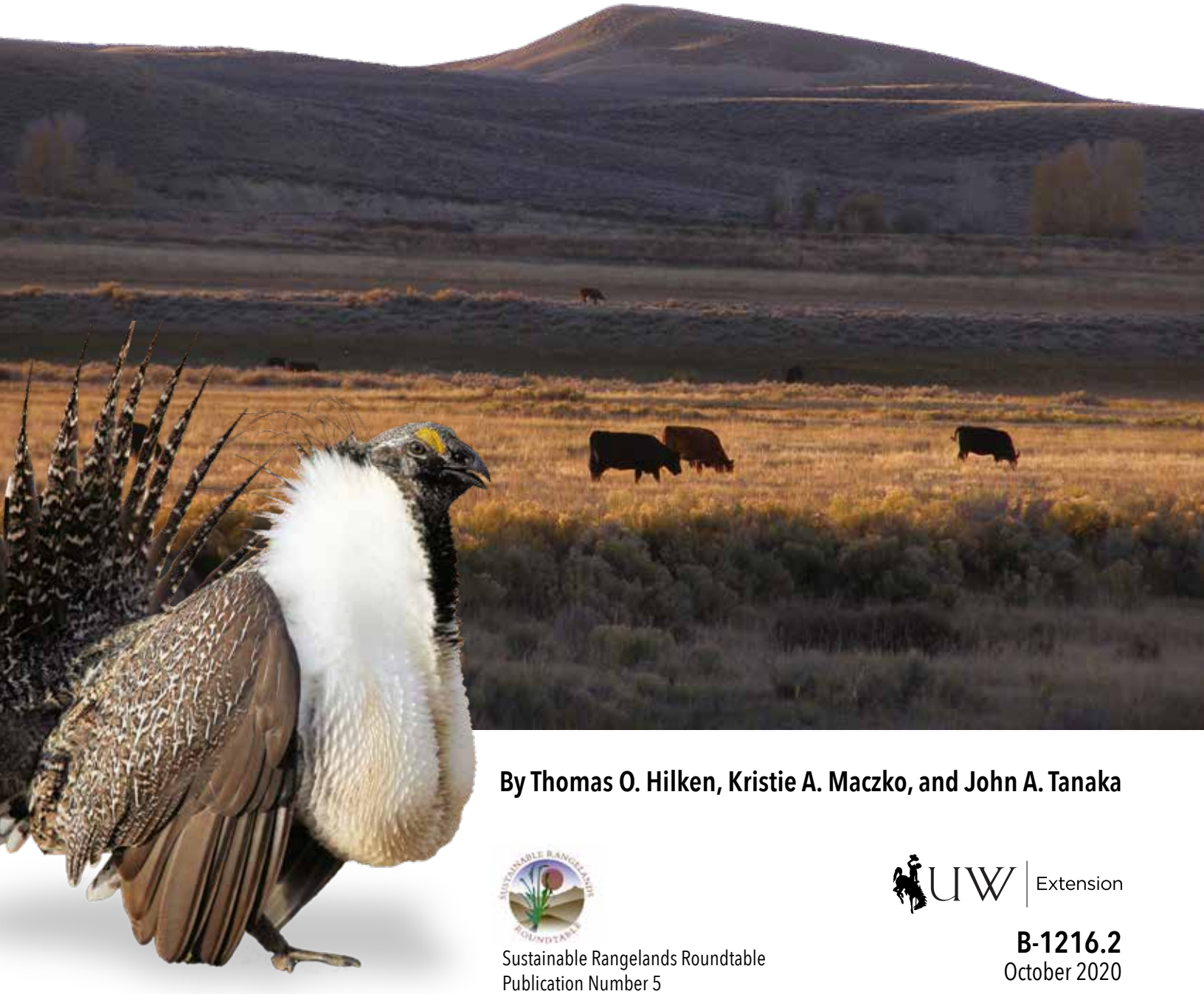
Sustainable Ranching for Greater Sage-Grouse Habitat Conservation:

A RANCHER'S FIELD GUIDEBOOK



By Thomas O. Hilken, Kristie A. Maczko, and John A. Tanaka

Sustainable Rangelands Roundtable
Publication Number 5

UW | Extension

B-1216.2
October 2020

Sustainable Ranching for Greater Sage-Grouse Habitat Conservation: A Rancher's Field Guidebook

University of Wyoming Extension Bulletin 1216.2

Sustainable Rangelands Roundtable Publication No. 5

Authors

Thomas O. Hilken, research assistant, University of Wyoming Department of Ecosystem Science and Management; retired regional program manager, U.S. Forest Service, Pacific Northwest Region, Portland, Oregon.

Kristie A. Maczko, research scientist, UW Department of Ecosystem Science and Management; executive director, Sustainable Rangelands Roundtable (SRR), Fort Collins, Colorado.

John A. Tanaka, professor, UW Department of Ecosystem Science and Management; associate director, Wyoming Agricultural Experiment Station; director, James C. Hageman Sustainable Agriculture Research and Extension Center; science coordinator, SRR, Laramie, Wyoming.

Editors

Robert W. Waggener, freelance editor, writer, and photographer covering agriculture and natural resources in Wyoming and the West, Laramie, Wyoming.

Jessica Windh, Sustainable Rangelands Roundtable Project Manager

Design and Layout

UW Extension, Office of Communications and Technology, Laramie, Wyoming.

Project Funding

U.S. Department of the Interior, Bureau of Land Management, Grant DOIBLM41958.

Suggested Reference

Hilken, T. O., Maczko, K. A., and Tanaka, J. A., 2017, Sustainable ranching for greater sage-grouse habitat conservation: A rancher's field guidebook: University of Wyoming Extension Bulletin 1216.2, 64 p.

On the Cover

Sage grouse photo by Tom Christensen, scenic photo by Robert Waggener, cover design by Tana Stith

Table of Contents

Photo by Stan Harter

Sustainable Rangelands Roundtable

Mission Statement

The SRR promotes social, ecological, and economic sustainability of rangelands through conducting research, developing resources to communicate findings, and providing a forum for networking and collaboration.

What is the Sustainable Rangelands Roundtable?

The Sustainable Rangelands Roundtable (SRR) is a collaborative partnership process involving federal land management and research agencies, tribal, state, and local governments, non-governmental organizations (NGOs), scientific societies, academic institutions, and interested individuals.

The SRR operates as an inclusive, open partnership with all interested representatives having an equal voice. Participants include rangeland scientists and managers, ecologists, sociologists, economists, statisticians, policy and legal experts, environmental advocates, and industry representatives from more than 50 organizations.

The Roundtable:

- Focuses on science, research, education, and extension, and communication related to social, ecological, and economic complexities of Rangeland Sustainability.
- Promotes understanding and interaction among diverse interest groups, and private and public organizations and agencies.
- Includes representatives from non-governmental organizations, advocacy groups, public and private land management professionals, rangeland scientists, and university researchers.
- Meets frequently to promote dialogue and develop applications, models, publications, and products that advance the state of knowledge about Rangeland Sustainability, including soil health, plant communities, animal populations, water quality and quantity, productive capacities, social and economic characteristics, legal and institutional frameworks, and interactions among these elements.
- Welcomes new participants and stakeholders interested in all aspects of Sustainable Rangelands.

For more information, see the SRR website at sustainablerangelands.org, or contact:

Kristie Maczko, Ph.D., SRR executive director
Research Scientist
Department of Ecosystem Science and Management
University of Wyoming

Sustainable Rangelands Roundtable
240 W. Prospect Road
Fort Collins, CO 80526
office phone: 970-498-2573
fax: 970-498-1212
email: kmaczko@uwyo.edu

Acronyms Used in Publication

AU	animal unit
AUM	animal unit month
BLM	U.S. Department of the Interior, Bureau of Land Management
BMPs	best management practices
CCA	candidate conservation agreement
CCAA	candidate conservation agreement with assurances
EA	environmental assessment
EIS	environmental impact statement
ESA	Endangered Species Act
ESD	ecological site description
FAR	functioning-at-risk
FWS	U.S. Department of the Interior, Fish and Wildlife Service
GPS	Global Positioning System
MIM	multiple indicator monitoring
NEPA	National Environmental Policy Act
NF	non-functioning
NRCS	U.S. Department of Agriculture, Natural Resources Conservation Service
PFC	proper functioning condition
SEPA	State Environmental Policy Act
SGI	Sage Grouse Initiative
USDA	U.S. Department of Agriculture
USFS	U.S. Department of Agriculture, Forest Service
UW	University of Wyoming

Sustainable Ranching for Greater Sage-Grouse Habitat Conservation: A RANCHER'S FIELD GUIDEBOOK

By Thomas O. Hilken,[1] Kristie A. Maczko,[2] and John A. Tanaka[3]

[1]Research assistant, University of Wyoming (UW) Department of Ecosystem Science and Management; retired regional program manager, U.S. Forest Service, Pacific Northwest Region, Portland, Oregon.

[2]Research scientist, UW Department of Ecosystem Science and Management; executive director, Sustainable Rangelands Roundtable (SRR), Fort Collins, Colorado.

[3]Professor, UW Department of Ecosystem Science and Management; associate director, Wyoming Agricultural Experiment Station; director, James C. Hageman Sustainable Agriculture Research and Extension Center; science coordinator, SRR, Laramie, Wyoming.

Introduction

Executive Summary

The purpose of this guidebook is to help ranchers and land managers use integrated business planning and socio-economic and ecological monitoring to ensure their ranches are managed in a sustainable manner while maintaining or enhancing greater sage-grouse habitats. The assessment questionnaire included in this bulletin provides an opportunity for ranchers to gain insight about their operations. It includes information that will help agricultural producers and land managers develop or amend an existing ranch plan that may include habitat conservation and/or restoration for the iconic bird of the West. This guidebook is closely tied to the 2013 University of Wyoming Extension publication B-1216, *Sustainable Ranch Management Assessment Guidebook, Do You Know Whether Your Ranch is Sustainable? A Communication Tool for Ranchers, Technical Service Providers, and Agencies*, particularly in regard to the development of the sustainable ranch plan. Most importantly, this guidebook provides ranchers with information to develop socio-economic and ecological monitoring programs for their operations, including sage-grouse habitats. And finally, this guidebook, used in conjunction with UW Extension's B-1216, can help inform a rancher's decision-making processes by offering a framework for assessing, planning, monitoring, and evaluating overall ranch management, which may include sage-grouse habitat management and conservation.

Key Words

Centrocercus urophasianus, ecological monitoring, habitat conservation, greater sage-grouse, integrated business planning, ranch management, socio-economic monitoring, sustainable ranching

Background Information

The greater sage-grouse (*Centrocercus urophasianus*) is the largest species of grouse in North America and is considered a sagebrush obligate species, depending on shrubs in the genus *Artemisia* for food and cover during all of its life stages, particularly during winter when sage-grouse rely on sagebrush for forage and cover. The greater sage-grouse is often thought of as an iconic symbol for the health of western sagebrush habitats, which span ~165 million acres in 11 western states and two Canadian provinces. The total historic habitat may have encompassed more than 463,509 square miles, and one estimate suggests that sage-grouse habitat has

Photo by Tom Christiansen

Diversity of grasses and forbs is important for sage grouse habitat

decreased by roughly 56% from its historic range (Schroeder et al., 2004, and others). This decline is associated with the widespread loss of sagebrush habitats as a result of many factors, including the conversion to cropland, urban/rural development, and other human-related development, and the adverse modification of existing sagebrush habitats (U.S. Fish and Wildlife Service, 2015a). In the western portion (Fig. 1) of the sage-grouse's range, some sagebrush habitats have undergone large-scale change primarily due to the introduction of exotic annual grass species at low elevations resulting in altered fire regimes. At higher elevations, meanwhile, expansion of native conifers—notably juniper, including Utah (*Juniperus osteosperma*), western (*J. grandis* and *J. occidentalis*), and Rocky Mountain (*J. scopulorum*), as well as piñyon pine (*Pinus* spp.)—has largely degraded some sagebrush habitats (Davies et al., 2011b). In the eastern portion (Fig. 1) of the bird's range, large-scale anthropogenic developments (oil and gas development and associated roads, wells, and infrastructure) has largely impacted sagebrush habitats (Naugle et al., 2011). The greater sage-grouse has been considered for listing eight times under the federal Endangered Species Act (ESA). In 2010, it was warranted for listing under the ESA, but precluded by higher priority actions. In September 2015, the decision was made not to list, but to reevaluate the listing decision in 2020 (U.S. Fish and Wildlife Service, 2015b).

Sage-grouse are dependent on the sagebrush ecosystem for all four seasons of the year and every life stage, including lekking and breeding, nesting, brood rearing, and surviving the winter. Properly managed livestock grazing is usually not a threat to sage-grouse and, in some locations, may actually benefit some sage-grouse habitats (Boyd et al., 2014a). Researchers have documented positive effects of livestock grazing on sage-grouse habitat, but also negative effects (Beck and Mitchell, 2000; Davies et al., 2011b; Pyke, 2011; Boyd et al. 2014a, 2014b; Chambers et al. 2014a, 2014b). On the negative side, prolonged heavy grazing and other grazing mismanagement, particularly during the growing season, can (1) degrade sage-grouse habitat conditions and exacerbate sage-grouse nest predation and nest abandonment; (2) modify vegetation structure and plant species composition in ways that decrease food and cover; and, (3) at lower elevations, increase the spread of nonnative, fire-prone, annual grasses (Reisner et al., 2013; Boyd et al., 2014a, 2014b; Chambers et al., 2014a, 2014b). In addition, repeated heavy grazing and other grazing mismanagement, over time, can decrease vigor and production of perennial bunchgrasses and forbs, and may cause compositional shifts toward increased shrub dominance (Mueggler, 1950; Laycock, 1967; Bork et al., 1998; Ganskopp et al., 2004). On the positive side, appropriately managed grazing can improve sage-grouse habitat under certain conditions. For example, if applied properly, prescriptive grazing can reduce excessive shrub cover, increase habitat heterogeneity, and reduce fine fuels from annual grass production, the latter of which reduces wildfire risk (Davies et al., 2009b, 2010, 2011b, 2014; Boyd et al., 2011; Strand and Launchbaugh, 2013; Chambers et al., 2014a; Sheley et al., 2014). Studies show that light to moderate livestock use (i.e., up to approximately 50% of available yearly perennial grass biomass) can be compatible with maintenance of perennial vegetation (Sneva et al., 1984; Miller et al., 1994), but the net impact of different use levels varies strongly in accordance with climatic variability, local site characteristics, and timing of grazing (Westoby et al., 1989; Crawford et al., 2004). Because of this, there is a degree

of complexity in deciding where, when, and how to apply different types of management under varied local ecological conditions (Boyd and Svejcar, 2009); furthermore, sage grouse habitat is spatially distributed across private, state, and federal (both BLM and USFS) land, making cooperation among agencies and private landowners, with potentially different grazing regulations, essential.

In general, however, managing livestock grazing to maintain adequate residual grass height and cover under shrubs, particularly during the nesting and early brood-rearing season, will likely minimize the effects of grazing on sage-grouse productivity (Boyd et al., 2014a). In many places, properly functioning livestock operations provide excellent wildlife habitat and often maintains many basic ecological processes on these landscapes (Davies et al., 2011b). From a rancher's perspective, maintaining functioning, healthy sagebrush steppe is good for the ranching industry, sage-grouse conservation, rural western economies, and many sagebrush ecosystem organisms, such as songbirds and small mammals. It has been reported that approximately 350 vertebrate wildlife species inhabiting sagebrush may also benefit from greater sage-grouse conservation. A common saying across the West is "What's good for the bird is good for the herd" (Correll et al., 2017).

Purpose

In January 2013, the University of Wyoming Extension published the *Sustainable Ranch Management Assessment Guidebook: Do You Know Whether Your Ranch is Sustainable? A Communication Tool for Ranchers, Technical Service Providers, and Agencies.* The purpose of Bulletin 1216 (Hamilton et al., 2013) was to help ranchers and land managers use integrated business planning and ecological monitoring to ensure their ranch is managed in a sustainable manner. The guidebook also provided the impetus and incentive for the development of this companion guidebook. Though similar and closely tied to the 2013 guidebook, this 2017 publication places emphasis on sustainable ranching in regard to sage-grouse conservation.

The purpose of *Sustainable Ranching for Sage-Grouse Habitat Conservation* bulletin is to help ranchers and land managers (1) assess, plan, and monitor their ranching operations and/or land under their management; and (2) determine if their ranch is being managed sustainably while maintaining and/or improving sage-grouse habitat.

Part One of the guide—Assessment Questions—is a questionnaire primarily focused on current ranch management practices and other considerations including sage-grouse conservation. The purpose of filling out the assessment questionnaire is to gain insight about a rancher's family and ranch operation, as well as their relationships with those with whom they may consult with on the business of managing the ranch, including the challenges of maintaining and/or restoring sage-grouse habitat. The assessment should also provide background information for ranchers and land managers to develop business and monitoring plans for their operations, taking into account sage-grouse habitat that may occur on their private land, private leased lands, or permitted state or federal land. It is our hope, too, that the assessment acts as a confidence-builder when it comes to decision-making.

Part Two is a brief discussion on the development of an integrated business plan following procedures outlined in the previously discussed companion UW Extension publication, *Sustainable Ranch Management Assessment Guidebook* (Hamilton et al., 2013). For those ranchers having an informal business plan, this assessment should help in the development of a more formal plan. In addition to the 2013 guidebook, there are many other useful publications including the U.S. Small Business Administration's SCORE program, which offers technical assistance and information about business planning, notably financial (SCORE Association, 2017), and the handbook *Sustaining Western Rural Landscapes, Lifestyles, and Livelihoods* (Wyoming Business Council, 2003). Some of the information derived from the assessment part of the *Sustainable Ranching for Sage-Grouse Habitat Conservation* bulletin can feed directly into the worksheets and categories required for the development of a sustainable business plan.

Part Three assumes that an overall business plan and a monitoring plan have been established following recommendations in the companion guidebook (as referenced above) and that appropriate socio-economic and ecological indicators were developed and identified for a rancher's sustainable business and monitoring plan. The monitoring indicators identified in this guidebook are also specific for maintenance and/or restoration of sage-grouse habitat. Development of an effective site-specific monitoring program for sage-grouse habitat on a ranch requires a rancher's involvement, usually strengthened with some outside help from folks who are not

Photo by Tom Christiansen

Sage grouse hens use the sage brush as cover to hide their nests from predators

only familiar with the rancher and the ranching operation, but who are also very knowledgeable about sage-grouse and their habitat requirements.

Part Three also incorporates specific sage-grouse habitat indicators primarily found in the *Sage-Grouse Habitat Assessment Framework: A Multiscale Assessment Tool* (Stiver et al., 2015). These indicators are commonly used in conservation agreements and for ranching operations. They can be included in a rancher's existing sustainable ranch and monitoring plans, and the plans will evaluate ecological as well as socio-economic conditions. The collection, organization, and summarization of monitoring information for sage-grouse conservation is also valuable for sharing meaningful information with a rancher's neighbors, agency administrators, conservation groups, and others involved with sage-grouse conservation efforts.

Finally, and perhaps most importantly, this guidebook serves as a basis for partnering, networking, and having those very important conversations among a rancher's family; neighbors; local, county, state, and federal administrators; professional advisers including bankers, Extension specialists, rangeland scientists; and other successful ranchers who have sagebrush ecosystems containing sage-grouse habitat. Efforts by private landowners in undertaking voluntary sage-grouse conservation practices have been an important element in the "not listing" of the bird as a threatened or endangered species under the ESA (U.S. Fish and Wildlife Service, 2015c). Maintaining and documenting these voluntary efforts will be critical in future listing reviews. While programs involving private lands differ than those involving public lands, the program administrators work with ranchers, landowners, and other partners on long-term agreements to undertake proactive conservation measures that benefit sage-grouse. Through the Sage Grouse Initiative (SGI), more than 1,500 ranchers have restored or conserved more than 5.6 million acres across 11 western states to improve habitat for sage grouse while also improving ranching operations (Sage Grouse Initiative, 2020). The SGI is a partnership-based, science-driven effort that uses voluntary incentives to proactively conserve western rangelands, sage-grouse and other wildlife, and the rural way of life. Among the partners are ranchers, local, state, and federal agencies, universities, nonprofit groups, and businesses. Through the recently announced SGI 2.0 strategy, the U.S. Department of Agriculture (USDA) expects voluntary, private land conservation efforts to reach 8 million acres by 2018. On private and federal lands, the U.S. Fish and Wildlife Service (FWS) and U.S. Bureau of Land Management (BLM) have received commitments on 5.5 million acres through candidate conservation agreements (CCAs). Many of these projects also improve grazing and water supplies for ranchers, benefitting cattle herds and the long-term future of ranching in the West (U.S. Fish and Wildlife Service, 2015c). Ecologically healthy and economically stable private rangelands help support rural communities, which, in turn, support intact valuable local services, including expertise and infrastructure to help address important landscape-level conservation challenges, such as suppressing undesirable wildfire, treating exotic species invasions, and monitoring local field conditions (Murphy et al., 2013; Davies et al., 2014). Loss or decline of these local communities can make meeting these challenges difficult.

Part One: Assessment Questions

As you work through the various sections of the questionnaire, you will notice the questions will probe you for knowledge about your ranch and will identify issues and potential problem areas in your operation. You will also notice that there are particular questions relating to sage-grouse conservation and maintenance and/or restoration of sagebrush ecosystems. The questionnaire should also indicate where outside help and assistance may be needed to strengthen management plans, remedy problems, and move your ranch business toward sustainability while maintaining and/or enhancing sage-grouse habitat.

Part 1: Family resources.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Has your ranch family collectively explored and documented personal and family values as they relate to your ranch business and sage-grouse conservation?			
Has your ranch family collectively developed a set of written goals and objectives that describe the desired future state of your family and ranch business in regard to livestock production and sage-grouse conservation?			
Have you discussed conservation ranching, stewards of open spaces, and other market-based strategies (such as carbon sequestration, ecosystem services, etc.) that benefit your ranching operation and wildlife habitat?			
Do you value non-market value resources (such as non-game wildlife and the habitats they occupy) on your ranch?			
Are you familiar with Audubon's "Grazed on Bird Friendly Land" program (Audubon Rockies, 2017) or similar incentive conservation programs?			
Are you familiar with Nevada's "Shoesole" grazing program, which emphasizes adaptive management for sustainable results including maintaining and improving sage-grouse habitat (Shoesole Resource Management Group, 2017)?			
Do your family and non-family members of your ranch operation know the habitat and life history requirements of sage-grouse?			
Do you regularly utilize technical and financial assistance available from public and private resources?			
Is your family coordinating and communicating with other ranching families—both near and far away—that are also managing for sage-grouse habitat?			
Notes:			

Part 2: Ranch management programs and practices.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you, family members, or employees have college-level or other formal education or training in fields relevant to the ranch business and wildlife conservation?			
Does your ranch business operate under an existing sustainable business plan, following guidelines similar to those in the UW Extension publication *Sustainable Ranch Management Assessment Guidebook* (Hamilton et al., 2013)?			
Do you devote human and financial resources to measuring and monitoring changes in the condition of your ranch's rangelands?			
Do you, family members, and employees utilize continuing education opportunities to stay current on business and ranching knowledge including sage-grouse conservation?			
Have you completed an inventory of the land, natural resources, and property improvements associated with your ranch business?			
Have you completed an inventory of sage-grouse habitat including breeding (lekking sites), nesting, brood rearing, wintering, and migratory) habitats that may occur on your ranch?			
Does your ranch property have mapped sage-grouse "priority areas," "core areas," or "general habitat" (these terms and many others are explained in Appendix 3, Glossary of Terms)?			
Are you involved with any formal monitoring of your sage-grouse habitat?			
Do you have a cooperative monitoring agreement with the appropriate state and federal agency to formalize accountability and responsibility for both yourself and the land management agency to ensure adequate (required or voluntary) monitoring is completed?			
Ae you involved and participating in cost-share programs for range improvement projects for your livestock production and for the maintenance and/or enhancement of sage-grouse habitat?			
Do you use prescribed fire (and even managed wildfire) to enhance degraded sage-grouse habitat or maintain excellent habitat?			
Are you involved with invasive plant management—specifically annual grasses, e.g., cheatgrass (aka downy brome, *Bromus tectorum*), ventenata (aka African Wiregrass, *Ventenata dubia*), medusahead rye (*Taeniatherum asperum*), and juniper encroachment?			
Do you use different kinds of livestock (e.g., sheep, goats) to control invasive species and enhance livestock forage conditions and wildlife habitat?			

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you adjust your seasonal ranch operations either through timing or location changes (e.g., calving, haying, weaning, etc.) to minimize impacts to the life history and seasonal habitat requirements of sage-grouse?			
Do your livestock water tanks have escape ramps?			
Do you maintain contiguous sagebrush habitat by avoiding fragmentation (e.g., do you avoid subdividing property, establishing new roads, buildings, and powerlines, within sagebrush habitat)?			
Do you avoid building new infrastructures (roads, buildings, fences) within 0.6 miles of leks?			
If you cannot avoid building new infrastructure within 0.6 miles of leks or within sage grouse habitat, do you try to minimize new construction, or consolidate new construction to a localized area?			
Where feasible, do you try to bury new and existing power lines?			
Do you avoid known nesting and brood-rearing habitat as a location for activities that concentrate livestock such as stock tank placement, branding, and roundup?			
Do you avoid placing salt or supplements within 0.25 miles of riparian habitats?			
Do you implement a grazing strategy to maintain or enhance riparian habitat?			
Do you allow springs to be free-flowing (do not capture all water) at the point of diversion or source of the spring to maintain or enhance a riparian area?			
Do you fence riparian areas to protect habitat from trampling or install markers (to prevent sage grouse collisions)?			
Do you have a drought management plan whereby you adjust season of use, intensity, and/or duration of livestock use as a result of drought?			
Do you maintain a 40% or less utilization of forage, particularly in sage-grouse habitat areas?			
Do your gravity-fed overflow devices return water back to the spring or wetland area?			
Do you ensure float devices in tanks are operational?			
Do you try to graze only 20% of your rangelands that contain nesting and early brood-rearing habitat in any one year?			
In nesting and brood-rearing habitat, do you use a three (or more)-pasture deferred rotation grazing system or something similar to allow for periodic rest and/or deferment?			

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you regularly move where your cattle, sheep, bison, goats, horses, etc., graze (using herding or cross-fencing) to meet conservation goals by using targeted or precision grazing methods?			
Are you required to delay turnout in nesting and brood-rearing habitat on your state or federal managed lands?			
If possible, have you considered periodic dormant-season grazing to rest your spring–summer range from livestock use for conservation reasons?			
Notes:			

Part 3: Land management relationships and partnerships.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you participate on county boards, committees, and local working groups that are addressing sage-grouse conservation?			
Do you know, and visit periodically with, local representatives of the state agriculture department, state economic development agencies, USDA Rural Development, U.S. Small Business Administration, and other state and federal agencies that provide educational, technical, or financial services relating to sage-grouse conservation?			
Do you have a working relationship with your local conservation and environmental organizations?			
Do you have a working relationship with your state conservation and environmental organizations?			
If your relationships are poor with the agencies (from questions 2, 3, & 4), are you working through a mediation or facilitation process to improve the relationships?			
Has any local (private or county-level) organization conducted a county or community assessment regarding sage-grouse habitat on your ranch?			
If an assessment of sage-grouse habitat has been done on your ranch, does the assessment address ranching activities and practices that have been or will be implemented to maintain or improve sage-grouse habitat?			
If there has been an assessment regarding sage-grouse habitat, have the economic impacts of current or suggested management been analyzed and evaluated on your private land?			

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you have a mitigation plan if the implementation of land health standards and guidelines on your permitted or leased public land results in negative economic impacts to your ranching operation?			
Are you visiting with local representatives of the USDA Natural Resources Conservation Service (NRCS) or other federal or state agencies that provide educational, technical, and financial services in regard to sage-grouse conservation?			
Are you partnering in a local Rangeland Fire Protection Association, fire district, or similar group to improve fire protection in sage-grouse habitat?			
Notes:			

Part 4: Adjunct lands–private, state, and federal rented, leased, and permitted lands.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you know, and visit regularly, with local representatives of the BLM, NRCS, U.S. Forest Service (USFS), office of state lands, and other federal and state agencies about your ranch and leased/permitted public lands?			
Are you familiar with the assessment tools detailed in the *Sage-Grouse Habitat Assessment Framework* (Stiver et al., 2015)?			
In the past, has your relationship with any of the lessor or permittor entities resulted in a negative impact on your ranch operation, e.g., temporary loss of a permit, decreased stocking rates, increased rent, improvement costs, etc.?			
In the past, has your relationship with any of the lessor or permittor entities resulted in a positive impact on your ranch, e.g., improvement in livestock forage conditions, improved livestock performance, etc.?			
Do you work cooperatively with conservation groups and other organizations on programs or activities that affect your ranch?			
Do you work cooperatively with your agency partners when they are directed to implement land and water protection programs on your leased and permitted lands?			
Do your rented, leased, and permitted lands contain sage-grouse habitat?			

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Are your federal grazing permits or grazing leases covered by current and up-to-date environmental regulations (e.g., National Environmental Policy Act [NEPA], or State Environmental Policy Act (SEPA) documents, such as an environmental assessment [EA] or environmental impact statement [EIS]) that address sage-grouse habitat?			
Are you actively engaged in the public participation land management planning process such as the NEPA and SEPA state environmental policy act process when your federal permit or state lease is up for renewal?			
Do you know when your state lease and/or federal permit or federal lease is scheduled for renewal?			
Do you know the priority of your federal allotment's term permit renewal in regard to the updated rescissions schedule?			
Do you work with a rangeland consultant or third party when developing your ranch and monitoring plans?			
Do you inform agencies that you want to be involved in the permit renewal process?			
Notes:			

Part 5: Soils, soil erosion, and soil management.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Are there existing soil maps, aerial photography, or satellite imagery for each of your land units (pastures, fields, etc.)?			
Do you have an NRCS soil survey map showing soil mapping units?			
Do you know if ecological sites have been identified and "correlated" to the soil mapping units on your managed lands?			
Do you know how to obtain soil maps and aerial photography, etc.?			
Have you had your local NRCS conservationist, university Extension specialist, and/or soil and water conservation district employee on your ranch for consultation?			
Are there areas within fields or pastures on your ranch where soils appear to be limiting forage productivity and/or vegetation cover requirements for sage-grouse habitat?			

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Have you taken any steps to evaluate what soil characteristics may be causing this limitation?			
Are there areas in fields or pastures that have had perceptible increases in bare ground in the past 10 to 20 years that are not attributable to drought?			
Are there areas on your managed rangelands that have had measurable increases in bare ground?			
Have you taken any action to mitigate increases in bare ground on your ranch?			
Are there areas on your managed rangelands that have had measurable decreases in plant cover not attributable to drought in the past 10 to 20 years?			
If there has been an increase in bare ground and measurable decrease in plant cover on your managed rangelands, do you have a mitigation plan to reduce bare ground and increase plant cover?			
Are there significant areas of accelerated soil erosion (gullies, head cuts, blowouts, etc.) in any of the pastures and fields on your ranch?			
Have you taken any action to mitigate accelerated erosion on your ranch during the past five years?			
Do you think that soil erosion has adversely affected the land and soils on your ranch?			
Do you think that soil erosion has adversely affected the water quality of the ponds, lakes, streams, or rivers on your ranch?			
Do you think that soil erosion has adversely affected the profit margin of your ranch?			
Do you know if ecological site descriptions (ESDs) have been developed for your sage-grouse habitat areas?			
Are there areas within your ranch or managed lands where sage grouse habitat appears to be limiting due to soil erosion?			
Is plant cover lacking in riparian/wet meadow areas?			
If plant cover is lacking in riparian/wet meadow areas, do you know the cause?			
Notes:			

Part 6: Water availability—quantity, duration, and quality.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you have adequate water supply (legal water rights, allocations, etc.) from rivers, streams, springs, and wells to meet all of your water needs throughout the year—including both water for grazing distribution and water for irrigation?			
Has there been a noticeable change in the frequency or duration of surface no-flow periods in streams or springs on your ranch during the past five to 10 years?			
Has there been a noticeable change in the depth to the groundwater table under your ranch during the past five to 10 years?			
Has there been a noticeable change in the amount of groundwater you can pump during the past five to 10 years?			
Do the streams, springs, ponds, or reservoirs on your ranch that dry up in mid-to-late summer adversely affect your operation?			
Do the streams, springs, ponds, or reservoirs on your ranch that dry up in mid-to-late summer adversely affect sage-grouse habitat?			
Are you aware of any significant deterioration in the water quality (chemical, biological, or physical) properties of the lakes, ponds, reservoirs, rivers, and streams on your ranch during the past five to 10 years?			
Do you think that poor water quality adversely affects the profitability of your ranch?			
Do you think that poor water quality adversely affects sage-grouse conservation or your ranch or managed lands?			
Do you have a water quality plan for your ranch?			
Do you have a water quantity plan for your ranch?			
Do you have a drought management plan for your ranch?			
Notes:			

Part 7: Plant communities, riparian areas, wetlands, invasive species, threatened and endangered species, wildfire, and prescribed fire.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you have a current (within last five years) inventory of the existing upland rangeland and riparian plant communities on your ranch?			
Do you have a current rangeland inventory of existing sagebrush-perennial grass-forb communities?			
Do you know the location of sagebrush plant communities that contain breeding, nesting, brood-rearing, and wintering habitats for sage-grouse on your ranch or managed lands?			
Are you working closely with your agency rangeland management specialists and wildlife biologists to ensure you have all the latest technology and tools (habitat maps, ecological sites, and/or ESDs, plant community type maps, aerial photos, satellite imagery, etc.) necessary to effectively identify and manage sage-grouse habitats on your state and federal leases?			
Do you know the percent (%) of canopy cover of sagebrush, perennial grass, and forbs, and the height of sagebrush, perennial grass, and forbs, within your sagebrush plant communities?			
Have you had a sage-grouse habitat suitability analysis completed for breeding, nesting, brood rearing, and wintering sage-grouse within sagebrush plant communities on your ranch or managed lands?			
If sage-grouse habitats are marginal or unsuitable, do you know what components of the habitat need to be restored to ensure suitability at some point in the future?			
Do you have a written plan that will provide guidance to maintain existing plant communities that provide suitable habitat for sage-grouse?			
Do you have a written plan that will provide guidance to improve existing unsuitable plant communities (i.e., ensure that they become suitable sage-grouse habitat)?			
Are your riparian/wet meadow plant communities in close proximity to sagebrush plant communities?			
Are your ranch's riparian zones used by livestock at the same time every year?			
Do you know both the location and total acreage of "wetlands" and "riparian areas" on your ranch? Use a broad definition—specifically identify those wetlands that fall under Section 404 of the U.S. Environmental Protection Agency's Clean Water Act, but also include other wetland areas that may be important, but do not fall under the "404" definition.			
Has a riparian "proper functioning condition" (PFC) assessment been completed on your managed lands?			

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
If a PFC assessment has been completed, have functioning at-risk (FAR) and/or non-functioning (NF) areas been identified on your managed lands?			
Do you have a mitigation plan for riparian areas that are FAR or NF on your managed lands?			
Do you actively manage wetlands and riparian areas to support conservation of wildlife (including waterfowl and sage-grouse) and water resources?			
Are you familiar with and using the latest technology from SGI (Sage Grouse Initiative, 2017) to map and prioritize riparian and wetland habitat?			
Have you identified the areas that invasive plant species have occupied on your ranch?			
Do you treat (fire, herbicides, or mechanical) woodland species and invasive annual grasses that have occupied or are encroaching into sage-grouse habitats?			
Is the use of prescribed burning as a vegetation management tool threatened by smoke management concerns?			
Do you avoid use of fire in precipitation zones with less than 12 inches annual rainfall?			
Are you restricted in the choice or application method of herbicides to use?			
If a plan is developed to use mechanical treatment to meet sagebrush cover requirements and encourage perennial grass and forb development, do you use a mosaic pattern of treatment rather than one large block?			
Have you visited with your neighbors about the presence of invasive species on their property?			
Do you believe that invasive species on your ranch adversely affect your ranching operation and your profit margin?			
Do you work and partner with neighbors, agencies, and others (e.g., form a coordinated weed management area) to control invasive annual grasses and juniper encroachment?			
Have you considered using a "flerd" to control invasive species and improve livestock forage conditions (flerd, a contraction of "flock" and "herd," is a mixed-species group of animals such as sheep, goats, and cattle grazing together)?			
Do you actively incorporate appropriate best management practices (BMPs) to minimize potential adverse impacts on threatened and endangered plant and/or animal species that you may have on your ranch or managed land?			
Have you mapped the locations and acreages of land on your ranch that burned, either by natural or prescribed fire, each year for the past 10 years?			

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
If so, have you identified those wildfire areas where fire was detrimental or beneficial to sage-grouse habitat?			
And have you identified those prescribed fire areas where the fire was detrimental or beneficial to sage-grouse habitat?			
Has restoration work following wildfire or prescribed fire been effective?			
Are you familiar with the three-part U.S. Geological Survey publication *Restoration Handbook for Sagebrush Steppe Ecosystems with Emphasis on Greater Sage-Grouse Habitat*? (Pyke et al., 2015a, 2015b, 2017)			
Are you familiar with the U.S. Department of Agriculture publication *A Field Guide for Rapid Assessment of Post-Wildfire Recovery Potential in Sagebrush and Piñon-Juniper Ecosystems in the Great Basin* (Miller et al., 2015)?			
Do you use certified weed-free seed mixes and mulches in your restoration work?			
Do any threatened and/or endangered plant and/or animal species, or species of special concern, on your ranch limit your ability to use a variety of tools (e.g., aerial application of herbicides, fire, mowing) to restore sage-grouse habitat?			
Do you work with agency specialists and others to plan any sagebrush treatments, avoiding areas currently providing suitable sage-grouse habitat?			
Do you avoid eradicating sagebrush to bolster grass resources for cattle and/or to convert rangeland to cropland?			
Notes:			

Part 8: Wildlife species of economic interest, threatened and endangered wildlife species, and greater sage-grouse.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
In addition to sage-grouse, do you actively manage for any other priority wildlife species on your ranch?			
Do you know what species of wildlife are of economic interest to you and occupy habitats on your ranch?			
Do you know habitat requirements and the population status of those species?			

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Are there any threatened and/or endangered species of animals or fish, or any wildlife species of special concern, on your ranch?			
Do you actively incorporate appropriate BMPs to minimize adverse impacts on threatened and/or endangered wildlife species on your ranch?			
Are there economic interests associated with wildlife on your ranch?			
If so, are there opportunities to "grow" that interest and include other species besides sage-grouse that utilize sagebrush rangelands on your ranch (e.g., wildlife viewing, birding, etc.)?			
Are you familiar with land health standards and guidelines for livestock grazing management relating to wildlife that may be occupy lands within your federal grazing leases?			
Do you allow for lek viewing and observation on your ranch?			
Do you treat mosquito larvae present in stock ponds using *Bacillus thuringiensis* or appropriate chemicals to help prevent the possible spread of West Nile virus?			
Do you install raptor deterrents on existing structures (power and other utility poles)?			
Do you avoid using carbaryl/malathion to remove insects that are beneficial to sage-grouse?			
Do you utilize "controlled" hunts (e.g., for any species in which a limited number of tags are issued), working in close cooperation with state wildlife agencies?			
Do you discuss strategies with state wildlife personnel to disperse big game where concentrated or overabundant populations can harm plant communities important to sage-grouse habitat?			
Do you consult with agency specialists to relocate, redesign (e.g., using more visible wood posts or buck and pole fence instead of less visible metal fence posts), or mark existing fences (with markers that are visible to sage-grouse) that occur within 0.6 miles of a lek, especially where previous collisions between sage-grouse and fences have been observed?			
Notes:			

Part 9: Productive capacity.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you estimate total forage production and/or animal unit months (AUMs) or animal units (AUs) by pasture and season on your ranch?			
Do you know the carrying capacity (AUMs) of your private, state, leased, or federal permitted land?			
Is your actual use less than your lease or permitted use on state and/or federal lands?			
Are you allowed flexibility in actual use in regard to your leased or permitted state or federal lands?			
Are you allowed flexibility in season of use in regard to your state or permitted state or federal lands?			
Do you have a weather station(s) on your ranch?			
Are you sharing weather information with agency personnel?			
Is formal monitoring of annual forage utilization done on your ranch?			
Are you involved in the process of formally monitoring annual utilization on your ranch or managed lands?			
Do you have long-term trend transects or photo plots of ranch or managed lands?			
Do you participate with monitoring long-term trends on your ranch or managed lands?			
Do you use the above collected data to inform your management decisions?			
Have you found a relationship between upwards trend in vegetative conditions and livestock performance and productivity on your ranch or managed lands?			
Is your overall ranch's productive capability negatively impacted with planning and implementing sage-grouse habitat maintenance or restoration projects?			
Is your overall ranch's productive capability positively impacted with planning and implementing sage-grouse habitat maintenance or restoration projects?			
Notes:			

Part 10: Ranch enterprises (forage and non-forage plants, livestock, wildlife viewing, hunting, fishing, guide services, and lodging.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you raise livestock (cattle, sheep, goats, etc.) as a revenue-producing enterprise?			
Do you offer game bird hunting (ring-necked pheasant, quail, chukar, dove, waterfowl, etc.) as a revenue-producing enterprise?			
Do you offer bird watching and/or observation of wild animals (sage-grouse lek sites, songbirds, raptors, small animals/watchable wildlife, etc.) as a revenue-producing enterprise?			
Do you, someone associated with your ranch, or a guide/outfitting service offer guided hunting, fishing, hiking, cycling, or wildlife watching services on your ranch as a revenue-producing enterprise?			
Do you rent cabins, a lodge, or other accommodations to clients as a revenue-producing enterprise?			
Have you explored developing niche markets for any of your existing products, e.g., bird watching, recreation such as hiking or cycling?			
Have you explored developing a niche market for invasive piñon pine and/or juniper that are negatively impacting sage-grouse habitat?			
Notes:			

Part 11: Ranch enterprises—financial considerations.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you monitor the financial aspects of your business using a set of generally accepted financial indicators?			
Has there been a recent "enterprise budget" representative of a ranching operation within your area that has assisted you with overall management decisions, such as determining which management practices are profitable and which are not?			
Do you use the financial information you collect and analyze from your ranch business to prepare cash flow statements and to determine unit costs and revenue of production, breakeven points, and rates of return for your various enterprises?			

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Do you use your financial information to determine breakeven points and rates of return for various ranch enterprises including sage-grouse conservation practices?			
Does the sum of your ranch enterprise incomes ever fail to cover the sum of your ranch enterprise expenses?			
Can you accurately estimate the costs of implementing sage-grouse conservation strategies?			
Do you practice adaptive management, e.g., changing management practices based upon information gained from financial and ecological monitoring programs?			
Do you use enterprise budgets as a helpful tool when making financial decisions?			
Do you receive federal, state, or non-governmental financial assistance or cost-sharing for restoration and habitat-improvement activities for sage-grouse and/or other wildlife?			
Do you analyze financial returns from conservation assistance programs that you participate in and that are designed to maintain or improve sagebrush and riparian plant communities for sage-grouse?			
For any conservation practices (e.g., installing fence markers to reduce sage-grouse and other bird collisions, improvement of livestock water, annual grass and piñon-juniper control, etc.) that you may cost-share with on state or federal land, do you analyze your return on your invested labor or capital?			
Do you analyze the financial impacts (either positive or negative) on your ranch operation as a result of terms and conditions or stipulations in biological assessments or biological opinions that may be in place for your state or federal permitted lands?			
Do you analyze economic impacts during your permit or lease renewal process that incorporates new grazing standards and guidelines for sage grouse habitat?			
Is investing in sage-grouse habitat improvement projects and implementing sage-grouse conservation practices profitable—or potentially profitable—for your ranching operation?			
Notes:			

Part 12: Legal and institutional issues–ecological, social, scientific educational, and research sites; and conservation and sustainable management of rangelands.

ASSESSMENT QUESTIONS	No	Undecided or Don't Know	Yes
Are there areas within your deeded ranch lands that are permanently protected under conservation easements or similar legal instruments that protect or conserve land and natural resources from development and other activities?			
Are there areas within your deeded ranch lands that are temporarily protected under social or environmental programs intended to conserve land and natural resources such as the federal Grassland Reserve Program or the Conservation Reserve Program?			
Do you participate in any research and development programs that affect the conservation and sustainable management of sagebrush rangelands?			
Do you "showcase" your ranch to environmental and conservation groups, particularly in regard to maintaining and/or restoring sage-grouse habitat?			
Do you document your successes and "tell your story" to the media?			
Do you work to ensure that any person interested in your ranching operation understands that your management activities are contributing positively toward achieving rangeland sustainability and conservation of sage-grouse habitat?			
Does your ranch provide the opportunity for research in regard to sage-grouse habitat?			
Do you have a conservation agreement (e.g. Candidate Conservation Agreement with Assurances (CCA)) on your ranch for maintenance and/or enhancement of sage-grouse habitat?			
Are you aware of any state or federal land permitted or leased to you that is regulated by a biological opinion and/or assessment?			
Have you been involved in the Section 7 consultation process of the Endangered Species Act (ESA) regarding any threatened, endangered, or special status species on your permitted or leased state or federal rangelands?			
Have you had a representative from a local conservation and/or environmental group on your ranch for consultation?			
Do you have a state or federal grazing permit or state lease that you feel may be jeopardized if the sage-grouse becomes listed under the ESA following the planned 2020 review or anytime thereafter?			
Notes:			

Photo by Derek Scasta

Sage grouse habitat and cattle grazing country overlap and proper management should account for both

Part Two: Business Plan Development

A good business plan with a financial tracking component coupled with a practical, easy-to-use socio-economic and natural resource monitoring program can help a rancher maintain and improve both the business and associated land base assets at productive levels. This, in turn, should help lead to profitability and long-term sustainability of the business, and conserve and/or restore sagebrush ecosystems that support sage-grouse. The steps identified in the companion publication, *Sustainable Ranch Management Assessment Guidebook* (Hamilton et al., 2013), should help ranchers compile information about how to develop a business plan and a monitoring plan for their ranch business using the idea that *ecologically sound management is also economically profitable and socially acceptable management,* i.e., *sustainable ranch management*. Briefly, the steps include identifying personal values and goals; conducting a needs assessment and resource inventory; evaluating feasibility of existing ranching enterprises; and summarizing strengths, weaknesses, opportunities, and threats for your ranching operation. Information collected in the assessment (Part One of this guidebook) should greatly help with the development of the sustainable ranch plan, particularly in regard to sage-grouse conservation. Most importantly, the business planning approach works best with technical advice and assistance from an array of professional advisers including bankers, Extension specialists and other educators, state and federal management agency resource managers, state wildlife agencies, other successful ranchers, and other specialists within the community. Sources such as the publication *Sustaining Western Rural Landscapes, Lifestyles, and Livelihoods* (Wyoming Business Council (2003), the SCORE program (SCORE Association, 2017), and the *Sustainable Ranch Management Assessment Guidebook* (Hamilton et al., 2013) provide valuable information for business plan development.

Photo by Jennifer Hayward

Technical experts (such as university Extension and NRCS) can help farmers and ranchers monitor sage grouse habitat

Part Three: Monitoring Plan Development

This section describes the indicators for assessing the sustainability of a ranch business and its human and natural resources including sage-grouse habitat. The ranch assessment indicators recommended here for use in ranch monitoring were selected with three characteristics in mind:

1. The measure for an indicator is quantifiable;
2. The indicator should support a business plan, and/or a conservation agreement, and/or stipulations in state and federal grazing permits or leases that allow ranchers to track progress toward individual ranch goals and/or objectives, including voluntary sage-grouse conservation requirements; and
3. The indicator is monitored at the ranch-scale (site-specific), is measurable by a rancher and/or technical specialists, and can be readily evaluated and interpreted by ranchers or their consultants. Monitoring has proven to be an effective tool for guiding management of grazing use, evaluating ecological status of grazing lands (including suitability and trends of sage-grouse habitats), determining the most effective and profitable livestock management strategies, and addressing social and economic aspects of the ranch. Furthermore, a monitoring approach encompassing social, economic, and ecological aspects of the ranch facilitates adaptive management decision-making processes. An important overall goal is being able to adjust management to help ensure ranch sustainability while meeting sage-grouse habitat conservation goals. If you want to manage land and natural resources effectively, you must measure the changes that occur, evaluate the results, and revise your activities, as needed, to move toward desired outcomes. *"If you don't measure carefully, you can't manage effectively"* (p. *vi*, Hamilton et al., 2013).

This guidebook includes two appendices that focus on various indicators that will help ranchers and land managers better manage their land for not only sage-grouse but livestock and other wildlife.

APPENDIX 1 describes indicator measurement protocols and methods for each of the indicators listed below, and it has a recommendation for ranchers and land managers when it comes to assessing and monitoring the indicators.

Soil Indicators

1. *Bare ground*: This indicator measures percent bare ground as a function of the potential for water and wind erosion.
2. *Soil aggregate stability*: This indicator measures the degree to which soil aggregates retain their structural integrity when exposed to a water bath (a small cup where soil and water are mixed and observed for a set period of time) and is an indirect indicator of erosion potential.

Water Indicators

3. *Frequency or duration of surface water*: This indicator addresses the season and length of time that reliable quantities of water are available on your ranch, and how that timing relates to needs for the desired uses. This is a companion indicator with the other water indicator (amount), and the two should be evaluated together.
4. *Volume of water available (amount)*: This indicator measures the quantities of water available across a pasture or operation and relates it to existing or projected needs—including the needs of water for maintaining aquatic and riparian resources over time.

Plant Indicators

5. *Key species/life form cover and abundance change*: This indicator measures the abundance and distribution of key plant species a rancher wants to manage for forage or ground cover, or that are sensitive to livestock grazing.
6. *Sagebrush/perennial grass/forb cover, height, and shape*: This indicator measures the cover, height, and shape of sagebrush/forb/perennial grass for nesting, early brood-rearing, summer/late brood-rearing, and wintering sage-grouse habitat. Site-specific height and cover requirements should be developed (1) after close coordination with local experts (e.g., NRCS for private lands, office of state lands for state trust lands, and BLM/ USFS for federal lands); (2) in accordance with local conditions (e.g., soils, climate, etc.); and (3) to ensure that the requirements are ecologically defensible.

a. Sagebrush cover: Sagebrush cover is measured on seasonal habitat (e.g., nesting and early brood-rearing habitat, summer and late brood-rearing habitat, and winter habitat) areas for sage-grouse.

b. Sagebrush height: Sagebrush height is used for nesting and early brood-rearing habitat, summer and late brood-rearing habitat, and wintering (sagebrush height exposed above snow).

c. Predominant sagebrush shape: Number of sagebrush plants by shape and most common sagebrush shape, an indicator used for nesting and early brood-rearing habitat. Sagebrush plants that are more tree-like or columnar-shaped, with no or few lower branches, indicates less protective cover near the ground than sagebrush plants with a spreading shape (see photo on page 26). Basin big sagebrush (*Artemisia tridentata* Nutt. ssp. *tridentata*), for example, often have this columnar shape, as do sagebrush species or subspecies that have been heavily browsed, grazed, or rubbed. Sagebrush communities in which the columnar shrub shape is predominant are assumed to require more herbaceous cover to compensate and provide adequate protection for nesting sage-grouse and young broods. Conversely, in suitable habitat, the spreading shape (see photo on page 61) should be predominant; however, there may be a small proportion of columnar plants present.

d. Perennial grass and forb height: Average height of perennial grasses and forbs for nesting and early brood-rearing habitat.

e. Perennial grass cover: Average percent cover for nesting and early brood-rearing seasonal habitat.

f. Perennial forb cover: Average percent cover for nesting and early brood-rearing habitat.

g. Preferred forb availability: Number of preferred forbs used for summer and late brood-rearing habitat.

h. Perennial grass and forb cover: Average percent cover for summer and late brood-rearing habitat.

APPENDIX 2 focuses on the life requisite feature, habitat indicator, and numeric values for suitable, marginal, and unsuitable categories for breeding; pre-laying, nesting, and early brood-rearing; summer and late brood-rearing for uplands; summer and late brood-rearing for riparian areas/wetlands; and winter sage-grouse habitats following recommendations in *Sage-Grouse Habitat Assessment Framework* (Stiver et al., 2015).

7. *Extent of invasive plants*: This indicator measures the presence and extent of invasive species such as knapweeds (*Centaurea* spp.), leafy spurge (*Euphorbia esula*), cheatgrass (*Bromus tectorum*), medusahead (*Taeniatherum* spp.), exotic thistles (e.g., *Carduus* spp., *Cirsium* spp., *Onopordum*, *Salsola* spp., etc.), and encroaching conifers (e.g. piñon, juniper) into sagebrush ecosystems.
8. *Extent of wildfire and prescribed fires (by year)*: This indicator measures the impacts of wildfire and prescribed fire on vegetative communities by tracking fire locations and extent (maps), by year, and how the fires affect desired management goals, including restoration of habitat for sage grouse and other wildlife, forage for livestock, erosion control, etc.
9. *Extent and condition of riparian areas*: This indicator measures the location, extent, and health of riparian areas on the ranch—those lands along streams and other wet areas where water-loving plants grow.
10. *Riparian resources in regard to sage-grouse habitat*: Riparian habitat should be evaluated using a proper functioning condition (PFC) assessment. A PFC class rating in riparian areas indicates adequate summer and late brood-rearing habitat for sage-grouse along with other height and cover indicators measured in riparian areas. In addition, availability of sagebrush cover should be within close proximity of wet meadow foraging areas.
11. *Habitat fragmentation*: The overall loss of habitat caused by the division of large, continuous tracts of sagebrush lands into smaller, isolated pieces along with ecological changes associated with other human development, conifer and annual grass encroachment, and increased wildfire are considered primary causes of sage-grouse decline across the West (Davies et al., 2011a; Naugle et al., 2011). Primary indicators are large tracts of sagebrush ecosystems lost to agriculture conversions, rural subdivisions, and other human development; infrastructure associated with energy development; grazing mismanagement; and ecological changes associated with juniper and piñon pine encroachment, the spread of invasive annual grasses including cheatgrass and medusahead, and the associated increased frequency of wildfire as a result of invasive annual grasses.

Photo by Leanne Correll

Columnar growth form of sagebrush indicates marginal to unsuitable habitat for sage grouse (See page 47)

Animal Indicators (Including Fish)

12. *Population estimates of fish and wildlife species important to the rancher*: This indicator measures specific key wildlife population levels (abundance) of species (upland game birds including sage-grouse and songbirds, large ungulates, game fish), with populations measured in terms of general trends. Monitored species will be those of interest to the rancher as part of a ranch enterprise—or for reasons of personal interest. These measurements

will be general trends obtained through annual counts on spotlight or daytime transects done at the same time each year, on the same route, with the same weather conditions.

13. *Sage-grouse lek sites*: This indicator is a traditional courtship display area attended by sage-grouse in or adjacent to sagebrush dominated habitat. A lek, by the Wyoming Game and Fish Department, is designated based on observations of two or more male sage-grouse engaged in courtship displays (see photo on page 44). Before adding a suspected lek to a database, it must be confirmed by an additional observation made during the appropriate time of day, during the strutting season. Signs of strutting activity (tracks, droppings, feathers) can also be used to confirm a suspected lek. Sub-dominant males may display on itinerant (temporary) strutting areas during population peaks. Such areas usually fail to become established leks; therefore, a site where less than five males are observed strutting is generally confirmed active for two years before adding it to the lek database (U.S. Fish and Wildlife Service et al., 2013). Land uses such as roads, highways, etc., should be located away from leks; also, trees or other tall structures should not be planted or built, respectively, within close proximity to the leks.

Productive Capacity Indicators

14. *Forage utilization*: This indicator measures levels of forage use in pastures on the ranch. In the short-term, utilization of forages (i.e., use levels, stubble height), are measured across the landscape in key areas; utilization measures represent the general adequacy of stocking rate management, distribution of grazing, provision of forage for alternative species, and soil surface protection.

15. *Livestock products*: This indicator measures the outputs of ranch enterprises that produce meat and other goods from livestock, and livestock-related activities.

16. *Quantity of non-livestock harvestable materials produced*: This indicator measures the output of non-livestock products that are produced on the ranch including hay, seeds, nuts, wood, and other plant materials. Alternative profit centers may be of particular value when viewed in the context (i.e., as a percentage) of all sources of income for a ranch operation.

Socio-Economic Indicators

17. *Cost of livestock production*: This indicator measures the livestock-related production costs of the ranch such as the cost of purchased and raised feed—generally one of the largest expenses for ranchers. All costs, including replacement costs (e.g., what you would have to pay to buy the same amount of hay or lease pasture), for hay and grazed forages should be determined and documented. Components of the cost analysis such as amortized cost of haying equipment in addition to direct costs should be calculated.

18. *Itemized income/expense of each product*: This indicator measures the cost per unit of production (a very effective interpretive tool), which can then be used to generate a breakeven price. The difference between this cost and the return per unit represents the net return to the operator. All enterprises (livestock, forage, hay, hunting, bird watching, sage-grouse conservation practices, rock hounding, facilities, etc.) should receive a separate analysis. The percentage of the operation's net return from each enterprise may be useful in allocating time and other resources to various profit centers. Pounds of harvestable materials (hay, seed, nuts, wood, and other plant materials) produced may be included when calculating this indicator. Alternative profit centers may be of particular value when viewed in the context of all sources of income for a ranch operation.

19. *Visitor use information for appropriate enterprises*: This indicator measures the number of visitor use days associated with enterprises that allow people to visit a ranch for a price based on a particular activity such as hunting, fishing, bird watching, rock collecting, etc. It is useful to document the number of visitor days per enterprise, and the dollars paid per visitor, on an annual or seasonal basis. In addition, cost trends would be useful in determining efficacy of non-consumptive land-use enterprises.

Legal and Institutional Indicators

20. *Continuing education and technical assistance*: This indicator measures the use of technical assistance and continuing education (university Extension, NRCS Grazing Lands Conservation Initiative and other NRCS programs, Sage Grouse Initiative (SGI), sage-grouse conservation agreements, land trusts, conservation easements, etc.) by members of the ranch family and

Photo by Tom Christiansen

Sage grouse habitat is very diverse, ranging from dense sagebrush to open ground

management team. How frequently a rancher seeks technical assistance and continuing education may be an indicator of a mindset that fosters ongoing assessment and improvement in an operation, which typically involves collaboration with others. A thorough approach includes setting educational/ training goals, scheduling periodic assessment of goals, and then setting new educational/ training goals, if need be.

Weather-Related Indicators

21. *Temperature*: This measures the daily high, low, and mean temperatures at selected points on your ranch. Ranchers may want to correlate temperature measurements with other events and conditions on their lands.
22. *Precipitation*: This measures the daily precipitation (from both rainfall and snowfall) at selected sites on your ranch. Ranchers may want to correlate precipitation measurements with other events and conditions on their lands. Drought conditions on your ranch can be identified using information obtained from data collected, assessed, and presented in useable form by government agencies and other sources.

Documenting successful sage-grouse conservation efforts is especially critical to landscape conservation efforts. Data collected can be used to monitor changes in habitat over time, often revealing trends. In summary, specifically for sage-grouse habitat, the following habitats should be monitored:

(1) lek habitat monitoring includes documenting potential 'natural' threats near the lek site over time, including vegetation changes such as conifer and sagebrush encroachment, as well as human-related disturbances such as home/outbuilding construction, fence building, energy development, grazing mismanagement, locating sheep camps within or near leks, etc.;

(2) nesting habitat monitoring includes measuring and documenting sagebrush and grass canopy cover and height;

(3) brood-rearing habitat monitoring includes measuring and documenting perennial forb and grass canopy cover, and compiling a list of the dominant riparian and wet meadow plant community species and recording changes in species' composition over time; and

(4) winter habitat monitoring includes measuring and documenting sagebrush canopy cover and sagebrush height. Conducting rangeland monitoring in sagebrush habitat also assists in assessing whether other intended planned rangeland goals are being achieved in these habitat areas. Actively participating in a cooperative rangeland monitoring program—particularly on permitted federal and state lands—helps ensure accountability of monitoring requirements and promotes agency-rancher relationships.

Conclusions

Ranchers are continually faced with many challenges. The assessment questionnaire in this guidebook provides an opportunity for ranch owners, managers, and employees to gain insight about their operations, as well as their relationships with neighbors, grazing and land-management consultants, agency representatives, financial planners, representatives of conservation and environmental groups, sportsmen, and others with whom they may consult concerning many phases of their ranching operation, from livestock forage to habitat for wildlife to sustaining the operation for current and future generations. The assessment questionnaire should also provide background information to help a rancher develop or amend existing business or monitoring plans that may include sustaining or improving habitat for greater sage-grouse. This guidebook is a valuable companion document and is closely tiered to the University of Wyoming Extension publication B-1216, version 2, *Sustainable Ranch Management Assessment Guidebook: Do You Know Whether Your Ranch is Sustainable?* (Hamilton et al., 2013)—particularly in regard to developing a ranch business plan. Specific ecological indicators for suitability of breeding, nesting, brood-rearing (upland and riparian), and wintering sage-grouse habitats are shown in this guidebook (Appendix 2). Development of effective site-specific and landscape-scale monitoring programs for sage-grouse habitats on a ranch and associated private and public leased lands require the active involvement of ranchers working in collaboration with natural resource professionals and others who are familiar with the rancher and ranching operation, sage-grouse habitat suitability requirements, and assessment and monitoring protocols and methods. Appendix 1 of this guidebook describes ecological, social, and economic indicators and protocols and methods to measure those indicators as well as recommendations on how a rancher can be involved. Readily available information on social, ecological, and economic aspects of a ranching operation can be provided by an up-to-date business and monitoring plan to ensure social, ecological, and economic goals are met or are moving in a positive direction. This guide in conjunction with the companion guide, UW Extension publication B-1216, as mentioned above, can help with decision-making by offering a framework for assessing, planning, monitoring, and evaluating overall ranch management. If such management is carried out effectively, it can help ensure that the ranch remains sustainable for current and future generations while also improving habitat for wildlife, including the iconic greater sage-grouse.

Acknowledgments

We extend our thanks to the reviewers for their time and work in assisting us in preparing this document: Michael "Sherm" Karl, rangeland management specialist, BLM, Denver, Colorado; Vicki Herren, national sage-grouse coordinator (retired), BLM, Washington, D.C.; Julie Suhr Pierce, Great Basin socioeconomic specialist, BLM, Salt Lake City, Utah; Richard Mayberry, rangeland management specialist, BLM, Washington, D.C.; Robert Hopper, rangeland management specialist, BLM, Portland, Oregon; Thad Heater, Sage Grouse Initiative coordinator, NRCS, Reno, Nevada; and Robert "Bob" Mountain, supervisory rangeland management specialist, USFS, Laramie, Wyoming.

We appreciate the diligent work of Tana Stith for layout and design, as well as Robert Waggoner and Jessica Windh for the technical editing of this guidebook.

Finally, we thank the BLM for funding this bulletin project under Grant DOIBLM41958.

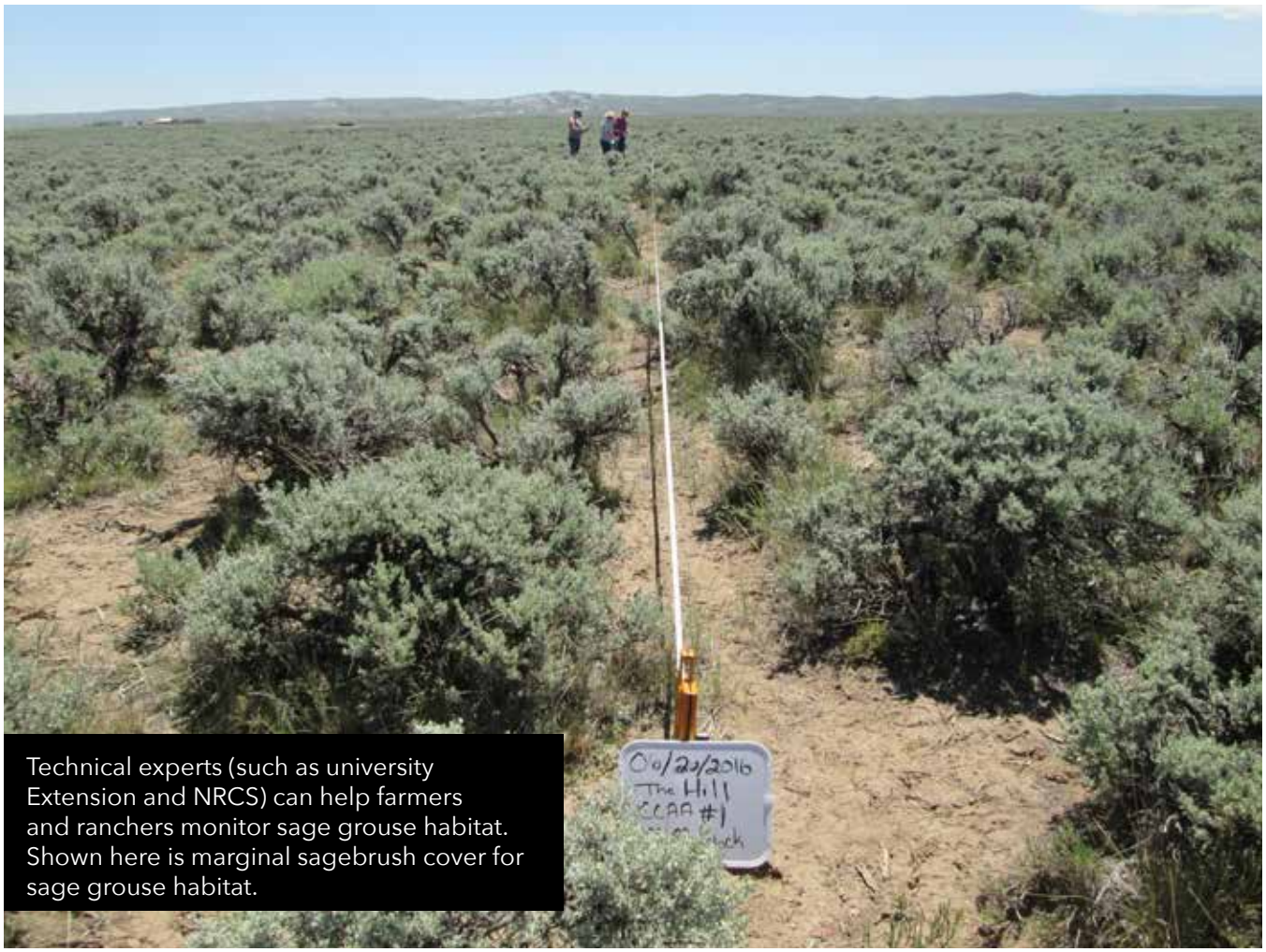


Photo by Jennifer Hayward

Technical experts (such as university Extension and NRCS) can help farmers and ranchers monitor sage grouse habitat. Shown here is marginal sagebrush cover for sage grouse habitat.

Appendix 1. Indicator Measurement Protocols and Methods, Including Recommendations for Ranchers.

1. SOIL INDICATOR MEASUREMENT METHODS AND PROTOCOLS

Bare Ground

This indicator measures percent bare ground as a function of the potential for erosion by water and wind. Insufficient vegetation cover also increases the effects of overland flow of water and associated movement of soil as sheet, rill, or gully erosion. Bare ground may be an artifact of excessive removal of herbage by grazing or other disturbance, low precipitation, or low productive potential. Annual grazing management should consider the degree of vegetation removal or residual herbage left as related to soil surface protection.

Measurement Methods and Protocols

Bare ground may be measured using a point intercept method commonly done along line transects. The categories recorded along the transect are: (1) live vegetation; (2) soil crust (moss and lichen); (3) bare ground; (4) litter; and (5) rock. The point intercept method can also be used to measure the kinds and amounts of different plant species in plant communities.

For additional information, and specific instruction on the point intercept method, see Herrick et al., 2005a, 2005b; and Pellant et al., 2005, in Appendix 4 (References Cited); and Coulloudon et al., 1999; Herrick et al., 2016; and U.S. Department of Agriculture, Agricultural Research Service, 2017, in Appendix 5 (Additional Resources).

Soil Aggregate Stability

This indicator measures the degree to which soil aggregates retain their structural integrity when exposed to a water bath and is a good indicator of erosion potential in drier areas. The degree of aggregate stability is a function of soil organisms as they bind the soil particles and organic matter on the soil surface. Increased stability will reduce soil erosion. Desired soil stability ratings are a function of the kind of soil and other ecological site characteristics. Preliminary information on "expected" soil stability ratings for monitoring sites can be found in the range health section of ecological site descriptions (ESDs) that may have been developed at similar sites on your ranch or at nearby locations.

Measurement Methods and Protocols

Soil aggregate stability is best evaluated in relation to reference values found in the ESD for the sites in the monitoring area. The assessment, or comparison, should be done at the beginning of the monitoring time period. In soils with little organic matter, recovery of aggregate stability seems to be tied to formation of biological crusts.

For detailed implementation information on this protocol, see Pellant et al., 2005, in Appendix 4. Complete soil stability kits can be obtained from Synergy Resource Solutions Inc., at the website www.countgrass.com.

Recommendations for Ranchers

Conduct and/or assist with any point intercept method and soil aggregate stability analysis that may occur on your managed rangelands. Take photos of key sampling areas and at intervals along the transect. Try to attend "Indicators of Rangeland Health" trainings when offered in your area.

2. WATER INDICATOR MEASUREMENT METHODS AND PROTOCOLS

These indicators address the water resources available for use on the ranch. The quantity (amount) of water available to support livestock, wildlife, riparian zones, and wetland habitat is important. Equally important is the seasonality (time) when water is available from sources such as wells, streams, springs, and reservoirs. Water availability should also be considered in a spatial context; in other words, is water accessible to livestock where it is needed? Is it being conserved and available in late-summer and brood-rearing greater sage-grouse habitat areas?

Lack of water when needed may significantly limit management options and opportunities, including implementation of best management practices that improve livestock distribution and provide for alternate sources of income such as that gained from enterprises such as haying, fishing, and hunting. Lack of water and associated wetland and riparian areas will impact brood-rearing habitats for sage-grouse and other wildlife.

Monitoring water resource indicators should provide the information needed to develop water systems that meet your ranch and sage-grouse conservation needs (particularly in wetland/riparian areas) in all but the most extreme cases.

Frequency or Duration of Water

This indicator addresses the season and length of time that reliable quantities of water are available on your ranch, and how that timing relates to your needs for the desired uses. This is a companion indicator with the other water indicator (amount), and the two should be evaluated together.

Measurement Methods and Protocols

This indicator should be evaluated both for 'permanent' and all intermittent water sources that are relied upon for the ranch operation. Annual evaluation is desirable to detect needs for management within the current year or season as well as to help detect long-term changes (trends). Answer the following questions now, and then annually evaluate and document:

1. Do I have enough water to meet operational needs during the planned seasons of use? This need could be for livestock, but also may include needs for sage-grouse conservation and other wildlife and fish habitat.
2. How reliable are my water sources (e.g., streams, springs, ponds, wells, etc.) for specific seasons?
3. What are the long-term trends in water availability by season?
4. If applicable, is the duration of stream flow adequate for the time that desired fish populations are present?
5. If applicable, is the duration of stream flow adequate for maintaining and/or restoring critical riparian areas?

Together, these variables can help describe the frequency and duration (timing) of water availability periods for all sources of water on the ranch operation.

Volume of Water Available (Amount)

This indicator measures the quantities of water available across a pasture or ranching operation and relates it to existing or projected needs – including the needs of water

for maintaining potential aquatic and riparian vegetation resources. It also provides the opportunity to evaluate the ability of water amounts to support management options such as recreational fishing, waterfowl hunting, summer and late brood-rearing riparian habitat for sage-grouse, and bird watching. As such, this is a companion indicator with the other water indicator (time), and the two should normally be evaluated together.

Measurement Methods and Protocols

This indicator focuses on the quantities of available water and the reliability of these quantities. Answers to some basic questions can help quantify this indicator. All of the questions need to be answered in consideration of the time that the water is needed for the desired uses and values.

1. Identify and inventory all sources of reliable water on the entire ranch operation, including leased and permitted lands. Evaluate all sumps, ponds, surface flows, springs, wetlands, and riparian areas and groundwater sources.
2. Determine the times that ephemeral water is available for use.
3. Determine how much water is available for use on the ranch in terms of volume, flow rate, and time available. Are these volumes protected, or limited, by legally defined water rights? Do you have adequate water supply or reserves to meet your existing and projected seasonal and year-round needs? Water volume in tanks and ponds can be estimated by measuring depth if the dimensions and shape of these storage units are known. Designing monitoring systems for stream flow will likely require technical assistance from a watershed specialist with the Natural Resources Conservation Service (NRCS), university Extension, and other agencies and organizations, but once a system is set in place, flow rates can be estimated.
4. Estimate useable water volumes in existing stock ponds and tanks—surface area and depth. Do you have adequate storage capacity (depth, volume, etc.) to meet your current and projected needs?
5. Estimate the volume of water available from water wells, streams, and springs in terms of flow rate and the period of time water is available. Obtain flow conversion charts to determine gallon supply from an agency watershed specialist (such as NRCS or Extension). Do you have sufficient flow from wells and springs to supply the water needed from those sources while ensuring enough water is retained at a spring site to maintain and support existing riparian vegetation?
6. Does your water system allow for grazing to be distributed across your entire ranch? Do you have enough water and is it adequately distributed to maintain satisfactory livestock (and wildlife) grazing distribution while maintaining or restoring sage-grouse habitat, particularly nesting and early brood rearing? Is water adequately distributed where you can rest a portion (~20%) of your available grazing land approximately once every three years to ensure maintenance and/or restoration of nesting and early brood-rearing sage-grouse habitat?

Photo by Bert Jellison

Water development is important to keep livestock grazing distribution uniform and to prevent overuse of riparian areas

To evaluate this indicator against your current or projected needs for consumptive uses, it will be necessary to determine the amount of consumption per day or month and relate this to the amount available in a given pasture or management area. Conversion factors are available from the NRCS or university Extension offices.

Evaluations should be conducted for all sources of surface water and groundwater on the ranch. Monitoring should take place whenever differences in water availability (timing and amount) are noted. By doing so, it will be possible to obtain a better picture of how the water resource may change if temperature and precipitation patterns are altered in the future. Assistance should be obtained from agency personnel in conducting this evaluation.

The depth to the water table on key riparian and meadow sites is manifested by changes in vegetation. For example, gully erosion that lowers the water table in a wet meadow, changing it to a drier meadow, can be seen when sedges and rushes are replaced by upland species like bluegrass. Maintaining the water table in key riparian areas is critical for water sustainability, sage-grouse conservation (particularly during early and late brood-rearing habitat areas), and meeting the needs of other wildlife.

Springs and seeps are difficult to monitor unless they are developed and the water flow captured. If developed, the flow can be monitored periodically throughout the season and across the years by simply determining how long it takes to capture a known amount of flow and then determining amount of flow per unit time (for example: gallons per minute). When developing a spring it's essential to ensure that enough water is retained at the source to support and maintain existing riparian vegetation for sage-grouse and other wildlife.

Recommendations for Ranchers

Annually document the frequency and/or duration of water by answering the above questions and following the suggestions. Document annual changes with photos. Work with NRCS and Extension specialists to determine amount, frequency, and duration of water availability on your ranching operation.

3. PLANT COMMUNITY INDICATOR MEASUREMENT METHODS AND PROTOCOLS

The first steps a rancher should take to evaluate vegetative communities on ranch lands are to map existing plant communities with technical assistance from Extension or NRCS. They can also help obtain high-quality aerial photos and/or satellite imagery for your ranch.

In addition, a technical specialist (NRCS or other state or federal agency) should be consulted to ascertain the degree

Photo by Tom Christiansen

Diversity of grasses and forbs is important for sage grouse habitat

of sagebrush habitat continuity (i.e., fragmentation) on your ranch. As explained in the *Sage-Grouse Habitat Assessment Framework* (Stiver et al., 2015), sage-grouse conservation is a scale-dependent process whereby priority landscapes for sage-grouse are identified across the species range (broad-scale) and appropriate conservation actions are implemented within seasonal habitats to benefit populations at the site-scale. Johnson (1980) describes four orders of habitat selection in which each higher order is dependent on the previous order. For example, a food item is nested within a feeding site, which is nested within a seasonal use area (i.e., fourth order), which is nested within a home range (i.e., third order), which is nested within a population area (i.e., second order), which is part of the species range (i.e., first order). Sage-grouse select nesting and feeding areas within their seasonal range and that seasonal range is nested in their home range.

Once the plant communities on the ranch are mapped, the species composition of key plant communities should be inventoried, then periodically (i.e., 3–5 years) monitored to help determine change in plant community composition

over time. Species composition is essential in assessing rangeland health, and it can be used, along with other measurements, to estimate forage productivity and help determine the suitability of sage-grouse seasonal habitats within plant communities. Also, if ecological site information is available from NRCS then information on rangeland health and forage production may also be determined following NRCS protocols. Another key step in the plant community data collection process is to determine whether ESDs and baseline data exist for ecological sites within areas of your ranching operation. For more information on ecological sites and ESDs, consult your local NRCS office; and see University of California, Davis, Soil Resource Laboratory, 2017; and U.S. Department of Agriculture, Natural Resources Conservation Service, 2017a, 2017b, 2017c, in Appendix 5.

Recommendations for Ranchers

Work with agency specialists to determine location(s) of key plant communities that may contain sage-grouse habitats on your ranch, e.g., lekking and breeding, nesting and early brood-rearing, late brood-rearing, and wintering habitats. Become familiar with any ESDs that may have been developed for your area and assist with long-term trend plant community monitoring and photo documentation.

Key Plant Species/Life Form: Cover, Height, and Abundance Change

This indicator measures the abundance and distribution of key plant species that a rancher wants to manage for forage or ground cover, or that are sensitive to livestock management and sage-grouse conservation. The abundance and distribution of key species can be effectively quantified by estimating their canopy cover. Changes in percent cover, a vertical projection of the plant canopy on the ground, provide an indication of land-management program efficacy in maintaining or improving conditions toward desired composition. This indicator also measures plant height of sagebrush, perennial grasses and forbs in order to assess plant height requirements for sage-grouse.

Rangeland plants provide forage for livestock and wildlife, and knowing more about them will help improve a rancher's ability to better understand the principal resource that keeps the livestock operation going while meeting sage-grouse conservation goals. It is recommended that ranchers assemble a plant collection, or a photo library of plants, that can be kept in a pickup to help in plant identification – particularly for forbs that are essential for early and late summer sage-grouse brood-rearing habitats. Collections can be made by taping or sealing plant specimens or photos onto card stock. It helps to add notes to the card, documenting location and time and pointing out features to look for when identifying the plant. Rangeland specialists can also help identify plants that are collected.

Measurement Methods and Protocols

Data collection for this indicator involves recording the presence of plants, by key species or cover class, at points along line-point transects in key or benchmark areas, as described below. The same transect used to assess bare ground (indicator 1) can be used for this indicator as well. Invasive weeds (particularly invasive annual grasses) encountered along the transect should also be identified by species.

The most practical method is to select an appropriate site and specific location in an area that is representative of the kind of vegetation and grazing level for the pasture, a key area. Such key areas should also be identified in specific sage-grouse seasonal habitat areas. The reliability of the monitoring and subsequent assessment can be increased with more areas being sampled if time is available. Global Positioning System (GPS) coordinates and witness posts should be recorded and established for key monitoring areas.

The *Sage-Grouse Habitat Assessment Framework* (Stiver et al., 2015) describes a line-point transect method that measures vegetative cover, and height and shape of grasses, forbs, and sagebrush within sage-grouse habitats. These measurements can be used to assess suitability of sage-grouse habitats as shown in Appendix 2. It is important to note that no single indicator or one-time measurement of the indicators in the tables shown in Appendix 2 should be used to determine habitat suitability. The indicators should be used in combination with each other to make a suitability rating, without reliance on a single indicator. The condition of a site will vary across time, driven largely by uses and environmental fluctuations such as drought and date of measurement; thus, it is critical that habitat condition be evaluated based on current conditions and long-term trends (Toevs et al., clarification memo to the field, 2017) Also be advised that the Bureau of Land Management and state and federal partners are beginning the process of updating the methods to summarize the suitability ratings to describe the proportion of each seasonal habitat in each suitability category (V. A. Herren, personal communication, 2017).

Where trends (i.e., changes in cover over time) in plant

Photo by Jennifer Hayward

Field days hosted by technical experts (such as university Extension and NRCS) are a good opportunity to see examples of suitable, marginal, or unsuitable sagebrush cover for sage grouse habitat

species are desired, all individual species or key species and other vegetation categories along with other soil cover should be identified. If the primary focus is on soil surface protection from raindrop impact, the recorded categories of vegetation and soil cover might be the life forms (including perennial grasses, annual grasses, and forbs) in addition to bare ground, litter, and rock. If the primary focus is sage-grouse conservation, the recorded categories would also include sagebrush, grass, and forb cover and height to determine sage-grouse habitat suitability. Where trends in some or all plant species are desired, individual species or targeted groups of species, rather than life forms, might be recorded.

For additional information on specific implementation procedures of this protocol, see Pellant et al., 2005; and Stiver et al., 2015, in Appendix 4; and Wyoming Range Service Team, 2008, in Appendix 5.

Recommendations for Ranchers

Conduct and/or assist with canopy cover measurements, and take photos at key areas. Use cover class reference photos (as shown in Appendix 2 of this guidebook) to help evaluate and estimate cover class (and shape-columnar or spreading) of sagebrush on your ranch. Annually measure height of key plants at key areas. Assemble a reference plant collection, including desirable forbs. Assist with initial assessments determining suitability of specific sage-grouse habitats within plant communities and participate in any follow-up monitoring including cover and height measurements and photo documentation. Try to attend "Indicators of Rangeland Health" training if offered in your area.

Extent of Invasive Plants

This indicator measures the presence and extent of invasive species such as knapweeds, leafy spurge, cheatgrass, and thistles, and it also measures the extent of conifer encroachment. Three stages (I, II, and III) of woodland succession are described by Miller et al (2005) and directly affect plant community structure, composition, seed pools, wildlife habitat, and ecological processes including hydrologic and nutrient cycles. Generally, shrub-steppe communities in Phases I and II are attractive to wildlife, however as juniper dominance increases, structural diversity declines with the loss of shrubs and forbs. This information can be used to help customize treatment programs, and it can serve as an indication of the efficacy of such programs for various invasive species. The mapping, if conducted periodically over time, can help to track the spread and increase in invasive plants and can help to relate such spread to management activities. For example, an area grazed heavily each year is at high risk of invasion, while treatment areas can also be monitored for effectiveness.

Measurement Methods and Protocols

Presence and extent of invasive species should be recorded by mapping them as they are encountered while making range inspections throughout the year. GPS coordinates for the spot or area infested should be recorded. Taking photographs from the GPS coordinate can complement hand-drawn maps.

For additional information on this protocol, and on creating invasive species maps and related protocols, see Swanson et al., 2006; and Wyoming Range Service Team, 2008, in Appendix 5.

Recommendations for Ranchers

Map and document (photograph) invasive species presence. Have a plant reference collection or photos identifying specific invasive plants in your area. Photo document before and after areas are treated.

Extent of Wildfire and Prescribed Fires (By Year)

This indicator measures the impacts of wildfire and prescribed fire on vegetative communities by mapping the location, date, and extent of rangeland fires. Over time, these maps can be used to explain changes in plant communities, wildlife populations, weed infestations, etc.

Measurement Methods and Protocols

1. Develop a map showing location of wildfires and prescribed fires on the ranch. Update as wildfires or prescribed burns occur, so location, extent, and sequence of fires can be determined. On the map, indicate areas of high, moderate, and low-intensity burns. As with invasive species, fire patterns can be recorded using GPS coordinates, photographs, and sketch maps. Aerial photos are especially effective right after a fire because the extent of the fire can easily be seen from the air. This is especially true for fires that burn in spotty or braided patterns.
2. It is also desirable to establish monitoring plots in prescribed burn areas. The best option is to establish one or more transects and several camera points in areas to be burned. Re-reading these transects or taking additional photographs over time after the burn provides good feedback regarding the effectiveness of the burn, the impacts of the burn on factors such as plant cover by species or life-form, and extent of bare soil.

Recommendations for Ranchers

Develop maps and establish photo points for wildland and prescribed fire areas. Conduct and/or assist with any plant cover measurements.

Extent and Condition of Riparian/Wetland Areas

This indicator measures the location, extent, and health of riparian areas located on the ranchlands found along streams and in wetlands characterized by "water-loving" plants like sedges and willows. In general, the grazing manager desires a grazing program that promotes the quantity and diversity of riparian vegetation that stabilizes streambanks, provides desirable wildlife and fish habitat, and supplies a reliable source of forage. Healthy riparian areas are critical to sage-grouse conservation particularly during the summer/late brood-rearing period.

Photo by Leanne Correll

Healthy riparian areas are critical sage grouse habitat in the summer/ late brood-rearing period

Measurement Methods and Protocols

The three primary methods used by agencies to monitor and assess riparian areas are the proper functioning condition (PFC), greenline, and multiple indicator monitoring (MIM). The greenline was originally developed to measure percent composition of plant community types and a stream reach stability score along the nearest vegetated line above the water in a stream (Winward, 2000).

Recently the greenline method has been incorporated into the MIM technique developed by Burton et al., 2011. The MIM protocol combines observations of up to 10 indicators (including the greenline) along the same stream reach into one protocol, using mostly simple adaptations of existing procedures. Three indicators provide data from which short-term livestock (or other herbivore) use information can be derived: (1) stubble height; (2) streambank alteration; and (3) woody species use. Short-term indicators provide information necessary to help determine whether the current season's livestock grazing is meeting grazing use criteria. They can be used as early warning indicators that current grazing impacts may prevent the achievement of management objectives and can also be used to help explain changes in riparian vegetation and channel conditions over time. Seven other indicators provide data from which long-term resource condition information can be derived: (1) greenline composition; (2) woody species height class; (3) streambank stability and cover; (4) woody species age class; (5) greenline-to-greenline width; (6) substrate; and (7) residual pool depth and pool frequency. Long-term indicators provide data to assess the current condition and trend of streambanks, channels, and streamside vegetation. They help determine if local livestock grazing management strategies and other land management actions (including sage-grouse conservation strategies) are making progress toward achieving the long-term goals and objectives for streamside riparian vegetation and aquatic resources.

A riparian and wetland assessment technique that is used in the *Sage-Grouse Habitat Assessment Framework* (Stiver et al., 2015) is the PFC assessment checklist. The method provides a consistent approach for considering hydrology, vegeta-

tion, and erosion/deposition (soils) attributes and processes to assess the condition of riparian streamside vegetation (Dickard et al., 2015) or wetland areas (springs, seeps, and bogs) (Prichard et al., 2003). The assessments involve using an identification team that has a good understanding of the concepts of the wetland riparian area (with rancher input). The team works through a qualitative checklist (yes/no questions) to determine the attributes and processes important to the riparian wetland area that is being assessed. Based on the team's discussion and evaluation of the checklist, the riparian wetland area will be given one of the three ratings: PFC, functioning-at-risk (FAR), or non-functioning (NF).

Using the greenline technique, MIM, or PFC requires extensive field training usually from an Extension or conservation district specialist or an agency conservationist and should be conducted with a specialist and where appropriate, an ID team of specialists. Identifying obligate aquatic plant species or upland species requires plant identification skills. Specimens of key riparian species can be collected and incorporated into a ranch plant collection to facilitate future monitoring of riparian zones.

For additional information on these protocols, see Winward, 2000; Prichard et al., 2003; Burton et al., 2011; Dickard et al., 2015; and Stiver et al., 2015 in Appendix 4.

Recommendations for Ranchers

Work closely with NRCS, conservation district, and university Extension personnel in implementing appropriate protocol (e.g., greenline, MIM, or PFC), take photos where riparian assessments and/or monitoring are occurring, and develop a riparian plant ID collection. Work on becoming familiar with annual indicator measurements such as: stubble height, bank alteration, and woody browse use, and assist agency personnel on long-term trend cover measurements. Try to attend PFC, MIM, or any local riparian assessments and monitoring workshops and training when offered in your area.

4. ANIMAL INDICATOR (INCLUDES FISH) MEASUREMENT METHODS AND PROTOCOLS

Animals include livestock, large and small game, non-game, threatened and endangered species, species of concern, as well as predators. Some species have commodity value, and others may be of special value for their mere presence (special status species including sage-grouse as well as threatened and endangered species). Depending on the species,

Photo by Leanne Correll

Sage grouse habitat and cattle grazing country overlap and proper management should account for both

objectives may be to increase, decrease, or maintain stable populations. Large ungulates like pronghorn antelope, mule and white-tailed deer, and elk typically hold the greatest potential for ranch commodity use when it comes to hunting, while the sage-grouse and associated sagebrush and riparian habitats may hold the greatest potential for conservation efforts both by the federal agencies and private landowners. About 45% of the grouse's habitat is on state and private lands, which often include wet meadows and riparian habitat that is essential for young chicks. Efforts by private landowners in undertaking voluntary sage-grouse conservation practices have been an important element in the not listing of the bird. While private lands programs differ, each works with ranchers, landowners, and other partners on long-term agreements to undertake proactive conservation measures that benefit sage-grouse and other sagebrush obligate species.

Animals on a ranch may be either domestic or wild. Domestic animals are generally those maintained by the operation for commercial purposes. Wild animals constitute a huge array of species from amphibians to deer, elk, mountain lions, bear, fish, and so forth. Normally these species are under the authority of the state. Some species may be of special value solely for their presence, such as endangered or threatened species as well as species of special concern.

At times domestic and wild animals may come into conflict, such as with certain predators, or where there is a conflict for forage resources. Depending on the species and the land ownership, management objectives may vary.

Public lands are often managed to promote multiple uses and often have requirements to sustain native wild species and habitats. On private lands, such requirements may or may not apply, and ranch objectives may be to increase, maintain, or decrease population numbers of certain species.

Large ungulates can often have a significant impact on ranch management and conversely can be significantly impacted by ranch management and activities. These animals also offer great potential for a ranch to diversify by focusing on the presence of those species as an additional source of income. Conservation practices to enhance sage-grouse can also improve (1) forage availability by management of invasive plants and of juniper and piñon pine encroachment; and (2) improve distribution of livestock grazing by development of off-site water, thereby improving riparian and wetland areas for livestock grazing and sage-grouse.

Population Estimates of Fish and Wildlife Species Important to the Rancher

This indicator measures trends in key wildlife population levels of species (upland game birds, songbirds, large ungulates, game fish, etc.), with populations measured in terms of general trends. Monitored species will be those of interest to the rancher as part of a ranch enterprise—or for reasons of personal interest. These measurements will be general trends obtained through annual counts on spotlight or daytime transects done at approximately the same time each year, on the same route, with similar weather conditions.

These key species will vary by ranch, but will often be those species that (1) have the potential to provide social or economic value such as bird watching, elk hunting, trout fishing, etc., or (2) can help indicate the effectiveness of management in sustaining viable habitats through implementation of conservation strategies to promote wildlife and improve livestock grazing.

Monitored animals may have aesthetic values, suggest the condition of habitats, or be of economic value. Ecotourism values and successful conservation strategies can often increase the value of the entire array of plant and animal biota common to an area; thus, placing more emphasis on maintaining the natural biological diversity of an area for livestock and wildlife.

Measurement Methods and Protocols

There are several general methods for assessing animal populations. The methods all yield estimates of key species populations, or trends, with varying degrees of accuracy of the information.

Photo by Stan Harter

Sage grouse hens use the sage brush as cover to hide their nests from predators

One method is to consult with the local office of the state fish and game department and the federal or state agency (or agencies) that manages the land you lease. They have employees in the field who know your area, and they have access to information from many sources such as departmental inventories, federal fish and wildlife agencies inventory and management data, and Christmas bird counts. This is an excellent means to obtain information if you are considering a new or expanded enterprise such as hunting leases, guided fishing trips, wildlife viewing, etc.

A second method of obtaining animal and fish information is to conduct your own counts using game trail cameras and/or direct observation such as observing recent activity on known sage-grouse lek areas. This method may be appropriate if you are knowledgeable in making species identification and population estimates, and if you have an enterprise that can support such intensive inventory practices.

A third method is to hire a professional fish and game consultant to estimate key species populations of interest to you. An advantage of this method is that the consultant can provide information and guidance for developing a successful management program. This method may or may not be fiscally justified depending on the size or profitability of your program.

Specific to observing sage-grouse, *leks* are open areas surrounded by sagebrush, without trees or other tall structures in close proximity, where males traditionally display and attract hens for breeding. Leks are usually separated by greater than one-half mile. A lek may have more than one activity center (small groups of birds in very close proximity), and do not necessarily remain active year to year (U.S. Department of Agriculture, 2010).

Sage-grouse lek surveys are applied as part of a resource management system to support one or more of the following purposes: aid in monitoring effectiveness of habitat improvements for sage-grouse, assist a landowner in determining the use of their property and surrounding lands by sage-grouse, and help determine population trends for the local area. Lek surveys are also an important tool to help determine population trends and habitat use within a given area. In addition, lek surveys also provide an opportunity for a landowner to become more familiar with the habits of sage-grouse and help foster a connection between the landowner and these unique birds.

For additional information on these protocols, see Pellant et al., 2005 in Appendix 4; and Swanson et al., 2006, and U.S. Department of Agriculture, Agricultural Research Service, 2017, in Appendix 5.

Recommendations for Ranchers

Participate and work closely with state game officials to determine sage-grouse populations and trends on your ranch. You may want to consider using game trail cameras and/or visual monitoring at known lek areas.

5. PRODUCTIVE CAPACITY INDICATOR METHODS AND PROTOCOLS

Productive capacity indicators are likely to be an area of key consideration in designing a monitoring program and crafting business plan goals, since these elements may be tied closely to economic return. Aspects to consider include forage utilization, livestock production, and comparable measures of other products produced for sale.

Forage Utilization

This indicator measures the percentage of forage removed in pastures on the ranch. In the short-term, utilization of forages, i.e., use levels across the landscape in key areas, are the result of the amount of forage produced, the number of grazing animals, and the livestock grazing system. Forage utilization and stubble height estimates are commonly used to manage livestock in a grazing system.

Measurement Methods and Protocols

Forage use levels may be recorded with use maps. These maps represent effects of animal numbers, distribution of grazing, provisions of forage for alternative species, and soil surface protection. Values will be impacted by slope, distance to water, and presence of shrubs.

While not an objective in itself, the forage use attribute selected should have grazing season target levels that the manager can correlate with trends in other resource values to calibrate the grazing management program. Possible measurements include the Livestock Utilization Landscape Appearance Method, stubble height measured along paced transects, paired plot sampling with grazed areas and grazing exclosures, and measurements taken before and after grazing. Animal use days for each pasture can be recorded. Note that multiple measurements are required both before and after grazing occurs.

Utilization is often monitored during a grazing season to determine if it is time to move livestock to another pasture. It is also monitored after the growing or grazing season to determine if enough plant material—both living plants and plant litter—is retained to meet basic needs of the plants, the soils, and wildlife.

Normally the results are compared with a criteria (such as 40% utilization of Idaho fescue in key upland areas, or a four-inch stubble height on sedges and rushes in the riparian key area) to determine how well the current year's management worked. The criteria are selected based on science, which indicates that consistently meeting goals will help to move the resource conditions toward desired outcomes. Stubble height objectives in riparian zones are primarily designed to filter the movement of sediment into the stream, thereby helping to maintain stream bank and riparian habitat condition.

For additional information on these protocols and methods, see Stiver et al., 2015, in Appendix 4; and Coulloudon et al., 1999; Swanson et al., 2006; Wyoming Range Service Team, 2008; and U.S. Department of Agriculture, Agricultural Research Service, 2017, in Appendix 5.

Recommendations for Ranchers

Keep accurate records of livestock use days in a pasture or area, and consider taking before and after photos of use along with plant height measurements (consider exclosure cages to show comparison of grazed/ungrazed areas). Consider use pattern mapping, working closely with agency specialists.

Livestock Products

This indicator measures the outputs of ranch enterprises that produce meat and other products from beef cattle, sheep, bison, goats, and other domestic grazing animals.

Measurement Methods and Protocols

The indicator measures pounds of livestock (beef, lamb, bison, goats, etc.) produced, as documented through *live-*

weight sales, rather than numbers of animals. It also may be important to document rangeland forage-fed as opposed to feedlot-fed pounds; the success of unconventional marketing strategies may be evident in net returns.

Pounds of domestic stock sold is frequently the only measure of output documented on a ranch; however, value per pound varies so additional information should be recorded when practical.

Such attributes include the specific product (e.g., cattle, goat, sheep, bison), season of sale, and size of an individual animal; these factors all may influence value.

Pounds of Harvestable Materials Produced

This indicator measures the output of non-livestock products that are produced on the ranch including hay, seeds, nuts, timber, and other plant materials. Alternative profit centers may be of particular value when viewed in the context (i.e., as a percentage) of all sources of income for a ranch operation.

Recommendations for Ranchers

Keep accurate sale records of livestock and non-livestock products.

6. SOCIO-ECONOMIC INDICATOR METHODS AND PROTOCOLS

In regard to sage-grouse, there is very little published research on the economics of managing sage-grouse (Boyd et al., 2014a). This is likely because there is no market-based value for sage-grouse and once the decision is made to treat their habitat, the best that can be done is examine the alternatives and find the lowest cost alternative. The least cost alternative is rarely the most economically efficient or optimal alternative (i.e., highest net return for society); it is only the least cost way to achieve an already decided upon management objective. For example, deciding to manage sagebrush density with a particular treatment may use a least cost method (e.g., chemicals versus mechanical) rather than determining if doing that treatment leads to the most profitable use of those funds. In this case, finding least-cost alternatives that will have the greatest benefit to the species is where limited investment funds should be put. For example, if standard livestock fencing of metal T-posts and barbed wire is found to have the greatest impact on bird mortality, the recommendation to replace that fencing with wooden posts could be analyzed by funding the costs of removing the T-posts and installing wooden posts. If, however, wildfires are found to have the greatest impact on bird populations, then funds should be invested in the least-cost alternatives to reduce fire risk. Risk of bird mortality from each alternative infrastructure change should also be part of the evaluation. While large-scale wildfires would be expected to have significant short- and long-term effects on bird populations, the risk of a wildfire occurring in any given location may be low. On the other hand, if a fence is left in place there may be a low probability of a bird hitting it, but a relatively high probability of mortality if it does. If those probabilities were known in each case, better investment decisions could be made. At present, it is more likely that professional estimates drive these kinds of decisions rather than research-based measurements. From a societal standpoint, if investment funds at limited, they should be used where they will have the greatest return on investment (Workman, 1981; Tanaka and Workman, 1990). In general that will mean either maintaining or improving conditions in the best habitat. Investments in areas that are marginal habitat will not result in very significant returns and are, by definition, not good economic investments. Alternatively, there may be spatial linkages between poor and excellent habitat that impact this generality. For example, high probability of ignition in annual grass communities near excellent habitat suggests that maintaining the excellent habitat could involve fuels treatment. It is very important to note that when economic analyses of rangeland improvement practices have been done as part of ecological or livestock management research studies, it is rare to find any with positive economic returns when livestock production is the sole benefit (Tanaka et al., 2011). In these cases, consideration of the (largely unknown) economic values for other ecosystem services may be what makes these decisions economically feasible.

In regard to livestock, socio/economic indicators are designed to capture the economic elements of a ranching operation, as well as the social factors that may impact the operation's sustainability; income and expenses tend to be the predominant factors. Three indicators fall into this category for ranchers and are listed below.

Cost of Livestock Production

This indicator measures the production costs of goods produced on the ranch such as the cost of purchased and raised feed for livestock—generally one of the largest expenses for ranchers. All costs, including opportunity costs (replacement costs, i.e., what would you have to pay to buy the same amount of hay or lease pasture), for hay and grazed forages should be determined and documented. Components of the

Photo by Robert Waggener

Sage grouse habitat and cattle grazing country overlap and proper management should account for both

cost analysis such as amortized cost of haying equipment in addition to direct costs should be calculated.

The benefits and costs of grazing on state or federal lands through a lease or grazing permit should be analyzed separate from the deeded lands. This would provide valuable information on the value of those permits and leases to the overall operation and help identify potential costs to replace that forage if it was no longer available.

This analysis identifies the best opportunities for managers to reduce the cost of production and subsequently reduce the breakeven cost for their operations. The measurement could be combined with other indicators to capture all of the costs associated with operating a sustainable ranch. For demonstrative purposes, it could be expressed as the total cost to produce each 1,000 pounds of domestic livestock (and/or other products as noted above).

Measurement Methods and Protocols

This indicator requires information and data normally gathered through a formal business accounting system tailored to the ranch enterprises. The system should be designed to determine costs, revenues, unit costs, return on investment, and profitability of each livestock production enterprise.

Good guidelines are available from many university Extension offices. Working in collaboration with others, numerous Extension specialists have developed enterprise budgets that outline the production system and typical returns and costs for different types of operations within the ranch. These can be tailored to specific ranches.

Costs for all inputs should be based on their market value. For example, while hay may be raised on the ranch, it should be treated as a separate enterprise with its returns equal to what it could be sold for on the open market. Similarly, when it is fed to cattle on the ranch, the cattle enterprise should consider this as another purchased input (even though it is being purchased from the same ranch).

Examples of cattle enterprise budgets for a 300 cow-calf herd can be found at the Oregon State University Extension Service website and the University of Idaho College of Agricultural and Life Sciences website.

All such enterprise budgets (costs and returns) are basically structured the same way. All of the sales products for the enterprise are listed with expected average weights and prices to calculate gross sales. In addition, all of the costs of production are listed with expected amounts for the current

Photo by Robert Waggener

production system. These are normally split into variable costs (those that change with the amount of product produced) and fixed costs (those you pay regardless of whether anything is produced). Subtracting variable costs from gross sales gives an indication of what the net operating profit may be. This net operating profit (also called gross margin) is what is available to pay the ranch owner (return to management) and cover the fixed costs; however, the true breakeven cost or unit cost of production includes all costs that are incurred while a crop is being produced that are specific or prorated to that crop.

Recommendations for Ranchers

Separate costs of grazing on leased or permitted lands from your private lands. Keep accurate records of all costs associated with sage-grouse conservation on your private lands as well as your leased/permitted lands. Consider using enterprise budgets (production costs and returns) for your area to assist with evaluating management decisions and determining breakeven points.

Itemized Income/Expense of Each Product Produced

This indicator measures the cost per unit of production, a very effective interpretive tool, which can then be used to generate a breakeven price. The difference between this cost and the return per unit represents the return to the operator.

All enterprises (livestock, forage, hay, hunting, bird watching, rock hounding, etc., in addition to including implementation of sage-grouse conservation practices) should receive a separate analysis. The percentage of the operation's net return from each enterprise may be useful in allocating time and other resources to various profit centers.

Pounds of harvestable materials (hay, seed, nuts, wood, and other plant materials) produced may be included in calculation of this indicator. Alternative profit centers may be of particular value when viewed in the context of all sources of income for a ranch operation.

Measurement Methods and Protocols

This indicator requires information and data normally gathered through a formal business accounting system tailored to the ranch enterprises. The system should be designed to determine costs, revenues, unit costs, return on investment, and profitability of each ranch enterprise and the overall business. It is important to allocate shared labor, equipment, and resources among the various enterprises. For example, if the same tractor is used to raise hay and feed cattle, its total annual cost must be split between the two enterprises based on some realistic criteria (such as hours of operation in each activity). Total annual costs include both operating costs and costs of ownership.

An important consideration in determining overall ranch profitability is the valuation of the land resources. Land should be evaluated as an enterprise of its own—requiring appropriate analysis and comparison with appropriate values as an investment.

Other input costs that are often difficult to place a value on include family labor and management. These have two very different opportunity costs, and both must be accounted for in the analysis. Both can be valued based on the opportunity cost principles. In the case of family labor, the easiest way to think about this is what you would have to pay to hire someone to work at the particular jobs.

The management cost is a different issue, but the same principles may apply. Information on what a ranch manager who is hired for that purpose would reasonably be paid in salary

and benefits is available from a variety of sources. While that provides a comparator value, the rancher needs to determine if the amount of net returns after all variable and fixed costs are paid is sufficient to compensate them for their management or ownership of the ranch.

Another way to look at this is to use a modified income statement approach outlined by John Workman in *Analyzing Ranch Income Statements: A Modified Approach* (Workman, 1981). While Workman's approach uses much of the same information as a traditional accounting approach, it better answers questions of "How much do I have to live on after all the costs are paid?" and "How much return is there on my investment?"

Recommendations for Ranchers

Keep accurate records of costs of production and revenues generated, and consider use of enterprise budgets if available for your area.

Visitor Use Information for Appropriate Enterprises

This indicator measures the number of visitor use days associated with enterprises that allow people to visit a ranch for a price based on a particular activity such as hunting, bird watching, rock collecting, etc. It is useful to document the number of visitors and the fees they pay to access the ranch to calculate and document dollars per visitor and the number of visitor days on an annual or seasonal basis. In addition, cost trends are useful in determining efficacy of non-consumptive land-use enterprises.

Measurement Methods and Protocols

Count the number of people (customers) who use a particular resource so that you may calculate user-days and cost/income per user day. The results can help identify the need to change prices/rents or spend more money on marketing, or the need to upgrade facilities, etc.

The procedure is basically the same as with any other ranch enterprise. Be sure to include all variable and fixed costs and allocate costs to this enterprise as with any other. Specific costs to these sorts of enterprises include extra insurance and liability costs and labor to manage the enterprise. As with any such service enterprise, the amount charged has to be based on what your costs are, what the going rate in the marketplace is for similar experiences, the quality of the service(s) you are providing, the expected number of visitors buying the service, and other such considerations.

Recommendations for Ranchers

Document visitor use days and keep accurate records on costs and revenues generated.

7. LEGAL AND INSTITUTIONAL INDICATOR METHODS AND PROTOCOLS

Indicators included in this category seek to identify legal constraints impacting the operation of a ranch and availability of opportunities for continuing education, training, and technical assistance. These indicators are generally somewhat less quantifiable than others in the monitoring framework, although they are equally important in the context of a rancher's business plan.

Continuing Education and Technical Assistance

This indicator measures the use of technical assistance and continuing education (university Extension, professional society conferences, NRCS programs including the Grazing Lands Conservation Initiative, private consultants, etc.) by members of the ranch family. How frequently a rancher seeks technical assistance and continuing education (particularly in regard to sage-grouse conservation) may be an indicator of a mindset that fosters ongoing assessment and improvement in an operation. A thorough approach includes setting educational/training goals, scheduling periodic assessment of goals, and then setting new educational/training goals. Despite being one of the most researched upland game birds in North America, key knowledge gaps persist in the understanding of sage-grouse biology. U.S. Geological Survey scientists and others are working to address these knowledge gaps in key areas including the development of population models that incorporate information about the complexities of the biological processes and dynamic habitats, improving the understanding of the landscape attributes that facilitate connectivity between populations, and refinement of monitoring strategies and creation of tools to improve information about sage-grouse population characteristics.

Ranchers can keep pace with an ever-changing social, economic, and political environment through education. A proactive rancher could consider incorporating this indicator into a business plan with a check-off at the end of the year to ensure that some sort of continuing education or improvement activity is completed. A more comprehensive approach could include setting educational/training goals, scheduling periodic assessment of goals, and then setting new educational/training goals to pursue.

Photo by Robert Waggener

Male sage grouse use open spaces adjacent to sagebrush habitat as courtship display areas, called leks

Measurement Methods and Protocols

Measurement of these indicator goals is simple – a "yes" or "no" answer suffices. The key to success is to persevere toward completion. Keep asking for assistance, implementing advice, evaluating progress, and asking for more help.

1. Set educational/training goals. Periodically (annually) assess progress toward the goals. Set new educational/training goals.
2. Be aware of and appropriately use technical assistance programs. Federal agencies and state Extension offices offer landowner assistance and education programs.

The U.S. Department of Agriculture's National Institute of Food and Agriculture provides rangeland-related information and educational programs to owners of private rangeland and permittees and lessees of public rangelands. Ranchers can learn about the impacts of grazing and other land uses on rangelands. Past educational efforts focused on commodity (animal) production while more recent programs emphasized ecological or aesthetic values.

Recommendations for Ranchers

Stay current with the latest science, technology and tools particularly in regard to the ever changing sage-grouse conservation efforts. Work closely with NRCS and university Extension personnel and become familiar with the agencies "tools in the toolbox" for land health assessments and land health monitoring procedures including: PFC, MIM, interpreting indicators of rangeland health, long-term vegetation and/or ecological site trend analyses, and annual utilization measurements. Actively participate in cooperative monitoring and any training and workshops that may be offered in your area.

8. WEATHER-RELATED PHENOMENA INDICATOR METHODS AND PROTOCOLS

Ranchers should monitor weather conditions because of the profound effects they can have on a ranching business.

These are general indicators that measure weather-related phenomena such as temperature, precipitation (including snowpack), and drought. Weather-related monitoring is perhaps the most important, and easiest, tracking activity that can be undertaken in a ranch operation. Nearly all of the biophysical indicators (soil, water, plants, and animals) are affected by weather. Measuring and recording precipitation and daily maximum/minimum (max/min) temperatures allow you to have a basis for evaluating trends in these other indicators. Max/min temperatures do not have to be read every day, or even every week, but a regular monitoring program of precipitation and temperature can provide useful information to a rancher that goes beyond explaining trends in vegetation. Wintering sage-grouse are sensitive to the amount of snow accumulation. Sage-grouse habitat suitability analysis is partly based on environmental fluctuation such as drought and it is critical that environmental conditions be taken into consideration when making suitability ratings for sage-grouse habitats.

For example, in some environments with predominantly cool-season grasses, precipitation in a definite window of time can reliably predict the upcoming forage production amount.

This predictive ability allows advanced planning for making grazing and stocking adjustments that may be needed.

Temperature

This indicator systematically measures the temperature range at selected points on your ranch on a daily basis over the entire year. You may want to correlate temperature measurements with other events and conditions on your ranch.

Measurement Methods and Protocols

Monitor temperature with at least one on-site max/min thermometer that is read and recorded on a regular, systematic basis—every day, or at least every week on the same day. In the alternative, find the website that displays temperature records for a site near you that accurately reflects temperature variations on your ranch. It may be useful to chart some combination of max/min temperatures and rainfall on the same chart along with information on other events and incidents relating to your ranch operation.

Precipitation

This indicator measures total precipitation (rainfall and precipitation from snowfall) at selected sites on your ranch on a daily basis over the entire year. You may want to correlate precipitation measurements with other events and conditions on your ranch.

Measurement Methods and Protocols

Monitor precipitation with an on-site rain gauge (or gauges), or obtain data from nearby precipitation stations that are part of the nationwide monitoring system. Be sure such data are representative of precipitation on your ranch.

Drought

This indicator monitors drought conditions on your ranch using information obtained from data collected, assessed, and presented in useable form by government agencies and other sources. You may want correlate drought condition reports with other events and conditions on your ranch.

Measurement Methods and Protocols

Drought conditions and status are monitored, synthesized into easily readable reports, and distributed by several organizations.

Recommendations for Ranchers

Monitor and record weather information in a systematic and easily reviewable format. Have your site-specific weather data readily available for agency personnel – particularly if habitat suitability ratings are being assessed and monitored on your managed ranchlands.

For more information about drought, precipitation, and temperature, see National Drought Mitigation Center, 2017 in Appendix 5.

Photo by Tom Christiansen

Diversity of grasses and forbs is important for sage grouse habitat

Photo by Stan Harter

Sage grouse eat sage brush leaves in the winter, as it is often the only forage not covered by snow

Appendix 2. Sage-Grouse Habitat Indicators.

Table 1. Breeding (lek) habitat life requisites, indicators, and suitability categories for site-scale habitat descriptions.[1-2]

Life Requisite Feature	Habitat Indicator	Suitability Categories		
		Suitable	Marginal	Unsuitable
Cover and food	Availability of sagebrush cover	Lek has adjacent sagebrush cover within ~300–350 feet[3]	Sagebrush provides very little protective cover adjacent to the perimeter of the lek	Adjacent nesting habitat unavailable
Security	Proximity of detrimental land uses[4]	Detrimental land uses are not within line of sight of lek and absent or uncommon within ~2 miles of lek	Detrimental land uses are within line of sight of lek and uncommon or few within ~2 miles of lek	Detrimental land uses are within the immediate vicinity of the lek site
	Proximity of trees or other tall structures	Trees or other tall structures are not within line of sight of lek and absent or uncommon within ~2 miles of lek	Trees or other tall structures are within line of sight of lek and uncommon or scattered within ~2 miles of lek	Trees or other tall structures are within the vicinity of the lek site

(1) Use period may vary based on elevation and annual weather conditions. Usually occurs from March 1 to June 30.

(2) From Table 15 in *Sage-Grouse Habitat Assessment Framework* (Stiver et al., 2015).

(3) A U.S. Geological Survey study (Manier et al., 2014) acknowledges that there is no single distance appropriate for all populations and all habitats across the range, so distance variations based on local data, best available science, landscape features, and existing protections should be considered.

(4) Definition of Detrimental land uses include sonic and physical disturbances such as highways, railroads, and industrial parks are examples. (Stiver et al., 2015)

Table 2. Breeding (pre-laying, nesting, and early brood rearing) habitat life requisites, indicators, and suitability categories for site-scale habitat descriptions.[1-2]

Life Requisite Feature	Habitat Indicator	Suitability Categories		
		Suitable	Marginal	Unsuitable
Cover (%)	Sagebrush cover (%)	~15–25%	~5 to <10% or >25%	<5%
	Perennial grass cover—mesic	>15%	~5 to <15%	<5%
	Perennial grass cover—semiarid or arid	>10%	~5 to <10%	<5%
	Perennial forb cover—mesic	>10%	~5 to <10%	<5%
	Perennial forb cover—semiarid or arid	>5%	~3 to <5%	<3%
Height	Sagebrush height—mesic site[3]	~15–30 inches	~8 to <15 inches or >30 inches	<8 inches
	Sagebrush height—semiarid or arid site	~12–30 inches	~8 to <12 inches to >30 inches	<8 inches
	Perennial grass and forb height	>7 inches	~4 to <7 inches	<4 inches
Shape	Predominant sagebrush shape[4]	Spreading	Mix of spreading and columnar	Columnar
Food	Preferred forb availability[5]	Preferred forbs are common with several species present	Preferred forbs are common, but only a few preferred species are present	Preferred forbs are rare

Breeding season usually occurs from March 1 to June 30.

From Table 16 in *Sage-Grouse Habitat Assessment Framework* (Stiver et al., 2015).

Mesic (land generally receiving a moderate amount of moisture), semiarid (land generally receiving light to little precipitation) and arid (land generally receiving little to no precipitation) sites should be defined on a local basis; annual precipitation, herbaceous understory, and soils should be considered (Connelly et al., 2000).

Sagebrush plants that are more tree or columnar shaped, with no or few branches, provide less protective cover near the ground than sagebrush plants with a spreading shape.

Relative to ecological site potential.

Table 3. Summer/late brood rearing habitat life requisites, indicators, and suitability for upland sagebrush site-scale habitat descriptions.[1-2]

Life Requisite Feature	Habitat Indicator	Suitability Categories		
		Suitable	Marginal	Unsuitable
Cover	Sagebrush cover (%)	~10–25%	~5 to <10% or >25%	<5%
Height	Sagebrush height	~40 to 80 (15–30 inches)	~8 to <15 inches or >30 inches	<8 inches
Cover and food	Perennial grass and forb cover	>15%	~5 to <15%	<5%
Food	Preferred forb availability[3]	Preferred forbs are common with appropriate numbers of species present	Preferred forbs are common with appropriate numbers of species present	Preferred forbs are rare

Summer season usually occurs from July 1 to September 30.

From Table 17 in *Sage-Grouse Habitat Assessment Framework* (Stiver et al., 2015).

Good abundance, diversity, and availability relative to ecological site potential.

Table 4. Summer/late brood rearing habitat life requisites, indicators, and suitability for riparian or wet meadow site-scale habitat descriptions.[1]

Life Requisite Feature	Habitat Indicator	Suitability Categories		
		Suitable	Marginal	Unsuitable
Cover and food	Riparian and wet meadow stability	Majority of areas are at proper functioning condition	Majority of areas are functioning-at-risk	Majority of areas are non-functioning
Food	Preferred forb availability[2]	Preferred forbs are common with appropriate number of species present	Preferred forbs are common but only a few preferred species are present	Preferred forbs are rare
Cover	Availability of sagebrush cover	Sagebrush cover is adjacent to brood-rearing areas (<300 feet)	Sagebrush cover is in close proximity to brood rearing areas (~300–900 feet)	Sagebrush cover is unavailable (>900 feet)

(1) From Table 18 in *Sage-Grouse Habitat Assessment Framework* (Stiver et al., 2015).

(2) Good abundance, diversity, and availability relative to ecological site potential.

Table 5. Winter habitat life requisites, indicators, and suitability categories for site-scale habitat descriptions.[1-2]

Life Requisite Feature	Habitat Indicator	Suitability Categories		
		Suitable	Marginal	Unsuitable
Cover and food	Sagebrush cover (%)	>10%	~5 to <10%	<5%
Height	Sagebrush height above snow	>10 inches	>4 to <10 inches	<4 inches

Winter season usually occurs from December 1 to February 28 or 29.

From Table 19 in *Sage-Grouse Habitat Assessment Framework* (Stiver et al., 2015).

It is worthy to note that direction from Bureau of Land Management (BLM) (Toevs et al., 2017) is that no single indicator from the habitat objectives tables (or one-time measurement) of the indicators should be used to determine habitat conditions. The indicators should be used in combination with each other to make a suitability rating, without reliance on a single indicator. Environmental conditions that affect the indicator values, e.g., drought, date of measurement, should also be taken into consideration, and that habitat condition be evaluated based on current conditions and long-term trend. Also, BLM and State and Federal partners are beginning the process of updating the methods to summarize the suitability ratings to describe the proportion of each seasonal habitat in each seasonal suitability category (V. A. Herren, personal communication, 2017).

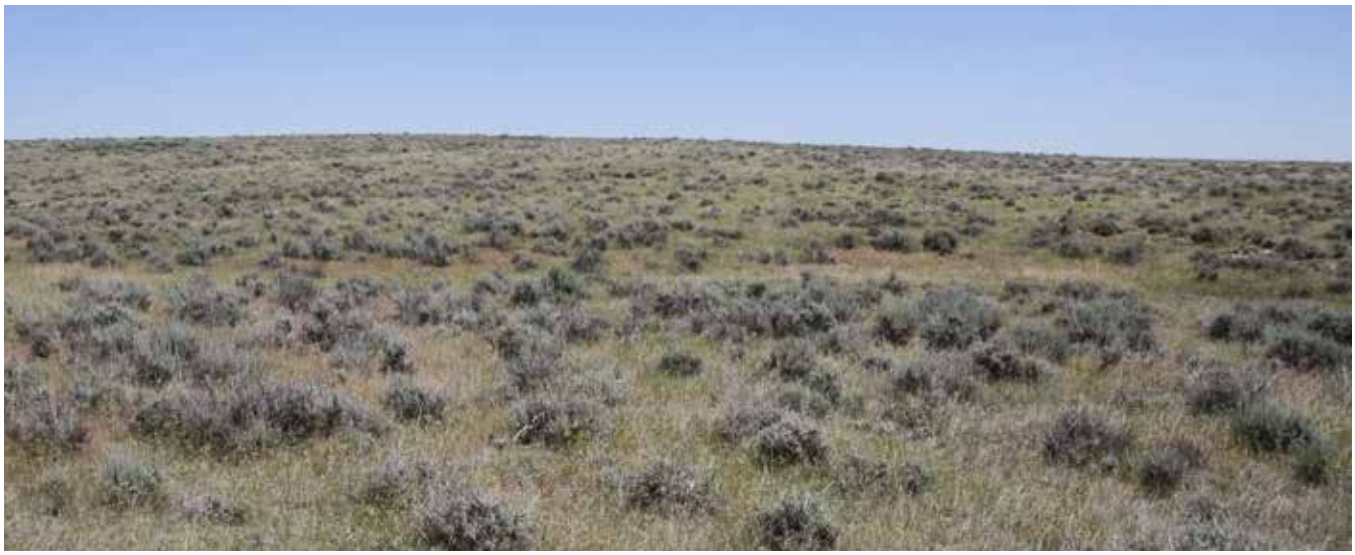


Photo by Leanne Correll

Suitable sage grouse habitat (as shown here) has spreading rather than columnar sage brush structure and heterogeneity of grass and forb species

Appendix 3. Glossary of Terms.

Adaptive management: Recursive process in that the system continues to be monitored after adjusting the management design, ultimately providing evidence about the effectiveness of the change. Monitoring for rangeland sustainability entails repeated observations of various indicators with the goal of tracking changes in ecosystem, economic, or social variables in relation to management objectives and activities.

Balance sheet: Itemized statement that lists the total assets and the total liabilities of a business, and gives its net worth on a certain date. The preparation of a balance sheet or future projections is called the *pro forma* balance sheet. *Pro forma* balance sheets are used to project how the business will be managing its assets in the future.

For example, a *pro forma* balance sheet shows the projected amount of money tied up in receivables, inventory, and equipment. It can also be used to project the overall financial soundness of the company. A *pro forma* balance sheet can pinpoint a high debt-to-equity ratio. This statement provides two views of the same business: what resources the business owns, and the creditor and owner investments who supplied these resources. These divisions are generally set up in a two-column account form, with assets on the left and liabilities and equity on the right. An alternative is the one-column statement form or report form, which lists assets on top and liabilities and equity below.

Basal cover: Amount of surface area occupied by the stem of a plant that contacts the soil. It is an important variable for relating plant cover to the potential for surface water erosion on the soil, especially sheet erosion, and it is less sensitive to annual weather variations than canopy or foliar cover. For bunchgrasses, however, basal cover is less sensitive to decreases in cover related to decreases in tiller numbers because both the living and dead portions are often combined (Pyke et al., 2015a).

Breeding habitat: Leks and the sagebrush habitat surrounding leks that are collectively used for pre-laying, breeding, nesting, and early brood-rearing activities from approximately March through June (Connelly et al., 2000; Connelly et al., 2003).

Brood (sage-grouse): Hen or group of hens with at least one chick.

Brood-rearing habitat:

Early: Upland sagebrush sites relatively close to nest sites, typically characterized by high species richness with an abundance of forbs and insects, where sage-grouse hens raise young chicks (<21 days old) (Connelly et al., 2000).

Late: Variety of habitats used by sage-grouse from July through September, including, but not limited to, wet meadows, farmland, riparian areas, dry lakebeds, and sagebrush areas (Connelly et al., 2000).

Canopy cover: Percentage of the ground (1) included in a vertical projection of imaginary polygons drawn about the total natural spread of foliage of the individuals of a species (usually used for herbaceous plants); or, (2) covered by a projection of the crown, stems, and leaves of the plant onto the ground surface (usually used for shrubs) (Stiver et al., 2015). Includes the outline of the plant canopy and spaces among plant parts as the estimate of the canopy cover of the plant. Techniques that use this method are line intercept, where distances between plant parts of a defined amount are included in the cover measurement; or Daubenmire-type techniques, where a percent area of a polygon created by tracing the exterior of the canopy of the plant is estimated either visually or using various size classes. By definition, canopy cover should exceed foliar cover of a plant (Pyke et al., 2015a)

Cash flows: Cash flows fall into two categories: inflows and outflows. Inflows include revenues from sales, proceeds from loans, and capital injections by owners. Outflows include costs of sales, operating expenses, income taxes, repayment of loans, and distribution to owners. The cash flow statement will also show the breakeven point. The breakeven point is when cash income equals cash outflows.

Chick (sage-grouse): Sage-grouse up to 10 weeks of age (Connelly et al., 2003).

Connectivity: Degree to which habitats for a species are continuous or interrupted across a spatial area. Habitats defined as continuous are within a prescribed distance over which a species can successfully conduct key activities, e.g., effective dispersal distances of seeds or juveniles; mean distances moved for foraging, nesting, and brood-rearing). Habitats defined as interrupted are outside the prescribed distance (Wisdom et al., 2003).

Conservation measure: Any action to protect, enhance, and/or restore sage-grouse habitat to minimize or eliminate identified threats on a given piece of land.

Core area strategy: Policy framework by which to apply a set of conservation actions to core population concentration areas of greater sage-grouse whereby concentrated efforts can effectively ensure long-term sage-grouse species survival.

Cover: Relative amount of shelter or protection provided by all vegetation at a given point; it is normally used to assess nesting habitat (Connelly et al., 2003).

Cover type: Vegetation classification depicting genera, species, groups of species, or life forms of trees, shrubs, grasses, or sedges or a dominant physical feature (e.g., water or rock) or land use (e.g., urban or road) of an area. When a genus or species name is given to the cover type at a broadscale, it is typically representative of a complex of species or genera with similar characteristics (Wisdom et al., 2003).

Criterion: Category of conditions or processes that is an explicit goal of sustainable development or by which sustainable development can be assessed. A criterion is too general in scope to monitor directly, but can be characterized by a set of indicators that can be monitored over time.

Development: Using and developing resources in order for people to meet their social and economic needs.

Dispersal: Movement of individuals to new living areas, including initial movements from place of birth to first attempted breeding area (natal dispersal) and subsequent movements from one breeding location to another (adult dispersal) (Elphick et al., 2001).

Disturbance: Any relatively discrete event in time that disrupts ecosystem, community, or population structure, and changes resources, substrate availability, or the physical environment (White and Pickett, 1985).

Droop height: Height of a grass or forb measured from the ground to the point where the plant naturally bends (maximum natural height). There may be no droop to some plants with relatively short stature (Connelly et al., 2003).

Ecological site: Kind of land with specific physical characteristics. It differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its response to management.

Ecological site description (ESD): Description of the soils, uses, and potential of a kind of land with specific physical characteristics to produce distinctive kinds and amounts of vegetation (Pellant et al., 2005).

Ecosystem: Totality of components of all kinds that make up a particular environment; the complex of a biotic community and its abiotic, physical environment (Wisdom et al., 2003).

Encroachment: Advancement beyond the usual or proper limits; often used to describe the advancement of piñyon pine or juniper woodlands into sagebrush communities (Wisdom et al., 2003).

Enterprise budget: An itemization of costs (inputs) and income (outputs) associated with a specific enterprise, providing an estimation of the enterprise's profitability.

Foliar cover: Ground area covered by plants (leaves, stems, flowers) when the shape of each vegetation part is projected perpendicular to the ground. Techniques for measuring foliar cover include point intercept, line-point intercept, and line intercept—provided spaces between plant parts are not included (Pyke et al., 2015a).

Forb: Herbaceous plant other than a grass, sedge, or rush that has little or no woody material

Fragmentation: Process by which a species' habitat is reduced and fragmented into pieces and separated by areas of unsuitable habitat or non-habitat. Habitat fragmentation has not occurred when habitat has been separated by unsuitable habitat, but occupancy, reproduction, or survival of the species has not been affected (Franklin et al., 2002).

General habitat management areas: Occupied (seasonal or year-round) habitat outside of priority habitat. These areas have been identified by the Bureau of Land Management in coordination with respective state wildlife agencies (BLM, 2015).

Ground cover: Soil surface that is covered by plants, litter, rocks, biological soil crusts, or bare ground (exposed soil surface not covered by the other objects). For plants, ground cover is often used for determining the absolute cover of a plant species or a site-specific relative cover (plant composition) of a species at the site. This can be estimated using numerous techniques, but each technique may vary in its estimate because of observer differences or the type of ground cover being measured and may create ambiguous results. Depending on the measurement technique, ground cover provides an estimate of either canopy or foliar cover of plants. The difference is described in the foliar and canopy cover definitions (Pyke et al., 2015a).

Habitat: Area with a combination of resources (e.g., space, food, cover, and water) and environmental conditions (e.g., temperature, precipitation, presence or absence of predators and competitors) that promote occupancy by individuals of a given species and allow those individuals to survive and reproduce (Morrison et al., 1998).

Habitat indicator: Component or attribute of habitat that can be observed and/or measured to characterize suitability for space, food, and cover.

Habitat quality: Measure of two components: (1) habitat use (selection) by animals; and (2) fitness consequences associated with that habitat (Van Horne, 1983; Aldridge and Boyce, 2007).

Habitat selection: Process by which an animal chooses its habitat or habitat components (Johnson, 1980). The orders of selection are as follows:

First-order: Selection of the physical or geographic range of a species.

Second-order: Selection of the physical or geographic home range for a subpopulation (e.g., for a sage-grouse or lek group).

Third-order: Selection of seasonal habitats (cover types) within a home range (e.g., sage-grouse seasonal habitat areas).

Fourth-order: Selection of habitat components (food items and shelter provisions for feeding, nesting, and roosting areas) within a seasonal use area.

Habitat suitability: Relative appropriateness of a certain ecological area for meeting the life requirements of an organism (e.g., space, food, cover, and water).

Suitable habitat: Area that provides environmental conditions necessary for successful survival and reproduction to sustain stable populations (Cooperrider et al., 1986; Morrison et al., 1998).

Marginal habitat: Area that supports the species, but has generally lower survival rates and reproductive success by comparison and may or may not have the potential to become suitable in the future (Cooperrider et al., 1986).

Potential habitat: Area that is currently unoccupied, but has the potential for occupancy in the foreseeable future (<100 years) through succession or restoration.

Unsuitable habitat: Area that does not currently provide one or more of the life requisites and, therefore, does not provide habitat, but it may provide habitat sometime in the foreseeable future (<100 years) through succession or restoration.

Non-habitat: Area within the historical distribution of sage-grouse that is unoccupied, and does not have the potential to provide habitat in the foreseeable future (<100 years).

Herbaceous (vegetation): Plants that die back to the ground each year, normally with soft, non-woody stems (Connelly et al., 2003).

Hiding cover: Horizontal cover that is explained by rotating a raindrop 90 degrees and projecting it horizontally (parallel to the soil surface) into the vegetation from a defined height and for a defined distance. This is often estimated using a cover pole or board with bands or grid cells of known size, where an observer determines how many grid cells or how much of each band, or both, are visible from the defined distance and height (Pyke et al., 2015a).

Home range: Area traversed by an animal during its activities during a specified period of time (Morrison and Hall, 2002).

Invasive plant: Plant species that is not part of, or is a minor component of, a pre-disturbance plant community and that has the potential to become a dominant or codominant species on the site if its future establishment and growth is not actively controlled by management interventions (Pellant et al., 2005).

Income statement: Records revenues versus expenses for a given period (also called the statement of income and expenses or profit and loss statement).

Indicator: Variable that can be assessed in relation to a criterion. It should describe attributes of the criterion in an objectively verifiable and unambiguous manner as practicable, and is capable of being estimated periodically to detect trends.

Key area: Location that represents either general or specific conditions of the entire area of which it is a part, and is often an important monitoring location.

Key species: (1) Forage species whose use serves as an indicator to the degree of use of associated species; and (2) those species that must, because of their importance, be considered in the management program (Glossary Update Task Group, 1998).

Landscape cover: Term often used in conjunction with broad regional or continental maps classified from remotely sensed data (for example, aerial photography or satellite imaging). Landscape cover is the proportion of an entire landscape area that is dominated by a common vegetation type or species (Pyke et al., 2015a). Landscape cover of sagebrush has been measured by resource management planning tools including:

Landfire Existing Vegetation Type (https://www.landfire.gov/NationalProductDescriptions21.php);

U.S. Geological Survey (USGS) GAP Land Cover Data Set (https://gapanalysis.usgs.gov/gaplandcover/data/);

and, USGS Sagemap (http://sagemap.wr.usgs.gov/GISData.aspx).

Lek: Open area surrounded by sagebrush, without trees or other tall structures in close proximity, where males traditionally display and breeding occurs (Connelly et al., 2000). Categories of leks are as follows:

Occupied lek: (1) greater sage-grouse—A lek that has been active during the prior five years; (2) Gunnison sage-grouse—A lek that has been attended by males in the previous five years. Note: The specific terms and definitions for lek status may vary by state. Use the terminology appropriate for your area.

Unoccupied lek: (1) greater sage-grouse—A lek that has not been active during a period of five years; and (2) Gunnison sage-grouse—A lek that has been inactive for five years. Note: The specific terms and definitions for lek status may vary by state. Use the terminology appropriate for your area.

Undetermined lek: Any lek that has not been documented as active in the last five years, but for which survey information is insufficient to designate the lek as unoccupied. Note: The specific terms and definitions for lek status may vary by state. Use the terminology appropriate for your area.

Life form (plant): Characteristic form or appearance of a species at maturity, such as grass, forb, tree, or shrub (Habich, 2001).

Life requisite: Item an animal needs to survive, including food, shelter, or cover, water (Morrison et al., 1998), and space.

Line intercept/Daubenmire frame: Two techniques for measuring canopy cover that involves placing a measuring tape between two points and measuring the amount of plant (crown, stems, leaves) that intersects a vertical projection of this line (Canfield, 1941). The line intercept technique is used for measuring shrub cover while the Daubenmire frame technique is used for measuring herbaceous cover.

Line-point intercept: Rapid, accurate method for quantifying soil cover, including vegetation, litter, rocks, and biotic crusts (Herrick et al., 2005a, 2005b). The methodology uses a measuring tape, two pins for anchoring the tape, and a straight, small-diameter rod to determine plant cover and composition.

Linkage area: Land cover type—other than occupied sagebrush shrubland—that sage-grouse frequently use and may move through to another habitat patch. If made into suitable habitat, this area will increase movement between populations and decrease the probability of extinction of the species by stabilizing population dynamics (Gunnison Sage-Grouse Rangewide Steering Committee, 2005).

Nesting habitat: Area with protective grass and high lateral shrub cover where hens rest, typically under sagebrush shrubs (Connelly et al., 2000).

Occupied habitat (sage-grouse): All sagebrush and associated plant communities known to be used by sage-grouse within the last 10 years. Sagebrush areas that are contiguous with areas of known use, and that do not have effective barriers to sage-grouse movement from those areas, are considered occupied unless specific information exists that documents the lack of sage-grouse use.

Plant community: Assemblage of plants occurring together at any point in time, thus denoting no particular successional status. A unit of vegetation (Glossary Update Task Group, 1998).

Potential plant community: One of usually several plant communities that may become established on an ecological site under present environmental conditions, either with or without human interference (Glossary Update Task Group, 1998).

Priority habitat management area: Areas that have the highest conservation value to maintaining or increasing sage-grouse populations. These areas would include breeding, late brood-rearing, winter concentration areas, and, where known, migration or connectivity corridors. Sage-grouse priority habitat includes core plus connectivity habitat (BLM, 2015).

Proper functioning condition assessment: Consistent approach for considering hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the condition of riparian-wetland areas. Function ratings follow (Dickard et al., 2015):

Proper functioning condition (PFC): Riparian-wetland area in which adequate vegetation or other structure components are present to dissipate energy from flooding, reduce erosion, improve water quality, filter sediments, aid in floodplain development, improve flood water retention and groundwater recharge, stabilize streambanks and shorelines, develop diverse ponding and channel characteristics for fish and wildlife habitat, and support greater biodiversity, among other things.

Functioning-at-risk (FAR): Riparian wetland area that is in functional condition, but has at least one attribute or process that makes it susceptible to degradation.

Non-functioning (NF): Riparian-wetland area that clearly does not provide adequate vegetation, landform, or large woody debris to dissipate energies associated with high flow and, thus, does not reduce erosion, improve water, etc.

Rangeland: Land on which the indigenous vegetation (climax or natural potential) is predominantly grasses, grasslike plants, forbs, or shrubs and is managed as a natural ecosystem. If plants are introduced, they are managed similarly. Rangeland can include natural grasslands, savannas, shrublands, deserts, tundras, alpine communities, marshes, and meadows.

Restoration: Process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. An ecosystem is recovered or restored when it contains sufficient biotic and abiotic resources to continue its development without further assistance or subsidy (Clewell et al., 2004).

Resilience: Capacity of an ecosystem to regain its fundamental structure, processes, and functioning when altered by stresses and disturbances. Resilient ecosystems reorganize after stressors like drought and disturbances like wildfire without crossing a threshold to an alternative state with different structure and function (Chambers et al., 2016).

Resistance: Capacity of an ecosystem to retain its fundamental structure, processes, and functioning (or remain largely unchanged) despite stressors, disturbances, or invasive species. Resistance to invasion is particularly important in Great Basin ecosystems and is a function of the attributes of ecosystems that limit invading species Applying resilience thinking as a land manager requires one to acknowledge that change is continually occurring and that ecosystems are adjusting to this change at scales ranging from the landscape to the site. Resilience and resistance concepts help managers understand key drivers of ecosystem change, identify relative risks of crossing thresholds to undesired states, and design appropriate management actions to promote desired ecosystem trajectories (Chambers, 2016).

Riparian habitat: Area that is saturated or inundated at a frequency and duration sufficient to produce vegetation typically adapted for life in saturated soil conditions (Prichard et al., 2003).

Sagebrush ecosystem: Arid and semiarid, sagebrush-dominated lands in the western United States and Canada that encompass the approximate boundaries of the historical range of greater and Gunnison sage-grouse (Wisdom et al., 2003).

Sagebrush focal area: Areas recognized by the U.S. Fish and Wildlife Service as "strongholds" for greater sage-grouse where the highest densities of grouse are noted and habitat characteristics are present for the persistence of the species.

Scale: (1) Dimensions in time and space. Note: A dependency between temporal and spatial scales is well recognized in ecology; (2) a progressive classification of ecological and socio-economic systems; and (3) in hierarchy theory, scale is the period of time or space over which signals regarding a system are smoothed to give a message. Signals come from data that are limited by the grain and extent (spatial and temporal sampling universe). For sage-grouse, scales are as follows:

Broadscale: Entire species range and populations (first-order habitat selection).

Mid-scale: Subpopulations (second-order habitat selection).

Fine-scale: Seasonal-use areas (third-order habitat selection).

Site-scale: Seasonal foraging and shelter habitat (fourth-order habitat selection).

Seasonal habitat:

Summer: Summer or late brood-rearing period from July through August, when hens and chicks use a variety of moist and mesic habitats where succulent forbs and insects are found in close proximity to sagebrush (Connelly et al., 2000).

Fall: Matrix of sagebrush habitat areas that sage-grouse slowly move through from September through November, transitioning from summer habitat to winter habitat and shifting their diet from large amounts of forbs to exclusively sagebrush (Connelly et al., 2000).

Winter: Sagebrush habitats that provide access to sagebrush above the snow for all food and cover requisite needs (Connelly et al., 2000).

Source habitat: Habitat in which local reproductive success exceeds local mortality, thus producing an excess of individuals to emigrate to other areas (Meffe and Carroll, 1997).

Sustainable development (Brundtland definition): Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. It includes the economic, social, and ecological realms. (Note: The definition was first expressed by Brundtland et al., 1987. Their report infers two key objectives for the United States: (1) an innovative, resource-efficient economy that delivers a desired quality of life; and (2) a healthy natural environment.)

Sustainable ranch management: Management of the land, natural resources, and business enterprises associated with a ranching operation to provide a desired mix of benefits to the present generation without compromising its ability to provide benefits for future generations.

Utilization: (1) The proportion of current year's forage production that is consumed or destroyed by grazing animals. May refer either to a single species or to the vegetation as a whole. Synonym: degree of use; and (2) Utilization of range for a purpose such as grazing, bedding, shelter, trailing, watering, watershed, recreation, forestry, etc.

Wet meadow: Meadow where the surface remains wet or moist throughout the summer, usually characterized by sedges and rushes (USFS 1969).

Photo by Leanne Correll

Spreading growth form of sagebrush indicates suitable habitat for sage grouse (See page 47

Appendix 4. References Cited.

Aldridge, C.L, and Boyce, M.S., 2007, Linking occurrence and fitness to persistence: Haitat-based approach for endangered greater sage grouse: Ecological Applications, v. 17:2, p. 508-526.

Audubon Rockies, 2017, Audubon Rockies conservation ranching program: Grazed on bird friendly land: *at* http://rockies.audubon.org/programs/audubon-conservation-ranching (accessed August 2017).

Beck, J. L., and Mitchell, D. L., 2000, Influences of livestock grazing on sage-grouse habitat: Wildlife Society Bulletin, v. 28, p. 993–1,002.

Bork, E. W., West, N. E., and Walker, J. W., 1998, Cover components on long-term seasonal sheep grazing treatments in three-tip sagebrush steppe: Journal of Range Management, v. 51, p. 293–300.

Boyd, C. S., and Svejcar, T. J., 2009, Managing complex problems in rangeland ecosystems: Rangeland Ecology and Management, v. 62, p. 491–499.

Boyd, C., Petersen, S., Gilgert, W., Rodgers, R., Fuhlendorf, S., Larsen, R., Wolfe, D., Jensen, K. C., Gonzales, P., Nenneman, M., Danvir, R., Dahlgren, D., and Messmer, T., 2011, Looking toward a brighter future for lekking grouse: Rangelands, v. 33, p. 2–11.

Boyd, C. S., Beck, J. L., and Tanaka, J. A., 2014a, Livestock grazing and sage-grouse habitat: Impacts and opportunities: Journal of Rangeland Applications, v. 1, p. 58–77.

Boyd, C. S., Johnson, D. D., Kerby, J. D., Svejcar, T. J., and Davies, K. W., 2014b, Of grouse and golden eggs: Can ecosystems be managed within a species-based regulatory framework?: Rangeland Ecology and Management, v. 67, p. 358–368.

Brundtland, G. H., and others, 1987, Our common future: From one earth to one world: World Commission on Environment and Development, 300 p.

Bureau of Land Management, 2015, FACT SHEET: BLM, USFS Greater Sage-Grouse Conservation Effort: at https://www.blm.gov/sites/blm.gov/files/BLM-USFS%20Sage-grouse%20Plans%20Fact%20Sheet%20Final915.pdf, (Accessed August 2017).

Burton, T. A., Smith, S. J., and Cowley, E. R., 2011, Riparian area management: Multiple indicator monitoring (MIM) of stream channels and streamside vegetation: Denver, Colorado, U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Technical Reference 1737-23 (revised), 155 p.

Canfield, R. H., 1941, Application of the line interception method in sampling range vegetation: Journal of Forestry, v. 39, p. 388–394.

Chambers, J. C., Bradley, B. A., Brown, C. S., D'Antonio, C., Germino, M. J., Grace, J. B., Hardegree, S. P., Miller, R. F., and Pyke, D. A., 2014a, Resilience to stress and disturbance, and resistance to *Bromus tectorum* L. invasion in cold desert shrublands of western North America: Ecosystems, v. 17, p. 360–375.

Chambers, J. C., Pyke, D. A., Maestas, J. D., Pellant, M., Boyd, C. S., Campbell, S. B., Espinosa, S., Havlina, D. W., Mayer, K. E., and Wuenschel, A., 2014b, Using resistance and resilience concepts to reduce impacts of invasive annual grasses and altered fire regimes on the sagebrush ecosystem and greater sage-grouse: A strategic multi-scale approach: Fort Collins, Colorado, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-326, 73 p.

Chambers, J.C.; Beck, J.L.; Campbell, S.; Carlson, J.; Christiansen, T.J.; Clause, K.J.; Dinkins, J.B.; Doherty, K.E.; Griffin, K.A.; Havlina, D.W.; Henke, K.F.; Hennig, J.D.; Kurth, L.L.; Maestas, J.D.; Manning, M.; Mayer, K.E.; Mealor, B.A.; McCarthy, C.; Perea, M.A.; Pyke, D.A. 2016. Using resilience and resistance concepts to manage threats to sagebrush ecosystems, Gunnison sage-grouse, and Greater sage-grouse in their eastern range: A strategic multi-scale approach. Gen. Tech. Rep. RMRS-GTR-356. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 143 p.

Clewell, A., Aronson, J., Winterhalder, K., and others, 2004, The SER international primer on ecological restoration: Society for Ecological Restoration International Science and Policy Working Group: Version 2, 14 p.

Connelly, J. W., Schroeder, M. A., Sands, A. R., and Braun, C. E., 2000, Guidelines to manage sage-grouse populations and their habitats**:** Wildlife Society Bulletin, v. 28, p. 967–985.

Connelly, J. W., Reese, K. P., and Schroeder, M. A., 2003, Monitoring of greater sage-grouse habitats and populations: Moscow, Idaho, University of Idaho, Idaho Forest, Wildlife, and Range Experiment Station, Contribution 979, 48 p.

Cooperrider, A. Y., 1986, Inventory and monitoring of wildlife habitat, Denver, Colorado, US Dept of the Interiot, Bureau of Land Management, 858 p.

Correll, L. L., Burton, R. M., Scasta, J. D., and Beck, J. L., 2017, Landowner guide to sage-grouse conservation in Wyoming: A practical guide for land owners and managers: Laramie, Wyoming, University of Wyoming Agricultural Experiment Station and University of Wyoming Extension, Bulletin 1295, 72 p.

Crawford, J. A., Olson, R. A., West, N. E., Mosley, J. C., Schroeder, M. A., Whitson, T. D., Miller, R. F., Gregg, M. A., and Boyd, C. S., 2004, Ecology and management of sage-grouse and sage-grouse habitat: Journal of Range Management, v. 57, p. 2–19.

Davies, K. W., Bates, J. D., Johnson, D. D., and Nafus, A. M., 2009a, Influence of mowing *Artemisia tridentata* ssp. *wyomingensis* on winter habitat for wildlife: Environmental Management, v. 44, p. 84–92.

Davies, K. W., Svejcar, T. J., and Bates, J. D., 2009b, Interaction of historical and nonhistorical disturbances maintains native plant communities: Ecological Applications, v. 19, p. 1,536–1,545.

Davies, K. W., Bates, J. D., Svejcar, T. J., and and Boyd, C. S., 2010, Effects of long-term livestock grazing on fuel characteristics in rangelands: An example from the sagebrush steppe: Rangeland Ecology and Management, v. 63, p. 662–669.

Davies, K. W., Bates, J. D., and Nafus, A. M., 2011a, Are there benefits to mowing Wyoming big sagebrush plant communities? An evaluation in southeastern Oregon: Environmental Management, v. 48, p. 539–546.

Davies, K. W., Boyd, C. S., Beck, J. L., Bates, J. D., Svejcar, T. J., and Gregg, M. A., 2011b, Saving the sagebrush sea: An ecosystem conservation plan for big sagebrush plant communities: Biological Conservation, v. 144, p. 2,573–2,584.

Davies, K. W., Vavra, M., Schultz, B., and Rimbey, N., 2014, Implications of longer term rest from grazing in the sagebrush steppe: Journal of Rangeland Applications, v. 1, p. 14–34.

Dickard, M., Gonzales, M., Elmore, W., Leonard, S., Smith, D., Smith, S., Staats, J., Summers, P., Weixelman, D., and Wyman, S., 2015, Riparian area management: Proper functioning condition assessment for lotic areas (second edition): Denver, Colorado, U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Technical Reference 1737-15, 176 p.

Elphick, C., Dunning, J. B., Jr., and Sibley, D. A., 2001, The Sibley guide to bird life and behavior: National Audubon Society, New York City, New York, Alfred A. Knopf Inc., 588 p.

Finch, D. M., Boyce, D. A., Jr., Chambers, J. C., Colt, C. J., Dumroese, R. K., Kitchen, S. G., McCarthy, C., Meyer, S. E., Richardson, B. A., Rowland, M. M., Rumble, M. A., Schwartz, M. K., Tomosy, M. S., and Wisdom, M. J., 2016, Conservation and restoration of sagebrush ecosystems and sage-grouse: An assessment of USDA Forest Service Science: Fort Collins, Colorado, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-348, 54 p.

Franklin, A. B., Noon, B. R., and George, T. L., 2002, What is habitat fragmentation?, *in* George, T. L., and Dobkin, D. S., Effects of habitat fragmentation on birds in western landscapes: Contrasts with paradigms from the eastern United States: Studies in Avian Biology, v. 25, p. 20–29.

Ganskopp, D., Svejcar, T., Taylor, F., and Farstvedt, J., 2004, Can spring cattle grazing among young bitterbrush stimulate shrub growth?: Rangeland Ecology and Management, v. 57, p. 161–168.

Glossary Update Task Group, 1998, Glossary of terms used in range management (fourth edition): Society for Range Management.

Gunnison Sage-grouse Rangewide Steering Committee. 2005. Gunnison sage-grouse rangewide conservation plan. Colorado Division of Wildlife, Denver, Colorado, USA.

Habich, E. F., 2001, Ecological site inventory: Denver, Colorado, U.S. Department of the Interior, Bureau of Land Management, Technical Reference 1734-7, 116 p.

Hagen, C. A., Connelly, J. W., and Schroeder, M. A., 2007, A meta-analysis of greater sage-grouse *Centrocercus urophasianus* nesting and brood-rearing habitats: Wildlife Biology, v. 13, supplement 1, p. 42–50.

Hamilton, S., Garretson-Weibel, C., Mitchell, J., Smith, M., Powell, D., Quimby, C., Fults, G., Stanley, C., Tanaka, J., Maczko, K., Brite, J. K., Loper, D., Hansen, N., and Bryant, L., 2013, Sustainable ranch management assessment guidebook: Do you know whether your ranch is sustainable?: A communication tool for ranchers, technical service providers, and agencies (version 2): Laramie, Wyoming, University of Wyoming Extension, Bulletin 1216, 69 p.

Herrick, J. E., Van Zee, J. W., Havstad, K. M., Burkett, L. M., and Whitford, W. G., 2005a, Monitoring manual for grassland, shrubland, and savanna ecosystems: Volume 1: Quick start: Tucson, Arizona, University of Arizona Press, 36 p.

Herrick, J. E., Van Zee, J. W., Havstad, K. M., Burkett, L. M., and Whitford, W. G., 2005b, Monitoring manual for grassland, shrubland, and savanna ecosystems: Volume 2: Design, supplementary methods, and interpretation: Tucson, Arizona, University of Arizona Press, 200 p.

Johnson, D. H., 1980, The comparison of usage and availability measurements for evaluating resource preference: Ecology, v. 61, p. 65–71.

Laycock, W. A., 1967, How heavy grazing and protection affect sagebrush-grass ranges: Journal of Range Management, v. 20, p. 206–213.

Manier, D. J., Bowen, Z. H., Brooks, M. L., Casazza, M. L., Coates, P. S., Deibert, P. A., Hanser, S. E., and Johnson, D. H., 2014, Conservation buffer distance estimates for greater sage-grouse: A review: U.S. Geological Survey Open-File Report 2014-1239, 14 p.

Meffe, G. K., & Carroll, C. R. (Eds.) (1997). Principles of Conservation Biology (2nd ed., pp. 3-27). Sunderland, Massachusetts: Sinauer Associates Inc.

Miller, R. F., Svejcar, T. J., and West, N. E., 1994, Implications of livestock grazing in the Intermountain sagebrush region: Plant composition, *in* Vavra, M., Laycock, W. A., and Pieper, R. D., eds., Ecological implications of livestock herbivory in the West: Denver, Colorado, Society for Range Management, p. 101–146.

Miller,R.F.,Bates,J.D.,Svejcar,T.J.,Pierson,F.B.and Eddleman,L.E.,2005.Biology,Ecology,and Management of Western Juniper (Juniperus occidentalis) Technical Bulletin 152. Oregon State University. Agricultural Experiment Station.76p.

Miller, R. F., Chambers, J. C., and Pellant, M., 2015, A field guide for rapid assessment of post-wildfire recovery potential in sagebrush and piñon-juniper ecosystems in the Great Basin: Evaluating resilience to disturbance and resistance to invasive annual grasses and predicting vegetation response: Fort Collins, Colorado, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-338, 72 p.

Morrison, M. L., Marcot, B. G., and Mannan, R. W., 1998, Wildlife-habitat relationships: Concepts and applications (second edition): Madison, Wisconsin, University of Wisconsin Press, *520* p.

Morrison, M. L., and Hall, L. S., 2002, Standard terminology: Toward a common language to advance ecological understanding and application, *in* Scott, J. M., Heglund, P. J., and Morrison, M. L., Haufler, J. B., Raphael, M. G., Wall, W. A., and Samson, F. B., eds., Predicting species occurrences: Issues of accuracy and scale: Washington, D.C., Island Press, p. 43–52.

Mueggler, W. F., 1950, Effects of spring and fall grazing by sheep on vegetation of the Upper Snake River Plains: Journal of Range Management, v. 3, p. 308–315.

Murphy, T., Naugle, D. E., Eardley, R., Maestas, J. D., Griffiths, T., Pellant, M., and Stiver, S. J., 2013, Trial by fire: Improving our ability to reduce wildfire impacts to sage-grouse and sagebrush ecosystems through accelerated partner collaboration: Rangelands, v. 35, p. 2–10.

Naugle, D. E., Doherty, K. E., Walker, B. L., Holloran, M. J., and Copeland, H. E., 2011, Energy development and greater sage-grouse, *in* Knick, S. T., and Connelly, J. W., eds., Greater sage-grouse: Ecology and conservation of a landscape species and its habitats: Berkeley, California, University of California Press, Studies in Avian Biology, v. 38, p. 489–503.

Pellant, M., Shaver, P., Pyke, D. A., and Herrick, J. E., 2005, Interpreting indicators of rangeland health (version 4): Denver, Colorado, U.S. Department of the Interior, Bureau of Land Management, National Science and Technology Center, Technical Reference 1734-6, 122 p.

Prichard, D., Berg, F., Hagenbuck, W., Krapf, R., Leinard, R., Leonard, S., Manning, M., Noble, C., and Staats, J., 2003, Riparian area management: A user guide to assessing proper functioning condition and the supporting science for lentic areas: Denver, Colorado, U.S. Department of the Interior, Bureau of Land Management, National Applied Research Science Center, Technical Reference 1737-16, 112 p.

Pyke, D. A., 2011, Restoring and rehabilitating sagebrush habitats, *in* Knick, S. T., and Connelly, J. W., eds., Greater sage-grouse: Ecology and conservation of a landscape species and its habitats: Berkeley, California, University of California Press, Studies in Avian Biology, v. 38, p. 531–548.

Pyke, D. A., Chambers, J. C., Pellant, M., Knick, S. T., Miller, R. F., Beck, J. L., Doescher, P. S., Schupp, E. W., Roundy, B. A., Brunson, M., and McIver, J. D., 2015a, Restoration handbook for sagebrush steppe ecosystems with emphasis on greater sage-grouse habitat, part 1: Concepts for understanding and applying restoration: U.S. Geological Survey Circular 1416, 46 p.

Pyke, D. A., Knick, S. T., Chambers, J. C., Pellant, M., Miller, R. F., Beck, J. L., Doescher, P. S., Schupp, E. W., Roundy, B. A., Brunson, M., and McIver, J. D., 2015b, Restoration handbook for sagebrush steppe ecosystems with emphasis on greater sage-grouse habitat, part 2: Landscape level restoration decisions: U.S. Geological Survey Circular 1418, 24 p.

Pyke, D. A., Chambers, J. C., Pellant, M., Miller, R. F., Beck, J. L., Doescher, P. S., Roundy, B. A., Schupp, E. W., Knick, S. T., Brunson, M., and McIver, J. D., 2017, Restoration handbook for sagebrush steppe ecosystems with emphasis on greater sage-grouse habitat, part 3: Site level restoration decisions: U.S. Geological Survey Circular 1426, 64 p.

Reisner M. D., Grace, J. B., Pyke, D.A., and Doescher, P. S., 2013, Conditions favoring *Bromus tectorum* dominance of endangered sagebrush steppe ecosystems: Journal of Applied Ecology, v. 50, p. 1,039–1,049.

Sage Grouse Initiative, 2017, Wildlife conservation through sustainable ranching: *at* https://www.sagegrouseinitiative.com (accessed September 2017).

Sather-Blair, S., Makela, P., Carrigan, T., and Anderson, L., 2000, A framework to assist in making sensitive species habitat assessments for BLM-administered public lands in Idaho: Sage-grouse (*Centrocercus urophasianus*): U.S. Department of the Interior, Bureau of Land Management, 45p.

Schroeder, M. A., Aldridge, C. L., Apa, A. D., Bohne, J. R., Braun, C. E., Bunnell, S. D., Connelly, J. W., Deibert, P. A., Gardner, S. C., Hilliard, M. A., Kobriger, G. D., McAdam, S. M., McCarthy, C. W., McCarthy, J. J., Mitchell, D. L., Rickerson, E. V., and Stiver, S. J., 2004, Distribution of sage-grouse in North America: The Condor, v. 106, p. 363–376.

SCORE Association, 2017, Helping small businesses: Herndon, Virginia, U.S. Small Business Administration: *at* https://www.score.org (accessed September 2017).

Sheley, R., Sheley, J., and Smith, B., 2014, Cost/benefit analysis of managing invasive annual grasses in partially invaded sagebrush steppe ecosystems: Weed Science, v. 62, p. 38–44.

Shoesole Resource Management Group, 2017, Collaborative, consensus-based resource management: *at* www.theshoesole.org (accessed August 2017).

Sneva, F. A., Rittenhouse, L. R., Tueller, P. T., and Reece, P., 1984, Changes in protected and grazed sagebrush-grass in eastern Oregon, 1937 to 1974: Corvallis, Oregon, Oregon Agricultural Experiment Station Bulletin 663, 11 p.

Stiver, S. J., Rinkes, E. T., Naugle, D. E., Makela, P. D., Nance, D. A., and Karl, J. W., 2015, Sage-grouse habitat assessment framework: A multiscale assessment tool: Denver, Colorado, U.S. Department of the Interior, Bureau of Land Management, and Western Association of Fish and Wildlife Agencies, Technical Reference 6710-1, 118 p.

Strand, E. K., and Launchbaugh, K. L., 2013, Livestock grazing effects on fuel loads for wildland fire in sagebrush dominated ecosystems: Moscow, Idaho, University of Idaho Rangeland Center, Great Basin Fire Science Exchange, unpublished report, 21 p.

Tanaka, J. A., and Workman, J. P., 1990, Optimal vegetation conversion: How much, how often?: Rangelands, v. 12, p. 33–36.

Tanaka, J. A., Brunson, M., and Torell, L. A., 2011, A social and economic assessment of rangeland conservation practices, *in* Briske, D. D., ed., Conservation benefits of rangeland practices: Assessment, recommendations, and knowledge gaps: Washington D. C., U.S. Department of Agriculture, Natural Resources Conservation Service, p. 371–422.

U.S. Department of Agriculture, 2010, Upland wildlife habitat management (645) sage-grouse lek survey protocols for Idaho: Natural Resources Conservation Service, Conservation Practice Job Sheet/Specification JS-26, 3 p.

U.S. Fish and Wildlife Service, 2013, Greater sage-grouse (*Centrocercus urophasianus*) conservation objectives: Final report: Denver, Colorado, U.S. Department of the Interior, Fish and Wildlife Service, 115 p.

U.S. Fish and Wildlife Service, 2015a, 50 CFR Part 17: Endangered and threatened wildlife and plants: 12-month finding on a petition to list greater sage-grouse (*Centrocercus urophasianus*) as endangered or threatened species: Washington, D.C., National Archives and Records Administration, Federal Register, v. 80, no. 191, p. 59,857–59,942.

U.S. Fish and Wildlife Service, 2015b, 2020 greater sage-grouse status review: *at* https://www.fws.gov/greatersage-grouse/PDFs/2020%20GRSG%20Status%20Review_FINAL.pdf (accessed August 2017).

U.S. Fish and Wildlife Service, 2015c, Historic conservation campaign protects greater sage-grouse: *at* https://www.fws.gov/news/ShowNews.cfm?ID=F5B7455D-0824-997C-47667F8ABBFFBA86 (accessed August 2017).

U.S. Fish and Wildlife Service, 2017, Endangered species: Gunnison sage-grouse: *at* https://www.fws.gov/mountain-prairie/species/birds/gunnisonsagegrouse/ (accessed August 2017).

U.S. Fish and Wildlife Service, U.S. Bureau of Land Management, Natural Resources Conservation Service, Wyoming Game and Fish Department, Wyoming Department of Agriculture, Wyoming Association of Conservation Districts, and U.S. Forest Service, 2013, Greater sage-grouse umbrella CCAA for Wyoming ranch management: A candidate conservation agreement with assurances for greater sage-grouse (*Centrocercus urophasianus*): Cheyenne, Wyoming, Wyoming Field Office, U.S. Fish and Wildlife Service, 75 p.

U.S. Forest Service, 1969, Forest Service Handbook, St. Louis Missouri, Royal McBee Corp.

Van Horne, B., 1983, Density as a misleading indicator of habitat quality: Journal of Wildlife Management, v. 47, p. 893–901.

Westoby, M., Walker, B., and Noy-Meir, I., 1989, Opportunistic management for rangelands not at equilibrium: Journal of Range Management, v. 42, p. 266–274.

White, P. S., and Pickett, S. T. A., 1985, Natural disturbance and patch dynamics: An introduction, *in* Pickett, S. T. A., and White, P. S., The ecology of natural disturbance and patch dynamics: New York City, New York, Academic Press, p. 3–13.

Winward, A. H., 2000, Monitoring the vegetation resources in riparian areas: Ogden, Utah, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-47, 51 p.

Wisdom, M. J., Holthausen, R. S., Wales, B. C., Hargis, C. D., Saab, V. A., Lee, D. C., Hann, W. J., Rich, T. D., Rowland, M. M., Murphy, W. J., and Eames, M. R., 2000, Source habitats for terrestrial vertebrates of focus in the interior Columbia Basin: Broad-scale trends and management implications: U.S. Department of Agriculture, Forest Service, and U.S. Department of the Interior, Bureau of Land Management, General Technical Report PNW-GTR-485, 530 p.

Wisdom, M. J., Rowland, M. M., Suring, L. H., Schueck, L., Wolff Meinke, C., Wales, B. C., and Knick, S. T., 2003, Procedures for regional assessment of habitats for species of conservation concern in the sagebrush ecosystem (version 1): La Grande, Oregon, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; U.S. Department of the Interior, Bureau of Land Management; and U.S. Geological Survey, Biological Resources Division, 153 p.

Workman, J. P., 1981, Analyzing ranch income statements: A modified approach, Rangelands, v. 3, p. 146–148.

Wyoming Business Council, 2003, Sustaining western rural landscapes, lifestyles, and livelihoods: Agricultural enterprise diversification resource guide, at http://www.sustainablerangelands.org/ranchassessment/pdf/wbc_introduction_part1.pdf, (accessed August 2017)

Photo by Leanne Correll

Unsuitable sage grouse habitat (shown here) does not have adequate sage brush cover to provide protection during sage grouse breeding and brood-rearing

Appendix 5. Additional Resources.

Editor's Note: Following are additional resources highlighted in Appendix 1. These are in addition to the references that are cited in the appendix.

Correll, L.L., Burton, R.M., Scasta, J.D., and Beck, J.L. 2017, Landowner guide to sage-grouse conservation in Wyoming: A practical guide for land owners and managers: Laramie, Wyoming, University of Wyoming Agricultural Experiment Station and University of Wyoming Extension, Bulletin 1295, 72p.

Coulloudon, B., Eshelman, K., Gianola, J., Habich, N., Hughes, L., Johnson, C., Pellant, M., Podborny, P., Rasmussen, A., Robles, B., Shaver, P., Spehar, J., and Willoughby, J., 1999, Sampling vegetation attributes: Interagency technical reference: Denver, Colorado, U.S. Department of the Interior, Bureau of Land Management, Technical Reference 1734-4, *vii* + 164 p.

Herrick, J. E., Van Zee, J. W., McCord, S. E., Courtright, E. M., Karl, J. W., and Burkett, L. M., 2016, Monitoring manual for grassland, shrubland, and savanna ecosystems (second edition): Volume 1: Core methods: Las Cruces, New Mexico, U.S. Department of Agriculture, Agricultural Research Service, Jornada Experimental Range, *vi* + 78 p.

National Drought Mitigation Center, 2017, U.S. drought monitor: Lincoln, Nebraska, University of Nebraska-Lincoln: *at* http://droughtmonitor.unl.edu/ (accessed September 2017).

Swanson, S., Bruce, B., Cleary, R., Dragt, B., Brackley, G., Fults, G., Linebaugh, J., McCuin, G., Metscher,V., Perryman, B., Tueller, P., Weaver, D., and Wilson, D., 2006, Nevada rangeland monitoring handbook (second edition): Reno, Nevada, University of Nevada Cooperative Extension, Educational Bulletin 06-03, *v* + 79 p.

University of California, Davis, Soil Resource Laboratory, 2017, Soil survey, *at* https://casoilresource.lawr.ucdavis.edu/ (accessed September 2017).

U.S. Department of Agriculture, Agricultural Research Service, 2017, The Jornada: Rangeland research programs: *at* https://jornada.nmsu.edu/ (accessed September 2017).

U.S. Department of Agriculture, Natural Resources Conservation Service, 2017a, Ecological site description system for rangeland and forestland data: *at* https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type-ESD (accessed September 2017).

U.S. Department of Agriculture, Natural Resources Conservation Service, 2017b, Ecological site information system: *at* https://esis.sc.egov.usda.gov/ (accessed September 2017).

U.S. Department of Agriculture, Natural Resources Conservation Service, 2017c, Soil geographic databases: *at* https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/geo/ (accessed September 2017).

Wyoming Range Service Team, 2008, Wyoming rangeland monitoring guide: A cooperative and voluntary approach to monitoring rangelands (version 2): U.S. Bureau of Land Management, U.S. Forest Service, Natural Resources Conservation Service, University of Wyoming Department of Renewable Resources, University of Wyoming Cooperative Extension Service, Wyoming Department of Agriculture, and Wyoming Section of the Society for Range Management, *iv* + 59 p.