesting, brood-rearing, and wintering; Coates et al., 2013).

For more than a decade, this flagship, ground-dwelling bird has captured the attention of federal, state, and local agencies; industry; private landowners; environmentalists; nongovernmental organizations; and political leaders across the West and in Washington, D.C. The Bi-State sage-grouse has been the subject of a series of ESA petitions, findings, court settlements, and other decisions by the FWS (FWS, 2015; see Table 1).

One of the primary threats to Bi-State sage-grouse is the expansion of pinyon-juniper woodlands into sagebrush-dominated communities (CFR, 2013). Multiple studies have reported evidence of avoidance of pinyon-juniper across different sage-grouse phenological stages (Doherty et al., 2008; Atamian et al., 2010; Knick et al., 2013). Even at low canopy cover levels (i.e., $<$4%), pinyon-juniper has been associated with lek inactivity in areas of the West (Baruch-Mordo et al., 2013) and has reduced sage-grouse survival specifically in the Bi-State (Coates et al., 2016 [this issue]). This is of great conservation concern because $\approx$54.6% of area within the Bi-State consists of sagebrush ecosystems with pinyon-juniper or pinyon-juniper woodland (Coates et al., 2016 [this issue]; Fig. 2), fragmenting sagebrush communities and potentially genetically isolating subpopulations of sage-grouse (Oyler-McCance et al., 2014). More recently, wildfire and the spread of invasive annual grass have been recognized as critical threats (CFR, 2013), even for this relatively high-elevation population. Other threats vary in risk and threat level across the Bi-State including urbanization, intensive grazing, energy development, mining, predation, and recreation (TAC, 2012).

Foundations for Conservation

The impetus for conservation of the Bi-State sage-grouse began in June 2000 when Nevada Governor Kenny Guinn convened a conservation team to coordinate a landscape-level approach to sage-grouse conservation and management. Habitat had been lost and fragmented, sage-grouse populations were potentially declining, and many feared sage-grouse recovery efforts would inflict economic impacts on the mining, agriculture, energy, and recreation industries of Nevada. In response, the Governor's team established a process for early grassroots engagement in sage-grouse conservation through a series of public meetings in libraries, schools, and community halls across the state. These community-based meetings led to the development of several local area working groups in 2003 to ensure stakeholder voices were heard as conservation measures were considered and implemented.

The Bi-State Local Area Working Group was formed to gather data on sage-grouse populations, movement, and habitat. A small team of

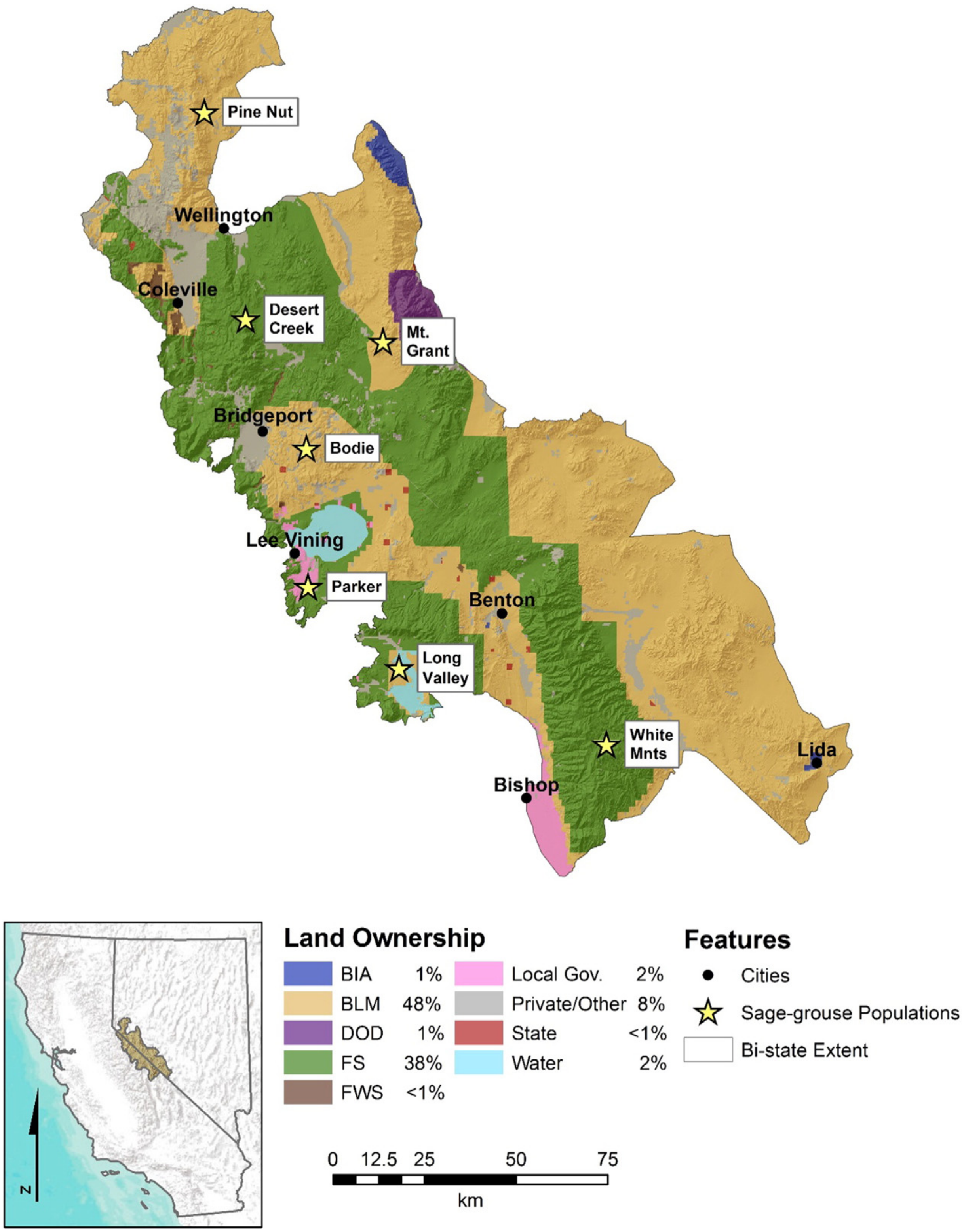

Figure 1. The Bi-State area across California and Nevada encompasses 1.8 ha of land. Land ownership is composed of a complex mosaic including Bureau of Land Management, US Forest Service, Department of Defense, and private, state, county, and tribal lands, with the majority of habitat located on public lands.

experts was established to provide technical expertise and guidance toward conserving sage-grouse populations and habitats. This team created the first Conservation Plan in 2004 with guidance from the Bi-State Local Area Working Group. The initial plan identified and prioritized risks to sage-grouse and projects to prevent, reduce, or mitigate impacts. Projects were initiated that year. In 2006, the Bi-State sage-grouse was determined "not warranted" for ESA listing. Nonetheless, agencies and private landowners continued implementing projects identified in the plan.

In 2010, renewed listing concerns reinvigorated Bi-State Local Area Working Group efforts, which were subsequently augmented by an Executive Oversight Committee and an expanded Technical Advisory

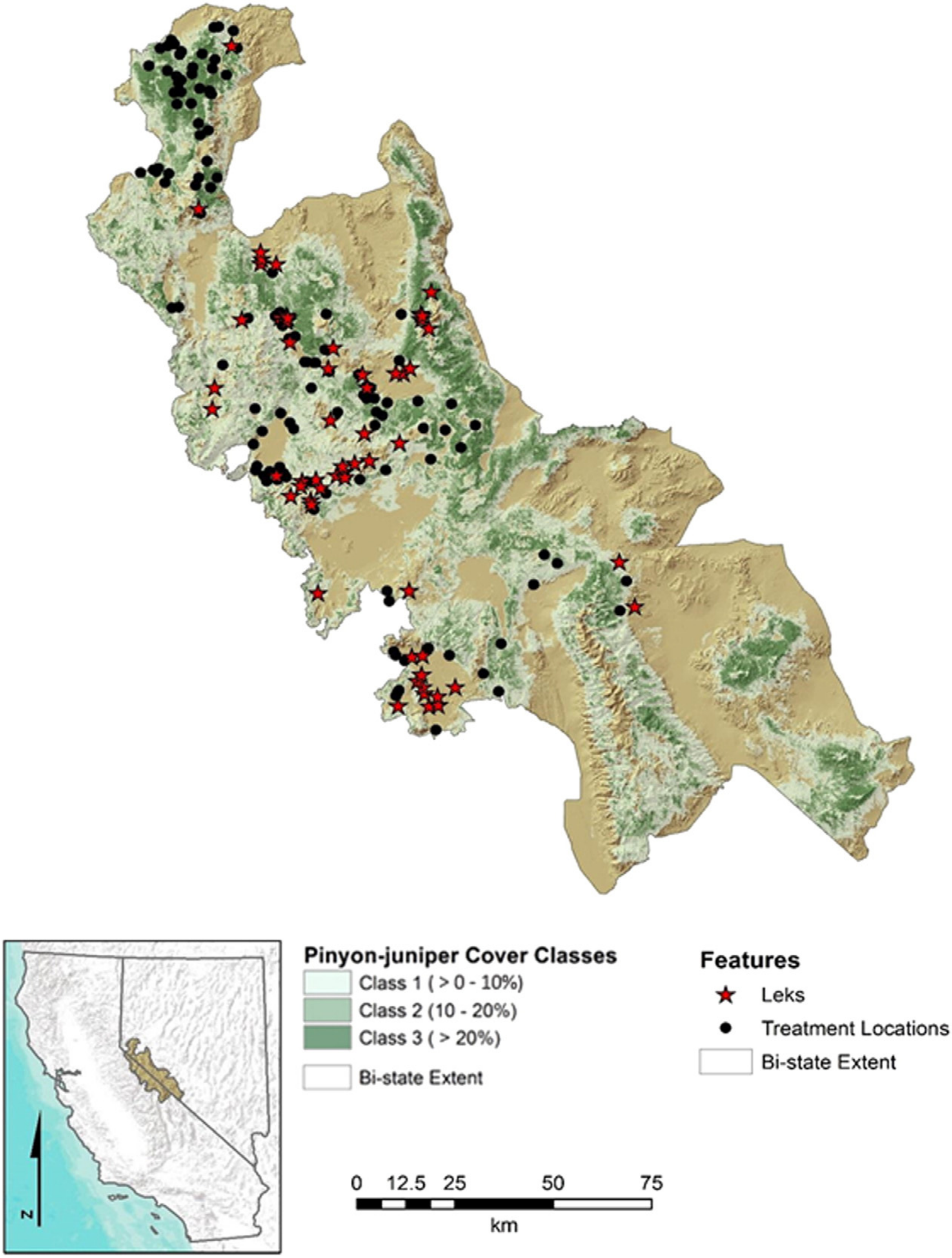

Figure 2. One of the primary threats to Bi-State sage-grouse is the expansion of pinyon-juniper woodlands. To address this threat, treatment areas for proposed pinyon-juniper removal were first delineated by state and federal resource agencies. A conservation planning tool prioritized conifer removal projects by using spatially explicit statistical models of sage-grouse resource selection functions, abundance, and space use from data collect over a decade across multiple agencies and universities.

Committee, both formed in 2011. The Executive Oversight Committee established a framework for interagency cooperation to provide clear, consistent, and coordinated multijurisdictional direction to conserve Bi-State sage-grouse populations and habitat on the basis of population and habitat conservation goals rather than landownership or jurisdictional boundaries. The Executive Oversight Committee assigned biologists from each of the participating agencies to form the Technical Advisory Committee. The Technical Advisory Committee provided technical expertise and guidance and identified and prioritized actions necessary for conservation of the Bi-State sage grouse. In combination, the Local Area Working Group and the two committees created a three-pronged partnership for conservation, which empowered local stakeholders, fostered coordination across ownership boundaries, and ensured the best available science was used in decision making. These collective efforts engaged directors of state wildlife and federal land management agencies in Nevada and California with regulatory and funding authority, biologists and researchers from state and federal agencies, local private landowners and citizens, members of the Paiute and Washoe Tribes of California and Nevada, university researchers and extension personnel, the Department of Defense Hawthorne Army Depot, and nongovernmental organizations.

Despite varying motivations, all stakeholders agreed to a common conservation goal of increasing habitat availability and suitability to support stable or increasing populations of sage-grouse over the long term. In 2012, stakeholders produced an updated Bi-State Action Plan, hereafter "the Plan," which 1) summarized and documented conservation actions over the previous decade and 2) developed a comprehensive set of strategies, objectives, and actions to address threats from pinyon-juniper, wildlife, urbanization, infrastructure, intensive grazing, invasive and noxious vegetation species, and loss of riparian areas. The Plan was based in the latest quantitative science contributed by federal and state wildlife agencies.

Collectively, stakeholders have implemented 68 habitat-based projects (11 pinyon-juniper treatment projects) with associated timelines for completion. A long-term population and vegetation monitoring framework was developed to track project success, as well as short- and long-term sage-grouse population response. Other important stakeholder activity included developing a coordinated interagency approach with a record of interagency cooperation agreements; a science-based adaptive management plan, which included an empirically grounded conservation planning tool; improvements to regulatory mechanisms and actions for small population recovery; voluntary, incentive-based conservation easements and enhancements on private lands; and a $45.4 million multiyear commitment to fund all conservation actions (see Appendix A). Additionally, partners have implemented 31 public awareness projects, including interpretation of the Plan and news and media outreaches. These cooperative actions culminated in a decision by the FWS in 2015 that the Bi-State sage-grouse was not warranted for listing under the ESA.

Ecological outcomes will continue to be monitored to demonstrate how conservation actions are impacting Bi-State sage-grouse populations and the sagebrush ecosystem; societal benefits and outcomes will be determined on the basis of the degree to which the system continues to provide for multiple land uses and values to support an increasing population within the landscape.

Dimensions and Drivers of Conservation in the Bi-State

Methods

To investigate the dimensions and drivers behind the Bi-State conservation effort, we conducted qualitative, semistructured interviews with "key informants." Key informants are people who have particular knowledge about a process or event due to their role (official or otherwise) or position within a community (e.g., elected official, agency director, religious leader, integral business persons). Key informant interviews provide a useful point of entry for in-depth, social research and facilitate gathering of data that cannot be ascertained with secondary data or quantitative survey techniques (Luloff, 1999). We employed systematic key informant telephone and in-person interviews to ensure our results captured the diversity of perspectives shared by stakeholders involved in the Bi-State conservation efforts.

Fifteen interviews were conducted with key informants representing federal agencies (7), state fish and wildlife agencies (2), county agencies (1), nongovernmental organizations (1), sportsmen (1), and private landowners (3). The number of interviewees by organizational type reflects the proportion of stakeholders engaged based on authority and responsibility for conservation action in the Bi-State. Additionally, the interviewees that were selected were well informed and had prolonged engagement in the effort and could provide first-hand knowledge related to the partnerships, process, and outcomes. While not fully representative of all stakeholder interests, the interviewees represented a diversity of perspectives and cross-section of involvement in the Local Area Working Group, Technical Advisory Committee, and Executive Oversight Committee. This focused and purposive approach allowed us to engage individuals with integral positions in the Bi-State conservation effort who brought years of experience and deep familiarity to bear on our research questions. We used an interview guide that focused questions on individuals' values and beliefs regarding the partnership, endangered species conservation, the role of scientific knowledge and expertise, and how stakeholders defined the challenges and worked toward common ground for conserving an at-risk species (see Appendix B).

We used a hermeneutic approach to analyze interview content (Patterson and Williams, 2002). First, we revisited interviews in their entirety to establish an understanding of general content before analysis. Next, we systematically identified independent ideas or "meaning units" within interviews (usually groups of sentences) and assigned thematic labels on the basis of how the idea related to our research questions (Patterson and Williams, 2002). Ideas raised by interviewees were assigned multiple thematic labels where necessary. We identified themes at the ideographic (individual) and nomothetic (across individual) levels and sought to understand interrelationships among themes as all interviews were analyzed.

Most analysis was conducted by the interviewer, combined with peer-debriefing of a subset of interviews to ensure consistency and quality of analysis (Creswell, 2014). Peer-debriefing is an independent analysis of interviews by multiple researchers followed by a discussion and refinement of interpretation. We used standard spreadsheet software to organize meaning units, thematic classification, and interrelationships among themes. This hermeneutic approach allowed themes to emerge directly from the interviewees and their experiences in Bi-State conservation efforts.

Our objective was not to infer conclusions in the Bi-State to any larger population or conservation trend. Instead, we hoped details of this case study might contribute to the conversation of how an SES framework may be employed in species conservation. We present these inductive findings in this forum to help extend the evidence of practical application of SES approaches and inspire additional questions for researchers and practitioners to consider.

Emerging Themes

Three themes emerged within and across interviews that connected policy, management, and learning elements of the Bi-State sage-grouse effort, including 1) ESA action was transformed into opportunity for system-wide conservation, 2) a diverse, locally based partnership anchored collaboration and engagement across multiple levels and scales, and 3) best-available science combined with local knowledge led to "certainty of effectiveness and implementation," as required by the FWS to meet the Policy for Evaluation of Conservation Efforts When Making Listing Decisions. As follows, we detail each theme and present supporting evidence from interviews.

Theme 1: ESA Action Was Transformed into Opportunity for System-Wide Conservation

Across all interviews, it was clear the ESA was a critical driver for sage-grouse conservation. Interviewees viewed the early, proactive establishment of a conservation team by the Governor of Nevada and subsequently the development of the Local Area Working Group, Technical Advisory Committee, and Executive Oversight Committee as key steps for addressing the potential listing of the Bi-State sage-grouse. Interviewees called attention to the urgency and uncertainty of regulatory impacts if the species was listed. They also noted that deadlines established by the FWS served as key pressure points for keeping stakeholders engaged. One FWS official recalled that members of the Local Area Working Group repeatedly expressed concern over whether the bird would be listed and regularly asked if it was going to be listed. In a similar vein, interviewees highlighted the potential loss that would occur with a listing. For example, one of the private landowners interviewed discussed the grazing permit challenges that would confront his family. Other interviewees pointed to the burdensome regulations they would face with respect to clearances and consultations for specific land practices or management needs.

In addition to these perspectives about the role of the ESA, an important nuance emerged during the interviews related to the overall conservation purpose of the effort. Interviewees described a shift from the narrow focus on the pending listing decision to the broader goal of conserving the entire sagebrush ecosystem to benefit sage-grouse populations *and* the human communities in the region. A long-standing member of the Local Area Working Group stated:

> "The potential of a listing was a driving force, but the vision has enlarged to think about the health of the environment. Sound science-based ecosystem management balances sustainable livestock production and benefits the bird, the landscape, and our environmental health."

Five interviewees called attention to the fact that they were actually focused on conservation of the habitat to support the species. When pressures related to the ESA listing process increased, individuals pointed the group to the Plan as a key place to focus energy. For example, a nongovernmental organization representative said:

> "We always reminded ourselves that what we were really working on was a conservation plan … staying focused on conservation, and staying away from political ramifications. If they [the FWS] did decide to list it [the sage-grouse], the plan would be important in the recovery process."

The cause of this shift—from a focus on the listing decision to conservation of the system—may ultimately be linked to three deeper values expressed by interviewees. First, interviewees shared a true concern or interest in the sagebrush ecosystem and for advancing conservation irrespective of a listing decision. Second, seven interviewees expressed the belief that local problems require local solutions; grassroots engagement is a means to reduce conflict between the federal government and affected parties with respect to divisive ancillary issues. Lastly, interviewees expressed the notion that cooperative conservation actions must be sustainable over the long term to fit within an adaptive management framework, not simply reactionary to a potential listing decision.

Key individuals, representing different agencies, organizations, and private interests, provided expertise and perspective that helped shape a common vision of long-term conservation for the species and sagebrush ecosystems. When asked about the long-term prospect of conservation in the Bi-State, interviewees expressed a desire to manage and restore the system to support multiple land-uses (e.g., mining, recreation, agriculture, and urban pressures). Another member of the Local Area Working Group said:

> "Sage-grouse has become and will remain a part of our lives as we know it—something to accept and embrace. It brought attention to the health of our rangelands. We applaud the fact that now we have been given the chance for other obligates and uses of the range, and continuing multiple use on public lands … The purpose has become bigger and more clear. The purpose is the maintenance and improvement of the Great Basin natural resource health and well-being, and to accommodate uses as our population grows."

The response to the initial angst created by the potential ESA-listing evolved from urgency to address declining sage-grouse populations to a system-wide, long-term focus on conservation of sagebrush habitat across multiple land ownerships and diverse land uses.

Theme 2: A Diverse, Locally Based Partnership Anchored Collaboration and Engagement Across Multiple Levels and Scales

When asked to identify the partners who played a key role in the effort, interviewees initially de-emphasized the importance of any one individual or entity to the overall success of conservation efforts. Interviewees resisted singling out any one person or agency because all deserved credit for the collaboration. For example, interviewees expressed the following statements: "there is really not one player to give all the credit to;" "everybody was a player;" and, "there is no 'I' in sage-grouse. Working cooperatively we make a difference."

While this collaborative approach was vitally important to interviewees, it also became clear across interviews that such an approach had been empowered by key people at multiple levels and scales, each committed to the success of the group rather than themselves. This was manifest in philosophical, technical, and financial support from a variety of individuals in different agencies and organizations. For example, a long-time federal biologist stationed in a local field office played a critical role championing stable sage-grouse populations and sagebrush habitat conservation. This individual committed financial and human resources to monitoring, land use planning, and project implementation, providing flexibility for staff to develop partnerships and address issues at the landscape-level, rather than on a project-by-project basis to be addressed solely within their agency.

Private landowners participating in the effort were described as "conservation minded" and "solution-oriented" with respect to long-term conservation of sage-grouse and the ecosystem. Agencies invested in partnerships with the landowners through voluntary, incentive-based assistance programs that benefited both agriculture interests and sage-grouse.

Interviewees described large institutional investments that reinforced smaller-scale efforts and let partners know their work was valued and essential to system-wide conservation. For example, one federal agency committed $12 million to ensure local, private landowner efforts would be implemented in the right areas to address key threats and positively impact sage-grouse populations. State fish and wildlife agencies from both California and Nevada held pivotal roles on the Executive Oversight and Technical Advisory Committees; their contribution of expert knowledge and tangible resources (e.g., population and vegetation monitoring data, $25 000 to support a facilitator and local area planning capacity) meant collaborative solutions would be implemented across political jurisdictions and landownership boundaries.

In addition to resource investments, interviewees said federal agency partners played active and empowering roles clarifying the key elements required to avoid an ESA listing. Other federal and state institutions provided technical support to map habitat, monitor populations, identify threats across sage-grouse life-stages, and use the information as a framework for developing analytical decision support tools.

With simultaneous engagement by multiple interests, interviewees also highlighted the importance of a central, galvanizing entity to ensure all efforts were complementary and well coordinated. State Extension filled this role by providing a dedicated facilitator, seasoned in extension education and natural resource management, to help coordinate the Local Area Working Group. Multiple interviewees commented on this individual's importance as "the glue" that kept the group working together, focused, and scheduled.

At all levels, stakeholders and agencies were committed to system-wide conservation to achieve social and ecological conservation-related outcomes. The Bi-State sage-grouse effort can be described as a culture of volunteers and professionals that, when confronted with a challenge, stepped back and asked, "how can *I* help to make *us* successful?" The variety of stakeholders, their cooperative commitment to a shared vision, and diversity in function became the ethos of the partnership. Interviewees believed that this approach promoted locally based efforts at a "workable" scale to contribute to system-wide conservation. Another member of the Local Area Working Group expressed the sentiment as follows:

> "The energy has to come from people within the geographic area. That determines the scale. The bigger it is, the more challenges with logistics. But when people are committed, it doesn't stop you. In rural areas, there is a big distance between where people live and get together. It is important to meet in person and sit in a circle and listen to each other. It has to be driven by the people that want to participate."

A state fish and wildlife agency interviewee likened the scale to baking a cake and having the right ingredients. The larger the scale, the more ingredients and mix of ingredients needed to achieve success (e.g., larger geography, threats, conservation actions required, diversity of stakeholders). Interviewees described a persistent recognition among conservation partners that the whole was greater than the sum part of the parts, and that by pooling their diverse skills, expertise, and resources (e.g., geospatial expertise, population modeling, plan writing, local contacts within population management units) and applying them at the right scale (e.g., system-wide to specific population management units), they could achieve widespread success.

Theme 3: Best-Available Science Combined with Local Knowledge Led to "Certainty of Effectiveness and Implementation"

The last theme expressed in the interviews related to the interplay among science, strategy, and the structure of partnerships, which led to the demonstration of "certainty of effectiveness and implementation" thus precluding an ESA listing. Across interviews, the Plan was ubiquitously seen as a critical galvanizing document for collective action. The Plan embraced a science-based, adaptive approach to habitat conservation, which ensured conservation efforts would be well informed, efficient at achieving desired outcomes, and likely to succeed because of shared ownership and partnership.

Best-available science was combined with local knowledge to prioritize threats and develop strategic conservation responses that maximized positive social and ecological outcomes. Importantly, interviewees recalled how the Plan was collaboratively written, thus creating ownership by all stakeholders and fostering a commitment to implementation. Many interviewees expressed this sentiment by saying, "we helped write it;" "the Plan was huge—everyone came together;" "people are behind this Plan … even the ranchers understand the importance of the Plan." Interviewees clearly believed the inclusive and deliberative manner in which the Plan was developed was critical for achieving "buy-in" and establishing trust among partners, critical for implementation.

Interviewees described how the Plan emphasized an integration of science and management. Scientists from state and federal agencies worked hand-in-hand with on-the-ground managers to coproduce analytical decision support tools that identified threats, prioritized projects, and measured project effectiveness. For example, to address a primary threat of conifer encroachment, treatment areas for proposed pinyon-juniper removal were delineated by state and federal resource agency staff with input from members of the Local Area Working Group who had intimate knowledge of their respective management areas (see Fig. 2).

Interviewees recalled how the Conservation Planning Tool, developed by the Technical Advisory Committee, initially prioritized Local Area Working Group conifer removal projects using spatially explicit models of sage-grouse resource selection functions, abundance, and space informed by data collected over a decade across multiple agencies and university research teams. The tool estimated ecological benefits to sage-grouse per unit dollar cost of implementation. This course-scale prioritization was carried out across the Bi-State region, but only after it was refined at local scales using more detailed, local sage-grouse data and engaging the stewardship expertise unique to members of the Local Area Working Group.

The importance of blending science with local knowledge to inform on-the-ground management was felt by many interviewees. One interviewee said it this way: "When they prioritized threats by each management unit, it was much easier to come up with actions." To ensure the science and planning actually motivated management actions instead of languishing on the shelf, the Plan explicitly laid out project implementation and funding requirements.

Interviewees believed partnerships, shared responsibilities, and trust were essential to the implementation of conservation actions. Partnerships were important at an individual level to interviewees, but had also been reinforced through structural organization at the system level. For example, interviewees described how the three main committees (i.e., the Executive Oversight Committee, Technical Advisory Committee, and the Local Area Working Group) collectively provided the capacity, chain of custody over specific initiatives, and influence necessary to accomplish complex tasks. These groups collectively assembled information and data, addressed gaps in science, committed planning and funding resources to priorities, calculated and communicated the sum of cooperative conservation (not just the parts), and ensured decisions were grounded in local knowledge. Each committee provided a critical base of resources and played a unique role. The Local Area Working Group brought institutional memory, local knowledge, and plan-writing skill. The Technical Advisory Committee focused on the science behind the action plan, project-level database development, monitoring progress using the latest rangeland and sage-grouse science and research, and meeting statutory requirements needed to avoid a listing. The Executive Oversight Committee provided regulatory, fiscal, and land management/wildlife authority to facilitate interagency cooperation and oversight necessary to accomplish Bi-State conservation goals.

Structurally and functionally, interviewees called attention to how the partnerships among stakeholders and these committees helped address policy, science and research, and management needs where other approaches would have failed. The Technical Advisory Committee was trusted by the Local Area Working Group to compile and analyze data and make recommendations. Conversely, the Local Area Working Group was trusted by the Technical Advisory Committee to understand and represent the perspectives of landowners and other groups. One interviewee said:

> "The agency results and plan reports were not always trusted. We formed the [Technical Advisory Committee], which started meeting and updated the risk assessment that had been done for 2004 … we took their work back to the [Local Area Working Group]."

Likewise, interviewees felt the Executive Oversight Committee provided a sense of gravitas and authority, as well as a venue for communicating local and regional accomplishments to national policy makers.

Despite the division of responsibilities, interviewees recalled that each committee sought ways to support one another and reinforce each other's roles. For example, to emphasize stakeholder inclusion and engagement—something of primary importance to the Local Area Working Group—the Executive Oversight Committee began holding meeting in communities across the Bi-State, not just in Reno, Nevada, where it was most convenient.

Through this process of blending best-available science with local knowledge, the group was able to meet the FWS Policy for Evaluation of Conservation Efforts When Making Listing Decisions for the Bi-State Sage Grouse.

Discussion

The story of the Bi-State sage-grouse provides an important case study of an SES approach to conservation in the context of the ESA. On the basis of our analysis, we found stakeholders were initially motivated to action by the ESA to avoid a listing decision for Bi-State sage-grouse. However, the focus of conservation efforts quickly shifted to broader system conservation and longer-term restoration of the sagebrush ecosystem. This SES approach to conservation successfully enhanced social interactions to coproduce conservation action and monitoring plans, which focused on tracking ecological outcomes (e.g., vegetation monitoring framework to track project success, sage-grouse population response). We also discovered that specific actors played key roles at different scales, from particularly committed individuals and local and state agency engagement to robust institutional support from federal partners. The collective successes of these efforts were possible because all partners were committed to system-wide, collaborative conservation. This systems approach was empowered by the Plan, which was coproduced to balance science and local knowledge with management and allocate resources toward implementation. Embedded within this case study are lessons of how an SES approach to conservation can be implemented to overcome challenges and improve social and ecological outcomes (Fig. 3).

The groundwork for an SES approach to sage-grouse conservation was initially provided by Governor Guinn's conservation team's call for a landscape-level approach to conservation and management. This comprehensive approach to conservation constituted a "systematic worldview," a key component of SES approaches to environmental management (Virapongse et al., 2016). This systems perspective inspired Bi-State stakeholders to view local sage-grouse conservation as connected to broader scale issues of ecosystem utilization and health. According to Virapongse et al. (2016), such a worldview of conservation is necessary because it helps stakeholders consider diverse options for the future, decentralizes power and decision-making authority, and embraces stakeholder engagement to understand current system structure, as well as defining and embracing future trajectories.

A systematic worldview permeated Bi-State conservation efforts and seemed to have become second nature or intuitive to our interviewees. Brunson (2012) proposed a conceptual model of linkages among ecological and human system components in rangelands. Across interviews, it became clear that stakeholders shared a similar conceptual understanding that sage-grouse conservation was embedded in a dynamic system where social and ecological connections existed at multiple scales. This mindset was shared by institutional leaders and committees, embraced by local actors, and reinforced through organizational structures and partnerships that consciously nested power and a collective narrative that local actions would sum to system-wide change.

SES approaches to conservation must be transdisciplinary, considering the roles and interrelationships among humans and biophysical elements of the system (Virapongse et al., 2016). Transdisciplinary approaches require trust, power sharing, codevelopment of knowledge, and diverse stakeholder involvement (Folke et al., 2003; Ostrom, 2009; Metcalf et al., 2015). The Bi-State conservation efforts were initially motivated over concerns that social systems would be impacted by ESA listing designed to protect an ecological element (i.e., sage-grouse). The severity of this "threat" was magnified by the division and lack of trust between federal regulators and local actors. However, as our interviewees described, the transdisciplinary approach adopted in the Bi-State helped bridge these divides through collaboration that fairly involved any and all stakeholders. Their coproduced knowledge successfully blended best-available science with professional experience and local understanding in a robust knowledge system, necessary for SES approaches (Bestelmeyer and Briske, 2012).

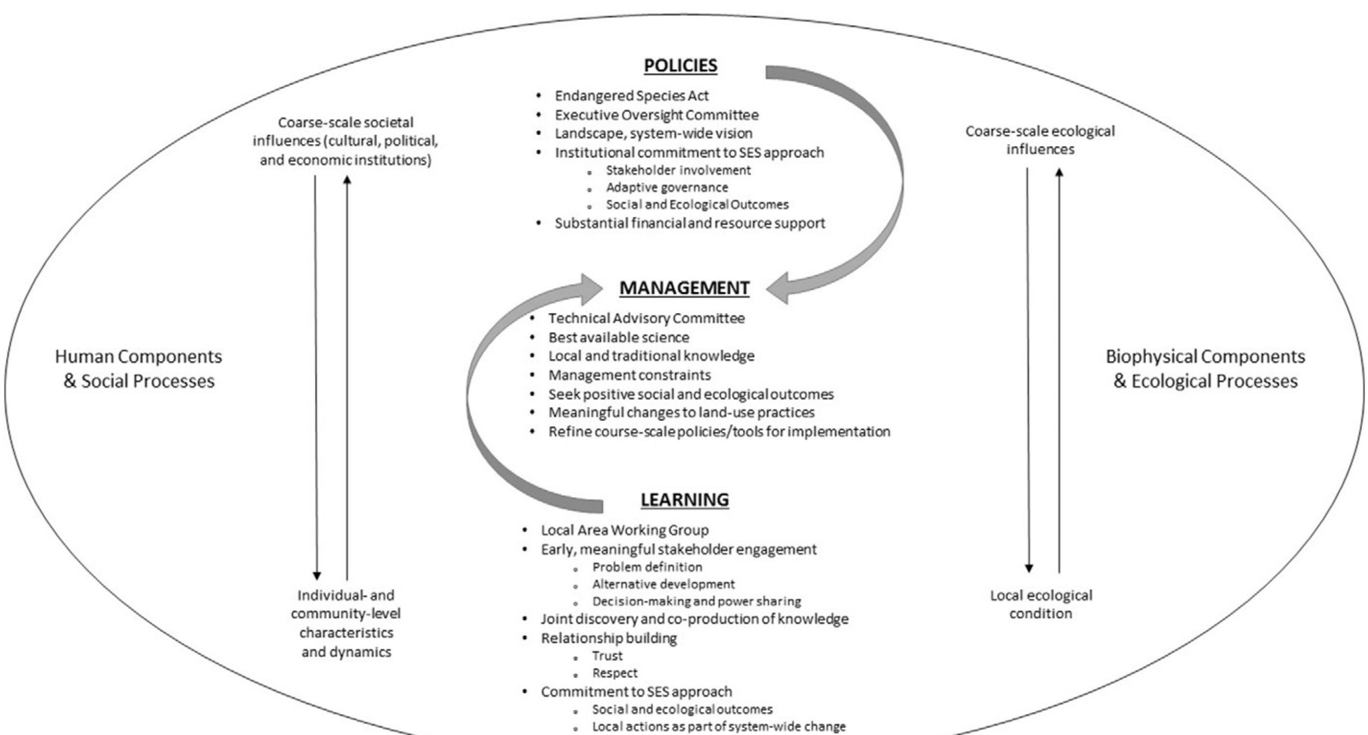

Figure 3. Conceptual Bi-State sage-grouse social-ecological systems model showing examples of and connections among science, policy, and management in the context of the Endangered Species Act (modified from Brunson, 2012).

This transdisciplinary systems approach was established and reinforced in the Bi-State through early, ongoing, and meaningful stakeholder engagement that slowly built trust and solidified a commitment to action. Throughout the effort, institutional leaders demonstrated a commitment to inclusivity; anyone concerned about sage-grouse conservation was invited to the table early and encouraged to play an active role in creating knowledge and constructing alternatives. Their input was honored, not just solicited, and had meaningful impacts at critical junctures. For example, local knowledge was used to refine the course-scale results produced by the Conservation Planning Tool. As social justice scholars have found in other contexts (Lachapelle and McCool, 2005), this approach fostered a sense of ownership over conservation decisions and a commitment to implementation among diverse stakeholders. Additionally, the locally based and rooted relationships allowed the system to move beyond top-down, regulatory protections to jointly produced conservation planning and design. This systems-wide conservation effort helped the Bi-State avoid the "emergency room" approach many have criticized is too frequently imposed by the ESA. Instead, Bi-State conservation efforts sought to improve both social and ecological outcomes and their myriad connections across scales.

SES approaches to conservation extend beyond adaptive comanagement, where small-scale resource utilization issues are well-defined, land use decision makers are clearly delineated, and bottom-up solutions can succeed without external support (Armitage et al., 2010). In the Bi-State, conservation success required embracing the complexities of social and ecological interrelationships, not simply improving past resource utilization techniques. To do so, stakeholders at all levels embraced adaptive governance, a SES component critical for enhancing system resilience (Folke 2006, Holling et al., 1998). Agency and institutional leaders were committed to modifying conservation efforts on the basis of local input and ongoing monitoring. When rules and decisions were made at one level, they were communicated to all. Power dynamics were equalized because decisions were linked across levels, and institutional investments supported local, self-organized decisions.

Institutional support in the Bi-State enabled conservation organization and action to promote system-wide, resilience-based management. The Bi-State was successful, in part, because agencies, local actors, and research units formed partnerships where active dialogue sought acceptable outcomes based on scientific information and stakeholders' values/interests (Smith et al., 2009). External support for these types of efforts is usually lacking because institutions can be averse to sharing power or enabling efforts that might reveal their own errors or challenge long-standing norms (Bestelmeyer and Briske, 2012). In the Bi-State, institutions overcame these constraints and provided staff, resources, and direct investment to empower these critical partnerships and enable system-wide conservation action. Ultimately, the Bi-State's systems-based approach at multiple levels and scales provides an example of how to build resilience and adaptive capacity into the ESA framework and, in so doing, strengthen the role and authority of conservation planning by local public and private actors (Benson, 2012).

Management Implications

More examples are needed of systems approaches to conservation that enhance the interconnections between positive social and ecological outcomes. The Bi-State provides one such example where key SES components were realized despite the complexity of system dynamics. In the context of endangered species management, this example helps demonstrate how at-risk species conservation may be achieved. Critical to this systems approach was an early (i.e., prior to species listing), system-wide frame; inclusive and meaningful stakeholder engagement at local, programmatic, statewide, and national levels; and an adaptive governance approach with substantial institutional commitment (i.e., technical and financial).

The role of the ESA in the Bi-State was critical for inspiring early action and defining the threshold of acceptable ecological outcomes. Remaining elements of the systems approach, critical to the success of sage-grouse conservation, were adopted because stakeholders and leaders believed they were the best approach for maintaining a healthy sagebrush ecosystem, not because they were required. Most importantly, conservation partners were able to transform the "threat" of ESA listing, often a divisive and conflict-prone situation (e.g., Dietrich, 1992), into a collaborative, system-wide opportunity. The dynamics and charisma that enabled that pivot are not fully understood and worthy of deeper investigation. Can scientists and managers in other contexts accomplish a similar shift when the potential for conflict is so high?

Conservation ultimately requires people to act and affect positive ecological change. To inspire and empower action, acceptable tradeoffs must be made between social and ecological goals if win-win solutions cannot be achieved. SES approaches have been suggested as a fruitful means toward these ends. In the case of the Bi-State, several SES components were achieved enabling successful conservation planning, design, and implementation. This case study provides examples for future conservation efforts of how SES principles can be tangibly employed. Although more evidence is needed to refine systems approaches to conservation, we believe this case study provides a useful example of how SES theory can be applied in a practical management scenario. The future of biodiversity conservation and other intractable conservation challenges like climate change increasingly hinge on the collective ability of groups to formalize SES approaches through emphasizing adaptive problem solving, learning, and meaningful stakeholder engagement across temporal and spatial scales. This resilience perspective may be the most important investment that rangeland conservation programs and institutions make to benefit the social and ecological systems of the future.

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Appendix A. Bi-State action plan for conservation of the greater sage-grouse Bi-State distinct population segment—certainty of implementation.

Agency/Entity	Financial commitment	Role in project implementation
Nevada Department of Wildlife	$3.6 million	Vegetation monitoring; population monitoring
California Department of Wildlife	$1 million	Translocation of grouse; population monitoring; monitoring predation effects; habitat acquisition via conservation easement with Eastern Sierra Land Trust
US Forest Service Humboldt-Toiyabe and Inyo National Forests	$13.9 million	National Environmental Policy Act (NEPA) planning for projects; planting and irrigation plans; grazing management; meadow restoration; telemetry monitoring
Natural Resources Conservation Service	$12 million	Landowner outreach on easement and habitat restoration opportunities; conservation easements; seek

(continued)

Agency/Entity	Financial commitment	Role in project implementation
		matching funds for partners; request rancher permission to share easement and conifer removal information; co-sponsor workshops on conifer removal; build capacity through field delivery, science, and communications; coordinate to identify priority conifer areas and utilize Environmental Quality Incentives Program to accelerate projects
Bureau of Land Management	$6.5 million	NEPA planning for projects; conifer removal; meadow enhancements for brood-rearing habitat; cheatgrass control; infrastructure evaluated and implemented; wild horse assessment and implementation; funding provided for Conservation Planning Tool and Science Advisor; collaring and monitoring of birds in partnership with states
US Geological Survey	$2.5 million	Develop and apply modeling and science to inform adaptive management; manage Conservation Planning Tool and Integrated Population Model; population monitoring
Mono County	$5.9 million	Coordinate on easement development and seek matching funds; pursue relocation/removal of landfill; raven management at landfill; education and outreach to landowners; general plan update for sage-grouse conservation; assist Bureau of Land Management via a cooperative agreement
TOTAL Partnership Commitment		**$45.4 million**

Appendix B. Bi-State Sage-grouse interview guide

B.1. Partnership Knowledge, Representation, And Resources

1) What is your role in conservation of the Bi-State population of Greater Sage-grouse?
2) What motivated you to become involved in conservation of the Bi-State population of Greater Sage-grouse?
3) In your view, which partners played an essential role in the Bi-State effort?
4) What did they do that was important?

B.2. Partnership Behaviors and Actions Related to the Plan

5) What is your perspective on the Bi-State Action Plan—its purpose, development, and effectiveness in conservation of the Bi-State Distinct Population Segment?
6) How did the partnership collaborate on the science that was required to develop the plan and then communicate this science to key decision makers?

B.3. Endangered Species Act

7) Can you describe how the potential listing of the species affected the process and/or partnership?

B.4. Ability to Navigate Challenges and Roadblocks

8) What key challenges or opposition (roadblocks) did the partnership face in the process?
9) What actions did they take to address the challenges?

B.5. Scaling of the Effort and Lessons Learned

10) What can we learn from the Bi-State about "scaling conservation up or down"? In other words, what elements of the Bi-State story should be shared with others trying to achieve landscape-scale conservation for sensitive species?
11) What is the long-term picture of conservation of the Bi-State, and why is it important?
12) Is there anything else that you would like to comment on related to the Bi-State conservation story, the partnership, or the results?

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