WILDFIRE AND INVASIVE PLANT SPECIES IN THE SAGEBRUSH BIOME:

CHALLENGES THAT HINDER CURRENT AND FUTURE MANAGEMENT AND PROTECTION

A GAP REPORT UPDATE

WAFWA WILDFIRE/INVASIVE SPECIES WORKING GROUP
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WAFWA
WESTERN ASSOCIATION OF
FISH & WILDLIFE AGENCIES

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FORWARD

Virgil Moore

In today's word it is widely accepted that natural resource issues are better addressed at the landscape level and that the solutions to these problem must be collaborative in nature. No one agency or private group has the knowledge or resources to solve these large-scale issues alone.

The Western Association of Fish and Wildlife Agencies led multi-agency Wildfire and Invasive Species Working Group was created in that collaborative spirit to provide insight and expertise in addressing the pervasive fire and invasive cycle that has gripped the western states (especially the Great Basin) and the negative effects on 350 species that depend on sagebrush habitats. Since its creation in 2013, the Working Group has been actively working to identify fire and invasive management problems and develop tools and approaches that managers can use to address these pervasive issues.

This Gap Report Update is the latest addition to the list of valuable products of the Working Group designed to help identify the challenges (gaps) and offer ideas to address those challenges. The Gap Report Update has something for every level, public and private, to consider helping address the fire and invasive threat. It is our hope that the leaders of the various state and federal agencies will review the recommendations in the report and determine if there are things they can affect directly to address the gaps. It took a multi-agency, multi-discipline Working Group to identify the problems and provide possible solutions to these conservation and management challenges, it will certainly take a broad-based coalition of agencies, and public and private groups working together to ensure a healthy Sagebrush Biome is available for generations to come.
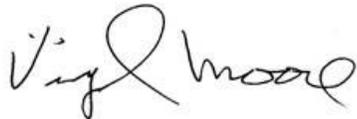
Virgil Moore, Director
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ABSTRACT

In 2013, the Western Association of Fish and Wildlife Agencies was contracted by the U.S. Fish and Wildlife Service and Bureau of Land Management to establish a multi-agency Wildfire and Invasive Species Working Group (WG) and conduct a collaborative assessment of fire and invasive plant management options for the conservation of sagebrush (*Artemisia* spp.) habitats across multiple ownerships in the Sagebrush Biome. The initial effort of the WG was to develop and publish a "Gap Analysis Report"(Gap Report). The Gap Report summarized the policy, fiscal, and science challenges that land managers have encountered regarding the control and reduction of the invasive annual grass/fire cycle, especially as it related to the 2015 status review for the Greater sage-grouse (*Centrocercus urophasianus*). Since publication of the Gap Report in 2013, much work has occurred that helped address the original 22 gaps identified by the WG. The following is an update on the original report and includes an overview of remaining work, with recommendations for actions to improve the conservation and management of the Sagebrush Biome.

Similar to the original report, the Top 5 gaps that need focused attention are identified. These gaps have been placed in priority order by the WG. The remaining 17 items were reorganized into 7 gaps (with associated sub-gaps) to better reflect major challenges. They include needs and information related to capacity and structure for invasive annual grass management; long-term restoration funding; seed availability and restoration methods; public involvement; cooperative weed management areas; rangeland fire protection associations; livestock grazing; importance of the Sagebrush Biome; strategic resource management, policy, and decision support tools; wildland fire prevention, suppression, and fuels management for Greater sage-grouse; seeding strategies; range-wide geospatial analyses and mapping; short- and long-term fire effects on Greater sage-grouse and sagebrush habitats; and drought and climate adaptation.

SAGE-GROUSE ON LEK

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INTRODUCTION

In 2013, the Western Association of Fish and Wildlife Agencies (WAFWA) was contracted by the U.S. Fish and Wildlife Service (USFWS) and Bureau of Land Management (BLM) to establish a multi-agency Wildfire and Invasive Species Working Group (WG) and conduct a collaborative assessment of fire and invasive plant management options for the conservation of sagebrush (*Artemisia* spp.) habitats across multiple ownerships in the Sagebrush Biome. The WG consists of nationally recognized experts in fire ecology and management, Greater sage-grouse (*Centrocercus urophasianus*; GRSG) ecology and wildlife management, rangeland management, plant ecology, invasive species management, soils, GIS, and database development and management. The WG was directed to:

» Compile and assess the tools and current work directed towards preventing, suppressing, and ultimately restoring areas containing invasive annual grasses, such as cheatgrass (*Bromus tectorum*), in different sagebrush habitats at various elevations in the Great Basin. While much of this effort was focused on the invasive annual grass/fire issue in the

SAGEBRUSH HABITAT

PHOTO CREDIT: WYOMING GAME AND FISH DEPARTMENT

Great Basin, important sagebrush conservation issues in other geographic areas were included.

» Summarize how fire prevention/ suppression actions and habitat restoration efforts could be strategically implemented to reduce or help control the dominance of invasive plant species and describe how/why agency coordination and funding initiatives may be necessary to support the reduction and control of invasive plant species.

» Review and evaluate the relative success of management actions and programs that have been undertaken to reduce or eliminate invasive plant species and/or reduce wildfire frequency, intensity, and spread.

» Identify the critical information gaps that hinder successful management of invasive plants and wildland fire. This includes identification of new information and mechanisms for integrating the best available science to inform land management agency policies and funding allocations.

» Identify current limitations and roadblocks, including policy and fiscal barriers, that hinder the control and

reduction of invasive plant species and wildland fire. Identify potential solutions to overcome those roadblocks.

As a result of this directive, the initial effort of the WG was to develop and publish a "Gap Analysis Report" (Mayer et al. 2013). The Gap

WORK COMPLETED BY THE WESTERN ASSOCIATION OF FISH AND WILDLIFE AGENCIES WILDFIRE/INVASIVE SPECIES WORKING GROUP

» Aided in the development of the Integrated Rangeland Fire Management Strategy

» A report on the contribution of fire and fuels management for Greater sage-grouse conservation

» A report on invasive plant management in the West, and developed the resistance and resilience concepts to reduce impacts of invasives and fire

» Held a Western Invasive Weed Summit

» Initiated the development of a Western Invasive Weed Action Plan

» Work has been extended to include the Bi-state range

» Contributed to the Western Governors Association and Western Association of State Departments of Agriculture invasive species efforts

Report summarized the policy, fiscal, and science challenges that land managers have encountered regarding the control and reduction of the invasive annual grass/fire cycle, especially as it related to the potential listing of GRSG as a threatened or endangered species under the Endangered Species Act. The original Gap Report (Mayer et al. 2013) has been used by federal agencies to help guide the planning and

initiation of work critical to the conservation of GRSG. These efforts contributed to the 2015 GRSG listing decision of "Not Warranted" by the USFWS.

Since its establishment, the WG has continued to provide technical support to discover, compile, integrate, synthesize, and summarize information and the best available science for managing wildland fire and invasive annual grass cycles across the Sagebrush Biome. The WG is led by a state association with membership from federal and state agencies. The products of the WG have helped inform the large-scale collaborative conservation of sagebrush, including the development of the Integrated

"This report provides an overview of what remains to be done and offers recommendations for action to improve the conservation and management of the Sagebrush Biome."

Rangeland Fire Management Strategy (IRFMS; USDOI 2015). Specifically, the WG has developed numerous products on using ecological resilience and resistance (R&R) concepts to manage sagebrush ecosystems and GRSG (Chambers et al. 2014a,b,c, 2016, 2017a,b), including a report on the contribution of fire and fuels management to GRSG conservation (Havlina et al. 2015) and a report on invasive plant management (Ielmini et al. 2015). The WG organized and held a Western Invasive Weed Summit and initiated the development of a Western Invasive Weed Action Plan. Furthermore, the work initiated by the WG in the Great Basin (WAFWA GRSG Management Zones (MZ III, IV and V); Stiver et al. 2006) has been extended to include the Bi-state range, a distinct population segment of GRSG, that occurs along the Nevada-California border; the Columbia Plateau (MZ VI; and the eastern

portion of the GRSG range (MZ I, II, and VII). The WG work has also contributed to the Western Governors Association (WGA) and Western Association of State Departments of Agriculture (WASDA) invasive species efforts.

Since publication of the Gap Report in 2013, much work has occurred that helped address the original 22 technical, policy, planning, and funding gaps identified by the WG. Moreover, WAFWA has committed to lead an effort to review the conservation status of GRSG in 2020 to evaluate potential conservation actions; guide adaptive management; improve management within the Sagebrush Biome using the results; and finally, identify research needs. The WAFWA 2020 conservation assessment framework will evaluate our collective efforts to conserve GRSG, effectively reduce and/or eliminate stressors identified in the 2015 "Not Warranted" finding. Given the importance of this review, the WG has been asked by the USFWS and BLM to "update" the 2013 Gap Report. The following report provides that update.

This Gap Report Update reviews the original 22 technical, policy, planning, and funding gaps and provides a brief description of the progress made toward resolving the issues identified by the WG. To help the reader, the original gaps are provided followed by the "update". These gaps include needs and information related to capacity and structure for invasive grass management; long-term restoration funding; seed availability and restoration methods; public involvement; cooperative weed management areas; rangeland fire protection associations; livestock grazing; importance of the Sagebrush Biome; strategic resource management, policy, and decision support tools; wildland fire

MALE SAGE-GROUSE IN FLIGHT

PHOTO CREDIT: WYOMING GAME AND FISH DEPARTMENT

resource specialists and consultants and pertinent information during fire suppression activities, and 3) developing information and guidelines on drought and climate adaption to manage sagebrush ecosystems. Similar to the original report in 2013, the WG identified the Top 5 gaps that need focused attention. These gaps have been placed in priority order based on a vote by the WG. The WG did not, however, prioritize the remaining 7 gaps (with associated sub-gaps). Rather, the WG suggests that the agencies prioritize these gaps based on the significance and the ability of the agency to affect change, the importance of the limiting factors, available funding, current work, and the ability to leverage resources, as well as the various agency roles and responsibilities, etc. Moreover, this update should be considered a "work in progress." As activities directed to the management and conservation of the Sagebrush Biome and GRSG progress, additional gaps will be resolved and new gaps and understanding of how best to manage this complex ecosystem will certainly emerge. Thus, the WG recommends that a periodic update (3-5 years) of this report be conducted as a reflection of the successes and as an opportunity to learn from the failures, which can also serve as a guidepost for future direction.

prevention, suppression, and fuels management for GRSG; seeding strategies; range-wide geospatial analyses and mapping; short and long-term fire effects on GRSG and habitat; and drought and climate adaptation. Where appropriate, the report provides an overview of what remains to be done and offers recommendations for action to improve the conservation and management of the Sagebrush Biome.

The WG found that all of the original gaps were still pertinent today and their resolution can help address the ongoing challenges identified in the original report (e.g., policy, fiscal, and science challenges that land managers encounter related to the control and reduction of the invasive annual grass/fire cycle). However, three additional gaps, labeled NEW, need to be addressed, including: 1) acknowledging the lack of program capacity and structure for invasive plant management, 2) expanding the use of

TOP 5 GAPS

1. CAPACITY AND STRUCTURE FOR INVASIVE PLANT MANAGEMENT (*NEW*)

The lack of program capacity and necessary structure for invasive plant management at all levels of government (county, state, federal, and tribal) – specifically, the severely limited capacity for invasive plant prevention, early detection and rapid response, control and management, regulatory activities and associated native plant restoration operations – is directly tied to the lack of common priorities for place-based conservation and consistent long-term dedicated (line-item) funding for invasive plant management programs. Invasive plant infestations in the West, particularly in the range of the GRSG, have reached enormous levels with estimates of invasive annual grass and perennial forb infestations at more than 100 million acres of public and private lands. The cost of managing these infestations increases annually commensurate with the nearly exponential annual increases in their spread across the landscape. As weed infestations increase and spread across the landscape, the funding appropriated/allocated each year in government programs is often barely enough to cover base salaries, with little room for program advancement to address the growing threat from invasive plant infestations. On private lands, the financial situation is more acute, with few landowners having the funding flexibility to effectively prevent and control invasive plant species threatening their lands each year. It is commonly held that most invasive weed management programs are addressing less than 10% of the average infested acres, while the annual rate of spread of invasive plants, can range from 15-35%. Lack of effort is due almost entirely to lack of capacity, not expertise. Although efficiencies are being achieved within current funding limits, diminishing returns and decline in effectiveness when trying to address the invasive plant species problem with less than adequate capacity and funding. One of the top priority actions carried forth from the 2015

TOP 5 GAPS

1. CAPACITY AND STRUCTURE FOR INVASIVE PLANT MANAGEMENT (*NEW*)

2. LONG-TERM RESTORATION FUNDING

3. SEED AVAILABILITY AND RESTORATION METHODS

4. PUBLIC INVOLVEMENT

5. LIVESTOCK GRAZING

Western Invasive Weed Summit emphasized the need to secure higher levels of funding obligated directly for invasive weed management programs at all levels of government (county, state, federal and tribal). The funding currently provided at most levels is often discretionary funding integrated within other resource management programs, and appropriated at relatively low levels on an annual basis. Making long-term commitments and planning for multi-year invasive plant management activities is almost never an option for resource managers due to the inconsistency of annual appropriations, leaving programs for weed prevention, control and subsequent site restoration in a precarious and unpredictable position from year-to-year. Few programs at the federal level have enough direct (line-item) funding exclusively for invasive plant management and rely on funding pulled from other resource programs (e.g., rangeland management, recreation, forest management, wildlife and fisheries management, fire management, etc.). Similarly, states and many counties have consistently indicated the struggle with funding invasive plant management programs; often using a variety of funding mechanisms they may have available such as direct appropriations, taxes and fees, trust funds, grants, etc. to operate weed management programs. As federal funding for invasive plant management on public lands declines, the burden for management operations is sometimes shifted to state and county programs to address. Many federal programs rely on contracts with county or state weed management offices to conduct the work on federal lands, due to lack of capacity with

existing funding and shifting priorities from other areas and land ownerships.

Most state invasive plant or noxious weed programs reside within their respective Departments of Agriculture and often focus on

> *"One of the top priority actions carried forth from the 2015 Western Invasive Weed Summit emphasized the need to secure higher levels of funding obligated directly for invasive weed management programs at all levels of government (county, state, federal, and tribal)."*

education and regulatory activities. Regulatory programs for invasive plants are mandated to prioritize actions against species listed on federal or state noxious weed lists under state or federal law. Funding for weed management tends to be prioritized for use against regulated noxious weeds in many county and state programs and some areas within the federal sector. Since many invasive plants are not listed as noxious weeds, they do not get prioritized for management action, and it may be difficult to allocate funding to address them if the money is legally intended only for "regulated" species. Management activities against invasive plants not listed as regulated noxious weeds, no matter how much of an environmental or economic risk, are often not funded at the same level as the regulated noxious weed species. In these cases, it is critical that new funding, without such limitations, be made available for state programs to address non-regulated species.

The Western Association of State Departments of Agriculture is leading the joint state-federal effort to develop the "Western Invasive Plant Management: An Action Plan for the Sagebrush Biome," that includes a set of priority action items (including sub-actions and timelines) to

address the major barriers associated with the lack of adequate and consistent funding for invasive plant management at local, state, and federal levels.

2. LONG-TERM RESTORATION FUNDING

Land management agencies need a long-term pre- and post-fire restoration funding initiative to secure dedicated funding to ensure that appropriate fuels/vegetation management can be accomplished to restore sagebrush ecosystems following wildfire. Due to the variability in annual precipitation in arid sagebrush ecosystems, multiple interventions over several years are often required to successfully restore or rehabilitate the site following a wildfire event. In other cases, specific restoration needs may be difficult to identify until a sufficient window of time has passed to identify the outcomes of natural recovery processes. In 2013, policies limited the use of federal fire rehabilitation funding following wildfire to three years and the policy included limitations on funding habitat restoration. Beyond three years, restoration needs and responsibilities may potentially be funded through resource programs (e.g., vegetation, wildlife, watershed, etc.). However, these funds were not increased to accommodate the additional restoration needs following wildfire.

The result was, and continues to be, lost opportunities to restore GRSG habitat following wildfires that were becoming larger and more frequent across the Sagebrush Biome. Land managers need policies that are less rigid and more ecologically responsive over several years to loss of sagebrush habitat after wildfires. One way to accomplish this objective is to establish a dedicated funding source that provides adequate funding for fuels management and post-fire restoration of sagebrush habitat without drawing from existing fire, fire rehabilitation, and resource programs.

UPDATE
Since the publication of the original Gap Report (Mayer et al. 2013), steps have been taken to bolster resources and modify policies to support pre- and post-fire activities by both state and federal agencies. Moreover, land management agencies have adopted many of the decision support tools developed by the WG and many other organizations (federal and state agencies, NGOs, universities, etc.) to help guide effective post-fire restoration, as well as pre-fire fuels management, planning and field implementation. In addition to these efforts, the Department of the Interior (DOI) established the Rangeland Fire Task Force in 2015 to ensure that land managers and other interested parties have access to the information needed to develop a

MALE SAGE-GROUSE ON LEK

PHOTO CREDIT: WYOMING GAME AND FISH DEPARTMENT

science-based approach to conserving sagebrush ecosystems, implement appropriate grazing practices, protect GRSG habitat, reduce the threat of wildfire and invasive grasses, and restore degraded areas. This effort resulted in the development of the IRFMS" (IRFMS; USDOI 2015), the "IRFMS Actionable Science Plan (IRFMSASPT; USDOI 2016)," and the "Science Framework for Conservation and Restoration of the Sagebrush Biome: Linking the Department of the Interior's Integrated Rangeland Fire Management Strategy to Long-Term Strategic Conservation Actions" (Science Framework; Chambers et al. 2017a).

While these efforts are improving fighting wildfires and conducting restoration activities, there is still no long-term durable commitment of funds for restoration efforts. Additionally, sufficient attention needs to be paid to the prevention, management, and control of invasive annual grasses before, during, and after fire. Until the invasive annual grass threat is

adequately addressed and effectively made part of any resource management activity, the battle with the pervasive wildfire cycle in the sagebrush ecosystem will continue, especially in the Great Basin.

The budgets for Emergency Stabilization (ES) and Burned Area Rehabilitation (BAR) are tied to the 10-year rolling suppression expenditure average, and 5 year rolling average acres burned, respectively. While they are meant to capture the general trends in fire season costs and acres burned, these formulas do not capture the year-to-year variability. As a result, budgets are commonly above or below what is needed by agencies in a given year, which leads to both carryover and deficits in funding. A more flexible budget process that is responsive to year-to-year variation/fluctuations is needed. The IRFMS (USDOI 2015) emphasized the importance of multiple interventions to ensure treatment success in post-fire landscapes; there was no commensurate increase in budget. Consequently, these policies heightened expectations for improved Emergency Stabilization and Rehabilitation (ESR) success while not increasing available funds. The DOI made significant strides in modifying funding policies to ensure that restoration funds allocated, but not used in a Fiscal Year (FY), could be rolled over and used the following FY (s). The DOI extended the timeframe for funding ES from 1 to 2 years (in certain circumstances) and BAR funds may now be applied for up to 5 years as described in the OWF Policy Memorandum 2016-01 Post Wildfire Recovery Program and Policy Changes and BLM Instruction Memorandum NO. 2016-083, DOI Policy Changes for Post Fire Recovery Programs (e.g., ES and BAR). As a result of more recent policy changes, certain funds may actually not be carried over from year to year and will be reprioritized by the DOI on an annual basis (see DOI OWF Policy Memorandum 2017-009). There are still opportunities to increase connection

GAP 2 UPDATE

» **Bolster resources to support pre- and post-fire activities**

» **Land managers have adopted decision support tools developed by the Working Group to help guide effective pre and post-fire restoration**

» **DOI establishment of the Rangeland Fire Task Force**

» **Development of the Integrated Rangeland Fire Management Strategy**

» **DOI extended the timeframe for funding ES from 1 to 2 years**

» **BAR funds may now be applied for up to 5 years**

between pre-fire and post-fire treatments both through financial responsibility and also consideration of various interests or concerns of multiple programs. For example, multiple species considerations, risk of increasing invasive annual grasses, adequate coordination with livestock operators, and consideration of free-roaming equids should be part of the discussion.

3. SEED AVAILABILITY AND RESTORATION METHODS

There is no program in place (e.g., a restoration account) that reliably provides sufficient native seed that can be appropriately matched to site conditions at any given time. Current post-fire rehabilitation policies and procedures create an artificial "boom or bust" seed availability situation tied to acreages burned by wildfires each season. This "boom and bust" cycle is a disincentive to the private sector to develop existing businesses or start new seed companies that can consistently produce the full range of species at the desired quantity in any given year. All of these factors contribute to an inadequate seed supply in big wildfire years. Also, current policy dictates that post-fire restoration be limited to one opportunity following the fire, ignoring the vagaries of annual precipitation and the need for a longer term approach to restoration of native plant communities.

In addition, seeding methods, seed mixes, and equipment used for post-fire rehabilitation or habitat restoration have not been adequately updated or developed to improve native plant establishment, especially on lower R&R sites. Some equipment and seeding technology issues are being addressed, such as coating seed to improve the success of native seedings but need further testing. Development of these types of innovative approaches needs to be accelerated with additional resources.

UPDATE

The National Seed Strategy for Rehabilitation and Restoration (Seed Strategy; PCA 2015) is led by the BLM in cooperation with federal and non-federal partners. Seed strategy actions are centered among four major goals: 1) identifying, quantifying, and meeting seed needs, 2) undertaking research and improving technologies for seed production and use, 3) developing tools for land managers, and 4) ensuring good communication. Full implementation of the Seed Strategy (PCA 2015) will require strong executive leadership support, staff coordination among public agencies and private businesses, and sustained/dedicated financial support. It provides an excellent

SILVER SAGEBRUSH SEEDS

PHOTO CREDIT: BLM CA370, SEEDS OF SUCCESS

opportunity for demonstrating strong public-private partnerships with long-range plans to provide seeds, increase seeds, sell/purchase and store/distribute seeds for site-identified native seeds for appropriate seed zones.

Increasing the number of native plant species available on the commercial market is crucial to implement rehabilitation and restoration projects that utilize genetically appropriate native seed. Although much research and development has been directed to the Great Basin, through the Great Basin Native Plant Project (GBNPP), it is important to also expand efforts to the eastern portion of the GRSG range. Seeds of Success (SOS) is the national native seed collection program, led by the BLM in partnership with a variety of federal agencies and non-federal organizations, to collect wildland native seed for research, development, germplasm conservation, and ecosystem restoration. Ensuring that there are dedicated funds for SOS and seed-collecting teams and that these teams are located throughout the range of GRSG is crucial for native plant materials development. Providing genetic variation and seed transfer guidance, through research that develops seed zones, is another critical aspect of achieving success. Empirical seed zones have already been developed for some Great Basin native perennial grass species (e.g., bluebunch wheatgrass (*Pseudoroegneria spicata*), Indian ricegrass (*Achnatherum hymenoides*), and Great Basin wildrye (*Leymus cinereus*), but more research is needed to develop these for additional species, especially native forbs. Federal and state seed storage facilities have been established (e.g., Ely, NV and Boise, ID). Forecasting future seed needs, developing indefinite delivery and indefinite quantity (IDIQ) increase contracts, implementing seed transfer guidance, and providing source identified seed, among others, are ways to streamline and improve the use and purchasing of genetically

appropriate native seed through the warehouse system.

Success requires an unprecedented level of collaboration. The Plant Conservation Alliance, a network of more than 350 public and private partners, developed the Seed Strategy (PCA 2015) as a framework for tribal, state, federal, local, and private partners. Expansion and

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GAP 3 UPDATE

- » **The National Seed Strategy for Rehabilitation and Restoration is being led by the BLM**
- » **A need to increase the number of native plant species available on the commercial market**
- » **Ensure there is adequate funding for the Seeds of Success program**
- » **Streamline the process for purchasing genetically appropriate native seed**
- » **A need for expansion and addition of new partners among the private and public sector**
- » **Seed harvest programs need continual funding**
- » **Continue sagebrush seedling transplant research**

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addition of new partners among the private and public sector will accelerate the pace and scale of genetically appropriate native seed available for restoration. An example of this partnership is in Oregon, where research by the USFWS and USDA Climate Science Hub has provided funding to support the Oregon Tribal Nursery Partnership. This project partners with the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and Burns-Paiute Tribe to propagate locally-sourced, seed-zone specific,

native sagebrush-steppe revegetation materials (seed and rooted-stock, containerized plants) for private landowners enrolled in Candidate Conservation Agreements with Assurances (CCAAs). Under their site-specific plans, landowners can acquire revegetation and restoration materials to support a wide variety of conservation measures, all of which are grown via this unique partnership with Oregon Tribal nurseries. Materials grown in FY16 were used to expand inventory and establish a native grass and forb seed bank that will support future planting, as enrollment in the GRSG CCAAs continues to increase in Oregon.

In 2010, the BLM's Shoshone Field Office began participating in the SOS program and is now in the process of increasing several different species of plants for use in restoration and rehabilitation of rangelands with locally-sourced

SILVER SAGEBRUSH

PHOTO CREDIT: BLM WY050, SEEDS OF SUCCESS

plant materials. The BLM's Upper Snake Field Office is working to ensure the right seed is harvested by designating sagebrush seed collection areas where sagebrush subspecies have been confirmed. The BLM and state agencies are also actively using locally sourced and identified seed through interagency agreements with Lucky Peak Nursery in Boise, Idaho. The BLM formed a partnership with the Institute of Applied Ecology to train prisoners to grow sagebrush plants for transplanting after wildfires on GRSG habitat. This program uses seeds collected by BLM near these fires to insure the correct genotypes are grown. As of November 2017, this program's funding is in jeopardy. Programs such as this should be supported and encouraged.

Additional research has been initiated to examine the effectiveness of using sagebrush seedling transplants versus seeding to improve restoration success. Results of scientific studies are expected in 2018. One program that is growing sagebrush seedling transplants is the "Sagebrush in Prisons Project," which is a collaborative project between BLM, the Institute for Applied Ecology (IAE), and the Sagebrush in Prisons Project (https://appliedeco.org/programs/sagebrush/). The program teaches inmates how to seed and grow a variety of sagebrush species that are planted on BLM-administered lands affected by wildfire, to help restore habitat for wildlife, especially the GRSG. The project started in 2014 with 20 inmates at one prison in Oregon and has expanded to 175 inmates growing sagebrush in 11 prisons across 6 western states. Work in this area and this program should be continued.

Research and development of prescriptions, strategies, and technologies to improve the success of seeding should be pursued. This includes techniques such as seed coatings and other seed amenity approaches that have the potential to maintain seed viability, optimize

germination timing, and improve overall establishment success. Development of demonstration areas, manuals, publications, and websites to facilitate application of research results to agency staff and the public is an important component of this research.

4. PUBLIC INVOLVEMENT

A. COOPERATIVE WEED MANAGEMENT AREAS (CWMAS)

Cooperative Weed Management Areas have been established in many areas in the Sagebrush Biome to address management issues with invasive plants. However, additional CWMAs need to be established across the Sagebrush Biome, as there is not range-wide coverage.

UPDATE

The National Fish and Wildlife Foundation (NFWF), in cooperation with the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) have established the Pulling Together Initiative (PTI) grant program for the purpose of encouraging the development and sustainability of CWMAs across the United States. Funding from this NFWF grant program has declined drastically over the years, as the original partner organizations and agencies declined to participate. To date, only three federal agencies remain as partners in the PTI program; U.S. Forest Service (USFS), USFWS, and the BLM, which provide the only funding for this grant program. This is the only formal, national CWMA support mechanism available. If all federal agencies were brought back to the collaborative table, additional funding for CWMAs could be built into the process. In areas where they are established, not all the CWMAs have been universally included in setting wildland fire and invasive plant management, planning and

restoration priorities. In many locations CWMA membership is difficult because of financial limitations across land ownerships. Participation is on a volunteer basis, and success depends on sharing limited resources and information. In some cases, there are policy and procedural roadblocks to writing agreements with the CWMAs and transferring federal or state dollars to either the group or individual members within the CWMA. Flexibility to use appropriate funds on the landscape is critical. Therefore, it is important that multiple federal agencies be able to use common Cooperative Agreements and Memorandums of Understandings to reduce the complexities and redundancies the CWMAs face when writing agreements for procurement, transfer of funds, and other common business practices.

The definition of a noxious weed or list of regulated species varies between states and the federal government. Selected species are regulated nationally through USDA-APHIS by prohibiting the importation and interstate movement of federally listed noxious weeds. Each state identifies noxious weeds as directed by their state law. As a result, invasive plant species may be on one state list and not on another. Generally, each state may have restrictions for use of appropriate state funding

"Flexibility to use appropriate funds on the landscape is critical."

for the treatment of only state-listed noxious weed species. This affects how a state can address specific invasive plant species, like cheatgrass, because with the exception of Colorado, cheatgrass is not listed as a state noxious weed species. Moreover, there are often different treatment priorities for invasive plant species management locally and/or regionally, but result in inconsistent management effort across the landscape. Over time, this leads to

inconsistent results or no action at all. There is also not a common approach to the tools available to fight invasive plants. For example, the use of various herbicides that are known to be effective in fighting invasive plants, such as cheatgrass, are not universally available for use across state lines and/or jurisdictions. The State Departments of Agriculture and federal agencies responsible for invasive and noxious weed management should work together to clarify these regulatory discrepancies and develop a system that facilitates a unified approach and coordinated funding for common priorities to effectively combat these invasive plant species. Including CWMA's into this process would help facilitate a cohesive solution to this gap.

B. RANGELAND FIRE PROTECTION ASSOCIATIONS (RFPAS)

Rancher, private landowner, and agency (local, state, and federal) fire management coordination (e.g., RFPAs) is being implemented in selected areas across the Sagebrush Biome to improve initial attack on wildfires. These efforts

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GAP 4 UPDATE

» **Additional funding for Cooperative Weed Management Areas is needed**

» **Definitions of a noxious weed or list of regulated species varies between states and the federal government which affects how states can address specific invasive plant species**

» **Different treatment priorities for invasive plant species management locally/regionally results in inconsistent management across the landscape**

» **Expand Rangeland Fire Protection Associations to all sagebrush states**

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are important components in habitat conservation and should be implemented across the range of GRSG as training and safety requirements allow.

UPDATE

Rangeland Fire Protection Associations have been established in Idaho, Oregon, and Nevada with great success. The BLM has added a full-time RFPA Coordinator position to help direct and guide the program. While the program has been established in some states, all sagebrush states should adopt similar programs when possible and should be encouraged to remove legal barriers that prevent them from establishing such associations. The BLM is presently seeking an avenue to strategically place firefighting assets with local cooperators (e.g., RFPAs and Rural Fire Departments) that routinely respond to fires on DOI-managed lands. Leveraging the knowledge, resources, and the ability for a quick response of the local private landowner is key to fighting destructive wildfires that have become common in the Great Basin (and not infrequent elsewhere).

In addition to RFPAs, the BLM Fire and Aviation uses several authorities to hire veterans for wildland fire positions. The partnership with Team Rubicon (TR), a non-profit veterans organization, began in 2015 and continues to grow. Team Rubicon brings together veterans seeking a sense of purpose, community, and identity often missing following their military service. In addition to TR, the BLM also has formed partnerships with Hire Hero's USA, a non-profit employment organization to expand veteran crews and recruiting efforts and Mission 43, a partnership of the J.A. and Kathryn Albertson Family Foundation. These veterans provide additional resources to accomplish vegetation management work and support the suppression of wildland fires threatening sagebrush ecosystems. This effort is

complementary to the goals and actions of the RFPAs.

5. LIVESTOCK GRAZING

There is insufficient information, policy, and administrative support to: 1) determine the appropriate time-frame for removal or reduction of livestock grazing to promote ecosystem recovery after wildfire and rehabilitation/ restoration treatments, 2) determine the utility of using livestock grazing to reduce fine fuels in wildfire prone habitat, and 3) ensure that existing livestock grazing is managed to promote R&R within the understory vegetative community before a fire occurs. This issue is compounded by:

» The lack of rigorous/credible studies on the longer-term effects of grazing by livestock, and free-roaming equids on post-fire rehabilitation and GRSG habitat, under various grazing systems (e.g., season of use, distribution, intensity of use, kind of use).

» Institutional barriers and funding limitations that block or hinder the implementation of necessary management changes/strategies on the ground.

» The lack of rigorous/credible studies on the effectiveness of targeted livestock grazing to reduce fine fuels where invasive annual grasses, such as cheatgrass, are dominant, especially in low elevation big sagebrush communities (*A. tridentata*) but also in other more mesic sagebrush communities where native plants dominate. Studies and pilot projects are needed to evaluate livestock as a fuels management tool at larger scales and to

determine the short and long-term environmental impacts relating to this potential tool.

» The inability to manage free-roaming equids at Appropriate Management Levels (AML).

UPDATE
A number of grazing studies have been completed or are currently underway (e.g., Diamond et al. 2009, Davies et al. 2015, 2016, 2017) since the publication of the original Gap Report (Mayer et al. 2013). The BLM has formed a "Targeted Grazing Team" to initiate demonstration areas and develop guidelines for using targeted livestock grazing to strategically reduce fine fuels as part of the implementation of the IRMFS (USDOI 2015). Additionally, the BLM is testing Outcome Based Grazing Authorizations as another potion to deduce invasive annual grasses and promote desirable species at the pasture and allotment level. The Team is compiling scientific publications relating to grazing and has posted the citations on the Great Basin Fire Exchange website (greatbasinfirescience.org). Additionally, an Environmental Assessment (EA) has been approved to conduct targeted grazing as an experimental fuel break on the Soda Fire in Idaho. A web-based "guidebook" to support these activities will be developed before the end of 2018. The Targeted Grazing Team has assisted in developing the "Elko Pilot Targeted Fuels Project," which is currently underway. Moreover, the BLM, together with Agricultural Research Service (ARS), is also evaluating additional proposals to collect monitoring data to evaluate the effectiveness of targeted grazing. In late spring 2017, the Team's work was temporarily halted due to other priorities and procurement issues. There is a need to re-form this Team and move forward with their goals and studies conducted by ARS, in

addition to proposals to collect monitoring data to evaluate the effectiveness of the treatments.

Universities (i.e., University of Nevada, Reno; Utah State University) and private collaborators have established seven demonstration ranches in Nevada, Oregon, and Utah to evaluate the effects of late fall season grazing and supplements on: 1) cheatgrass and/or medusahead wildrye (*Taeniatherum caput-medusae*) that function as fuels, and 2) cattle productivity. While these efforts are much needed and an excellent beginning, they will

benefit from consistent approaches that consider different ecosystem types, different types of grazing (rate, frequency, and timing) and economic efficiencies and that use consistent protocols for implementing treatments, replication, data collection, and analysis and reporting of data. If targeted grazing is shown to be effective, guidelines will need to be developed that consider interactions with free-roaming equids and other wildlife species (e.g., pronghorn [*Antilocapra Americana*], mule deer [*Odocoileus hemionus*]), as well as identifying the linkages to climate and restoration activities.

The USFWS has established a Sagebrush Ecosystem Grazing (SEG) Team with the purpose of developing consistent yet flexible recommendations to assist in the development, review, and/or implementation of federal, state and private land management plans. The recommendations are designed to address the impacts of improperly managed grazing from livestock and free-roaming equids on the sagebrush ecosystem, while working in a collaborative fashion with all involved partners. The SEG Team, in collaboration with the USFWS Invasives/Fire/Restoration Team, is currently working to apply remote sensing to assist in the development of appropriate thresholds to help better predict years of high production of fine fuels production that may trigger the need for targeted grazing to reduce wildfire risk. The Team is identifying an area in Southeast Oregon to expand upon the work completed by Boyte et al. (2017) in 2015 and 2016. This area will be paired with long term plot data that measured production from 2003-2012. The end goal of this project will be a retrospective look in time and identify precipitation and production patterns that result in high fine fuel loading so that land managers would have advance warning to adaptively manage fine fuels using livestock. There should be increased emphasis on the effects of both pre- and post-fire grazing to help

GAP 5 UPDATE

» **Additional gazing studies have been completed or are underway since the original Gap Report**

» **The BLM has formed a Targeted Grazing Team to initiate demonstration areas and develop guidelines for using targeted livestock grazing to strategically reduce fine fuels**

» **Universities and private collaborators have established seven demonstration ranches in Nevada, Oregon and Utah to evaluate cheatgrass and/or medusahead wildrye and cattle productivity**

» **The USFWS has established a Sagebrush Ecosystem Grazing Team with the purpose of developing consistent yet flexible recommendations to assist in the development, review, and/or implementation of federal, state and private land management plans**

» **There should be increased emphasis on the effects of both pre- and post-fire grazing to help better manage fuel reduction, fire rehabilitation and restoration activities**

better manage fuel reduction, fire rehabilitation and restoration activities. It is essential that the underlying components and processes of effective grazing management be recognized, understood, and documented and that guidelines be developed and distributed to the agencies and private landowners.

With respect to free-roaming equids, more rigorous/credible studies regarding their effects on fire rehabilitation and restoration activities and the spread of invasive plants are needed. Information on interactions of free-roaming equids with livestock and sagebrush dependent wildlife species is also needed. In the absence of effective wild horse and burro population control, it will likely be necessary to reconsider prioritization of post-fire restoration as well as conservation actions to ensure that the effects of these actions will not be negated by wild horse and burro use (Griffin et al. work in progress).

CATTLE GRAZING IN SAGEBRUSH HABITAT

PHOTO CREDIT: WYOMING GAME AND FISH DEPARTMENT

ADDITIONAL GAPS

In the 2013 Gap Report (Mayer et al. 2013), the WG identified and discussed 17 gaps in addition to the top five. For this updated report, the WG reorganized this section and combined gaps where overlap occurred or divided gaps where appropriate. The result of this effort is the reorganization of the gaps based on seven themes: importance of the Sagebrush Biome; resource management, policy, and decision-support tools; wildland fire; seeding strategies; range-wide ecological mapping; short- and long-term fire effects on GRSG and sagebrush habitat; and drought and climate adaptation. The gaps described below, are not prioritized and were identified as needs across federal and state programs, funding, policy, implementation, science and monitoring.

1. IMPORTANCE OF THE SAGEBRUSH BIOME

Historically (prior to the 1970s), sagebrush was considered an undesirable plant given its lack of palatability to livestock resulting in limited conservation (funding, management, policy, etc.) at all levels of government (federal, state, and local). Increases in internal and external communications and educational efforts need to continue about the importance of sagebrush ecosystems and the wildlife habitat and associated species that the Sagebrush Biome supports.

UPDATE
Addressing this gap has been an integral part of sagebrush conservation efforts for many state and federal agencies. It is critical these efforts continue and are expanded to recognize all sagebrush habitat types in the Sagebrush Biome. The Great Basin Fire Science Exchange is the primary source of information identified in the IRFMS (USDOI 2015) and is providing webinars, access to key resources and other educational materials throughout the Great Basin. Also, the Intermountain West Joint Venture (IMWJV), USFWS, BLM and others are working to implement the Sagebrush Ecosystem Communication Framework. The goal of the Framework is to build upon the communication efforts related to the GRSG and other sagebrush dependent species. Finally, the SAGEWEST Listserv has been established to share all forms of information related to the sagebrush ecosystem.

The WAFWA, in concert with federal agencies and NGOs, have initiated the development of a Sagebrush Conservation Strategy. The Strategy will evaluate the degree to which GRSG conservation efforts can serve as an umbrella for other sagebrush dependent species, and assess threats to, and opportunities for, sagebrush conservation. It will serve as a road map for where and how voluntary sagebrush conservation actions can be effective in maintaining healthy human and wildlife communities dependent on sagebrush. A science-based issues assessment will serve as the basis for a collaborative engagement process with stakeholders to develop a menu of appropriate conservation and management options for management of sagebrush rangelands (public and private) at regional and local scales.

Moving forward, new communication efforts

should focus on invasive plants and the critical threats they pose to the Sagebrush Biome. Invasive plant management is challenging and efforts (communication and management) are not well coordinated and remain underfunded range-wide. There is widespread recognition that invasive annual grasses and wildland fire are the most crucial threats to the sagebrush ecosystem, yet invasive annual grass management is not funded at a level to be effective in breaking the invasive annual grass/fire cycle. Moreover, as a result of the invasive annual grass/fire cycle and various land uses, a wide variety of other invasive plants are rapidly increasing in sagebrush ecosystems (e.g., Ielmini et al. 2015). To be successful, efforts like the Natural Resources Conservation Service, Sage Grouse Initiative (NRCS-SGI), where people and proper resource management are brought together, should be developed and supported.

ADDITIONAL GAPS

1. **Importance of the Sagebrush Biome**
2. **Strategic Resource Management, Policy, and Decision Support Tools**
   a. **Consistent Frameworks and Strategies**
   b. **Adaptive Management and Implementation and Effectiveness Monitoring**
   c. **Landscape Decision Support Tools**
   d. **Management Coordination**
   e. **Conflicting Policies Among all Agencies**
3. **Wildland Fire Prevention, Suppression, and Fuels Management for GRSG**
   a. **Focused Western Rangelands Fire Protection**
   b. **Fire Prevention**
   c. **Fire Suppression**
   d. **Fuels Management**
   e. **Fire Reporting**
   f. **Wildfire Resource Advisors (*NEW*)**
4. **Seeding Strategies**
   a. **Seeding vs. Transplanting Trade-off Analysis**
   b. **Seeding Success Predictions**
   c. **Post-fire Perennial Native Plant Survival and Site Recovery**
5. **Range-wide Geospatial Analyses and Mapping**
   a. **Ecological Mapping**
   b. **Nonnative Plant Species Maps and Risk Assessments**
6. **Short and Long-term Fire Effects on GRSG and Habitat**
7. **Drought and Climate Adaptation (*NEW*)**

Finally, all constituent groups like sportsmen and women, livestock organizations, conservation focused NGO's etc., need to join in these efforts, and for current active groups, there should be more formal and public recognition of their participation and contributions.

2. STRATEGIC RESOURCE MANAGEMENT, POLICY, AND DECISION SUPPORT TOOLS

A. CONSISTENT FRAMEWORKS AND STRATEGIES

There is no biome-wide strategy to manage wildfire, invasive plants, and GRSG in which all disciplines can engage. Previously, reports and plans had been developed by specific disciplines (e.g., sage-grouse experts), which often led to misunderstanding and a lack of buy-in at all levels and across all disciplines.

UPDATE

In an effort to address this gap, the WG developed two interdisciplinary and inter-agency decision support tools using R&R ecological concepts. These included "Using resistance and resilience concepts to reduce impacts of annual grasses and altered fire regimes on the sagebrush ecosystem and sage-grouse–A strategic multi-scale approach" (Chambers et al. 2014a) and its companion publication "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" (Chambers et al. 2016). A third tool, the Science Framework (Chambers et al. 2017a, Prentice et al. work in progress) was developed by U.S. Forest Service, DOI, and WG members and brought together the two earlier WG products into a single, cohesive biome-wide document and updated the science and datasets. Part 1 of the Science Framework focuses on the science basis and applications

and was published in 2017; Part 2 focuses on the management applications and will be published in 2018.

To implement the decision support tools developed by the WG, a core set of geospatial data, maps, and models on GRSG populations, vegetation cover, ecosystem threats, and soil temperature and moisture regimes characterized according to R&R were developed. These are available to the agencies and public through the U.S. Geological Survey (https://www.sciencebase.gov/catalog/item/576bf69ce4b07657d1a26ea2) and BLM Landscape Approach Data Portal (https://landscape.blm.gov. These tools are being used by public and private partners to help prioritize conservation, management, and restoration actions for sagebrush ecosystems and GRSG

THREE SUPPORT TOOLS

» **"Using resistance and resilience concepts to reduce impacts of annual grasses and altered fire regimes on the sagebrush ecosystem and sage-grouse–A strategic multi-scale approach" (Chambers et al. 2014a)**

» **"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" (Chambers et al. 2016)**

» **Science Framework (Chambers et al. 2017a, Prentice et al. work in progress) Part 1 of the Science Framework focuses on the science basis and applications and was published in 2017; Part 2 focuses on the management applications and will be published in 2018**

FIELD MONITORING AND ASSESMENTS

PHOTO CREDIT: WYOMING GAME AND FISH DEPARTMENT

habitat to determine effective management strategies. To apply the tools more broadly, models and spatial information similar to what is available for GRSG is needed for other species at -risk within the Sagebrush Biome.

The concepts and approaches in the WAFWA – Led work were incorporated into the DOI-led IRFMS (USDOI 2015). The IRFMS provides information and approaches that can be used to inform decision-making and implementation of wildfire suppression activities across the Sagebrush Biome. Also, two new chapters were added to the DOI's Departmental Manual that formalize the landscape approach to land management and the collaborative, science–based approach to activities within the sagebrush ecosystem (Part 604 DM 1, Implementing Landscape-Level Approaches to resource Management and Part 604 DM 2,

Conservation and Restoration of the Sagebrush Biome were approved on January 19, 2017).

Fire and Invasives Assessments (FIAT) that used the approaches developed in the WG publications for the eastern and western parts of the Sagebrush Biome were conducted by both the BLM and USFS to assess and prioritize GRSG habitat for management. In the western part of the Sagebrush Biome, the BLM has used this approach to develop an Integrated Program of Work (IPOW) for conserving and restoring GRSG habitat. This approach has yet to be implemented by the BLM in the eastern part of the Sagebrush Biome. Also, the USFS has yet to implement the FIAT effort in a consistent manner. The FIAT efforts need to be updated regularly to respond to new data/information and accomplished projects.

The WG has developed generalized ecological types and state-and transition models (STMs) characterized according to their resilience to disturbance and resistance to invasive annual grasses for the range of environmental conditions in both the eastern and western portions of the Sagebrush Biome (Chambers et al. 2014a, 2016, 2017a). These STMs relate directly to R&R as indicated by the mapped soil temperature and moisture regimes and to GRSG habitat as indicated by breeding habitat probabilities (Doherty et al. 2016). They use standard interagency protocols and provide information on the alternative states, ranges of variability within states, and processes that cause plant community shifts within states as well as transitions among states. Examples of how to use these resilience-based ecological types and STMs for managing ecosystem threats across the Sagebrush Biome are in the Science Framework (Chambers et al. 2017a). Information on how to use resilience-based ecological types and STMs for selecting appropriate treatments in sagebrush and juniper *(Juniperus spp.)* and piñon *(Pinus spp.)* ecosystems in the Great Basin are in Miller et al. (2014) and for assessing post-wildfire recovery and restoration decisions see Miller et al. (2015) and Pyke et al. (2015a, b, 2017), respectively. Additional work is needed to develop and maintain an effective education program for the management community on using strategic, multi-scale approaches for maintaining sagebrush ecosystem resilience to disturbance and resistance to invasive plants.

B. ADAPTIVE MANAGEMENT AND IMPLEMENTATION AND EFFECTIVENESS MONITORING

Institutional and cultural barriers limit the ability to re-think on-going management and thus successful adaptive management. There is also a lack of adequate funding and commitment for long-term implementation and effectiveness monitoring of fire rehabilitation, fuels management, invasive plant species management, and restoration treatments.

"Institutional and cultural barriers limit the ability to re-think on-going management and thus successful adaptive management."

UPDATE

Federal agencies mainly design business practices for land management planning and projects around implementing the National Environmental Policy Act (NEPA). While NEPA applies to all federal agencies, each agency and office has its own unique approach to implementation. This can create issues, especially where jurisdictions adjoin. For example, two adjoining BLM field districts will use different data and methods in NEPA analyses that may result in different land management decisions. Federal agencies and states need to continue to work together to resolve these issues, especially when it involves being adaptive. Having an effective monitoring program that is coupled with an adaptive management process/program is key to being able to adjust to new and emerging science and changing environmental conditions. The necessary direction/policy for implementing adaptive management or a system that encourage adaptive thinking and/or action is also lacking, and is constrained by institutional and policy constraints. A review of these agency policies and other barriers that hinder adaptive management should be initiated to identify and change, if appropriate, those constraints. There is a clear recognition of the need to monitor to determine when and where

treatments are successful and to provide data to guide adaptive management. The commitment to long-term monitoring to ensure that post-treatment management activities (e.g., livestock grazing, off-road vehicle use, etc.) are not negatively affecting the sustainability or value of treatments is often neglected. Moreover, there is a lack of specific policy direction and little dedicated funds to collect monitoring data from all treatment types and by all agencies. This is especially pronounced for long-term monitoring data collection activities. The lack of standardized and agreed upon protocols and

"Without a firm commitment to an investment in monitoring and adaptive management it will be difficult or impossible to succeed in providing long-term conservation and productivity of the Sagebrusch Biome."

databases within and between federal and state agencies limits opportunities for comparisons and combined analyses. This can result in all federal and state agencies spending more time and money to gain sufficient data to implement adaptive management. Without a focused effort mistakes will not be corrected, emerging problems will be unrecognized, and learning from success stories will be limited. Without a firm commitment to an investment in monitoring and adaptive management it will be difficult or impossible to succeed in providing long-term conservation and productivity of the Sagebrush Biome.

The BLM's Assessment, Inventory and Monitoring (AIM) strategy and Habitat Assessment Framework (HAF) data are currently available for analysis, or adaptive management decision support for landscape scale monitoring of current conditions. Often

management, especially invasive plant species management, is conducted at the local scale that requires a much finer resolution of data to determine effectiveness and over multiple years, pending consistent treatment of follow-up seeding. Reliable funding is still needed for both short- and long-term monitoring at all levels of management. Additionally, while actions have been initiated, more effort is needed to coordinate monitoring activities, expand the science of monitoring, and the use of remote sensing. Expansion and coordination of monitoring among agencies at multiple spatial scales is needed, along with linking those efforts from the site level to landscape scale. Crosscut Task #3 of the IRFMS (USDOI 2015), directed a group to pull together such an effort, but it lacked support among all DOI agencies. This group should continue to move forward and those participating agencies should implement common protocols and databases to demonstrate the strength that may be gained via such an approach.

The intensity and extent of natural and anthropogenic impacts that are detrimental to sagebrush ecosystems are thoroughly documented in many instances. However, conservation actions and their effectiveness to address these impacts are usually poorly documented. Even when conservation actions are documented, it can be difficult to determine the short- and long-term effects on GRSG, sagebrush-dependent species, or their associated habitats if there is a lack of post-action monitoring. The Conservation Efforts Database (CED) was co-developed by the USFWS, USGS, and the Great Northern

Landscape Conservation Cooperative (GNLCC) to enable partners to collect and organize information related to conservation actions and summarize post-action effectiveness across the Sagebrush Biome. The CED creates a common currency from which efforts from multiple partners can be evaluated for conservation benefit. While the CED collects information associated with many impacts, including but not limited to wildfire and invasive plant species, it can be an important tool, along with scientifically rigorous post-conservation monitoring to track implementation of landscape-scale adaptive management efforts.

C. LANDSCAPE DECISION SUPPORT TOOLS

There are no objective landscape decision support tools and models to predict where or if fuel breaks and/or green-strips should be established or what Best Management Practices (BMPs) are needed to accomplish fire suppression, desired vegetation, and/or GRSG objectives.

UPDATE

The needs related to this gap have evolved based on interdisciplinary work with fire and fuels specialists. Green strips are fuel breaks with vegetation that may retain moisture year-round or at least later into the summer than native vegetation and are primarily designed to allow firefighters to actively engage in fire suppression in a safe, strategic manner (Moriarti et al. 2015). Therefore, a single objective landscape tool for predicting where to place fuel breaks, or other BMPs, may not be appropriate for suppression strategies that necessitate fire managers incorporate social, economic, and practical considerations. However, a toolbox of available information to help fire managers and

MOUNTAIN BIG SAGEBRUSH

PHOTO CREDIT: WYOMING GAME AND FISH DEPARTMENT

stakeholders weigh risks and determine where to place practices continues to expand and improve. For example, interagency fire managers now utilize GRSG priority habitat maps, R&R information, burn probability maps, and many other pieces of new information in pre-suppression planning. Also, a range-wide GRSG wildland fire risk assessment is available and links to this geospatial dataset are in the Science Framework (Crist et al. 2017b, Appendix in Chambers et al. 2017a). A new WAFWA/USFWS-sponsored product that models potential locations for regional fuel break networks provides another tool (Welch et al. 2015). The BLM has funded USGS research to identify factors for creating effective fuel break network designs that can also address potential impacts to GRSG at broad-scales (e.g., habitat fragmentation).

Rather than producing a single objective tool, the use of broad-scale datasets and maps mentioned above can help develop broad-scale fuel break network designs that can maintain wildlife habitat connectivity and provide fire suppression opportunities. This information combined with fuel break planning and/or green strips can be advanced through interdisciplinary

SPRAYING CHEATGRASS

PHOTO CREDIT: WYOMING GAME AND FISH DEPARTMENT

teams working with local stakeholders using the best available science and technical expertise to weigh risks and trade-offs of proactive fuel breaks at the local level (Maestas et al. 2016a). To assist in this effort, the USGS has conducted a synthesis of existing information on fuel break effectiveness (Shinneman et al. 2018), funded by the BLM. The USGS has also initiated a research project, jointly funded by BLM, to evaluate the effects of linear fuel breaks on GRSG populations with results expected in 2019.

The BLM issued Information Bulletin (IB) No. FA-IB-2016-014, Best Management Practices for Fuels Treatments in Sage Grouse Habitat on June 20, 2016. Section 7(b) iii #3 of the IRFMS (USDOI 2015) directs agencies to review and update current BMPs for rangeland fuels treatments to better integrate ecological R&R concepts and science, and to identify a specific suite of preferred design alternatives for fuels treatments in sagebrush ecosystems. The IB is a product of a collaborative effort among the DOI bureaus, USFS, and NRCS. The CED can also provide useful context at multiple scales as it relates to conservation planning and siting. Information in the CED can be used in conjunction with risk presence information and to provide context to where conservation actions have been and/or are being implemented.

D. MANAGEMENT COORDINATION
Historically, mid-level management/regional direction has been lacking (because of funding and political realities) regarding where and what should be done to address the wildfire and invasive plant species problem. This lack of coordinated direction has resulted in inconsistent actions on the ground and thus has, in many cases, exacerbated the fire and invasive plant species problem.

CHEATGRASS INVADED SAGEBRUSH HABITAT

PHOTO CREDIT: JENNIFER STRICKLAND, USFWS

NATIVE STATE SAGEBRUSH HABITAT

PHOTO CREDIT: JENNIFER STRICKLAND, USFWS

UPDATE

This issue has become a recognized problem within the federal agencies and as such, measures have been initiated to address this gap. For example, in FY16, the BLM began implementing an IPOW that is designed to act as a "work plan" for all levels of the organization. The IPOW is intended to ensure BLM funds projects that target the most important work for GRSG and sagebrush ecosystems by leveraging funds from several internal programs including Fuels Management, Wildlife, Riparian, Forestry, and Range Improvement programs. The IPOW also includes projects that cross BLM boundaries and incorporates partners (e.g., USFS) to achieve landscape goals, reflecting a deliberate shift from localized vegetation management to a landscape approach focused on high priority resource objectives and priority areas while striving to reduce redundant and parallel processes. The Science Framework (Chambers et al. 2017a) suggests methods for geospatial analyses, and the FIAT has been established to direct and fund locally developed and driven conservation programs in the Great Basin. Additionally, the IRFMS (USDOI 2015) has embraced the need to involve managers in the planning and implementation of these higher level-planning efforts. However, this is just the beginning and a similar process needs to be completed for the eastern portion of the GRSG
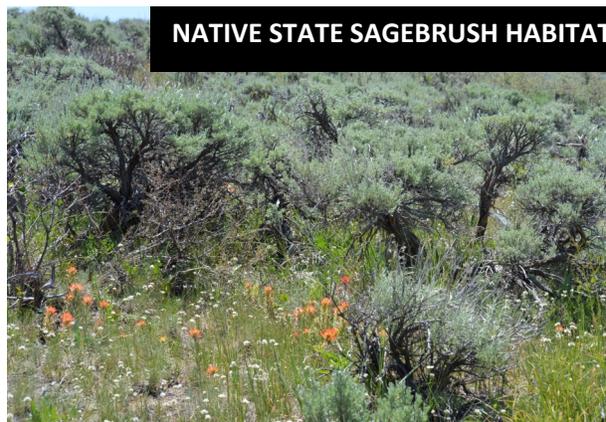
range. Also, more is needed to ensure all levels of the organizations are aware and engaged to help implement the conservation direction. Only by providing training and breaking down barriers between organizations, as well as within agencies (between and among the various departments and fields of expertise), will a shared conservation vision across the Sagebrush Biome be realized.

E. CONFLICTING POLICIES AMONG ALL AGENCIES

There are conflicting and/or differing policies between state and federal agencies that hinder initiating a cohesive and consistent approach to addressing the wildfire/invasive plant issue. Specific policies within federal agencies sometimes conflict with one another (i.e., from the Washington D.C. level to the field). Policies may seem reasonable at a regional or national scale, but sometimes conflict with realities at the field level. These conflicts occur within and between programs. An approach should be established that provides for "adaptive" policy development and implementation.

UPDATE

The need to address some of these inconsistencies was included in the report to the Secretary of the Interior in response to

Secretarial Order 3353 (Greater Sage-Grouse Conservation and Cooperation with Western States). Additional efforts have been initiated to address these issues. For example, the BLM has been working on an IPOW largely based on the IRFMS (USDOI 2015) to help address this gap. However, all federal and state agencies need to continue to identify issues and adaptively work to resolve them. Agencies need to insist on two-way communication and promote vertical communication throughout each agency. As these management efforts are being implemented on the ground, field staff need to be provided appropriate decision space to effectively deal with local realities (Boyd et al. 2014).

3. WILDLAND FIRE PREVENTION, SUPPRESSION, AND FUELS MANAGEMENT FOR GRSG

A. FOCUSED WESTERN RANGELANDS FIRE PROTECTION

Since the inception of the National Fire Plan following the 2000 fire season, fire management agencies have participated in numerous initiatives for reducing the threat of wildland fire in and around communities, typically termed the Wildland Urban Interface (WUI). Activities have included, but are not limited to: fuels reduction projects, expanded wildfire prevention and education activities, development of fire resistant construction products and methodologies, and improved wildfire suppression technology and capacity. Significant federal, state, and local funding, community involvement, volunteer labor and private sector contributions have, and continue to be utilized very successfully within the WUI. While reducing the threat of wildfire in the WUI will remain a high priority, taking a similar level of "focus" to western rangelands to protect priority GRSG habitats and other high value resource areas across the Sagebrush Biome from wildland fire is

currently a gap and a necessary next step. Consistent with the interagency National Cohesive Wildland Fire Management Strategy, designed to seek "all-lands" solutions to wildland fire management issues (e.g., the loss of critical habitat for GRSG), programs and planning efforts successfully applied in the WUI should be used across the Sagebrush Biome.

UPDATE

The IRFMS (USDOI 2015) is being supported, implemented, and expanded where appropriate across the Sagebrush Biome in both wildland fire and resource management for all federal agencies. Recent recommendations in response to SO 3353 (Greater Sage-Grouse Conservation and Cooperation with Western States) include continued DOI support for the IRFMS. In addition, the DOI's Departmental Manual includes two new chapters that address landscape scale management and collaboration. These chapters (Part 604 DM 1, Implementing Landscape-Level Approaches to resource Management and Part 604 DM 2, Conservation and Restoration of Sagebrush Biome) formalize that DOI agencies should continue a landscape approach to land management and further enhance collaborative, science–based approach to activities within the Sagebrush Biome.

B. FIRE PREVENTION

The IRFMS (USDOI 2015) highlighted the need for more fire prevention strategies and outreach/education to help reduce human caused ignitions across the Sagebrush Biome to help protect sagebrush habitats from loss due to fire, which nationally makes up a large majority of wildland fire starts.

UPDATE

Federal agencies have made efforts to address this gap through the development of the IRFMS (USDOI 2015). The BLM has allocated funding for fire education and prevention messages aimed at promoting GRSG habitat conservation,

protection, and restoration. For example, building on the "Steppe Up" Fire prevention campaign, Idaho BLM initiated the development of an Idaho BLM Junior Ranger Activity Book, Sagebrush Steppe educational cards, and Jr. Ranger patch. These products focus on the sagebrush community featuring Sammy the Sage Grouse in "Sammy's Quest to Save the West." Additionally, the BLM offices in GRSG states continued efforts initiated in 2015 with multiple comprehensive fire prevention campaigns. Multiple audio and video public service announcements (PSAs) were developed and aired on television and radio stations, as well as

"Benefits of fire suppression for sagebrush-dependent species can be measured, but information on the impacts those fuels treatments or fuel breaks have on sagebrush-dependent wildlife and native plant species is lacking."

placed on social media and websites. Messages targeted the most common human causes of fire ignitions in sagebrush habitats (vehicles, shooting, and equipment use). Information on the success of these programs should be developed.

C. FIRE SUPPRESSION

Across the Sagebrush Biome, a majority of fire starts are successfully suppressed during initial attack. Those that escape initial attack efforts, often occur during environmental conditions and weather that overwhelm suppression efforts and result in burning thousands of sagebrush acres. In addition, the costs of suppressing these fires make up the majority of fire suppression funding. Significant funding resources are available for fire suppression, but these often come from other program accounts that can

affect GRSG conservation. Resources are needed to better plan and implement programs that focus on pre-suppression and post-fire work to aid suppression activities and reduce adverse wildfire effects on sagebrush and GRSG.

UPDATE

To date, this problem has partially been resolved. There is still a need to address the federal agencies' ability to provide a comprehensive wildfire funding solution to avoid the disruptive practice of fire borrowing or fire transfer (primarily affecting funds directed to fuels management and fire prevention programs and BAR). Additionally, more resources are still required to plan and implement programs that focus on fuels treatments to support fire suppression operations and post-fire ES and BAR to reduce the duration of wildfire impacts on sagebrush and GRSG. Strategically restoring degraded sagebrush communities to a more resilient and resistant state is another important component to the issue of invasive plants and wildfires. One way to address this shortcoming would be to establish a funding mechanism that makes structural changes to the budget process and ensures success in our efforts to address the increasing wildfire threat. Without adequate attention to the funding issue, it will be nearly impossible to achieve long-term success in combating the pervasive invasive annual grass/fire cycle and the potential loss or degradation of sagebrush ecosystems, especially in the Great Basin. The current Omnibus Bill (2018) is a good start in resolving this problem, but more funding for fire prevention and fuels management is needed for proactive fire management in addressing the invasive/fire cycle. In addition, other agency program budgets may continue to be potentially

affected from the new direction in the Omnibus Bill (2018).

D. FUELS MANAGEMENT

Benefits of fire suppression for sagebrush-dependent species can be measured, but information on the impacts those fuels treatments or fuel breaks have on sagebrush-dependent wildlife and native plant species is lacking. There is no clear understanding of trade-offs between establishing proactive fuels management practices (e.g., fuel breaks or greenstrips) to aid suppression efforts versus potential negative impacts to GRSG habitat or likelihood for new establishment or spread of invasive plants. Alternatively, the trade-offs in short-term habitat losses resulting from fuels reduction treatments compared to long-term and large scale habitat retention or the short- and long-term impacts to GRSG population dynamics and other sagebrush-dependent species are poorly understood.

UPDATE

The IRFMS (USDOI 2015) emphasized the need for the wildland fire program to integrate with resource management and habitat conservation. The BLM is working on two Programmatic Environmental Impact Statements (PEISs) on vegetation and fuels treatments. This coincides with Crosscut #4 of the IRFMS "Develop and implement efficient and appropriate NEPA and other environmental compliance processes." The Fuel Breaks PEIS will analyze potential effects of constructing fuel breaks and the Fuels Reduction and Rangeland Restoration PEIS will analyze potential effects of reducing fuel loading, and restoring rangeland productivity within the Great Basin region, including portions of 6 states: Idaho, Oregon, Utah, Nevada-California, and Washington. Both projects would protect and conserve natural habitats from loss resulting from wildfires and the spread of invasive plant species. Although these proposals are similar,

THE R&R CONCEPTS CAN PROVIDE AN IMPROVED ECOLOGICAL FRAMEWORK FOR EVALUATING TRADE-OFFS BETWEEN PROACTIVE HABITAT DISTURBANCE AND RISK OF CATASTROPHIC ECOSYSTEM STATE CHANGES

PHOTO CREDIT: WYOMING GAME AND FISH DEPARTMENT

they have different purposes. The purpose of the Fuel Breaks PEIS is the protection of life, property, and natural resources (e.g., protect GRSG habitat) while also potentially reducing the size of wildfires on western rangelands. The purpose of the Fuels Reduction and Rangeland Restoration PEIS is to restore sagebrush habitats so they provide multiple use opportunities for all user groups and habitat for the hundreds of plants and animals that define the Sagebrush Biome. More efforts like this should be initiated.

Further research is still warranted to better understand the effects of proactive fuels management practices (e.g., fuel breaks) and would be helpful for informing the PEISs discussed above. Resistance and resilience concepts have been integrated into planning and prioritization of fuels management actions by land managers (e.g., FIAT). The R&R concepts can provide an improved ecological framework for evaluating trade-offs between proactive habitat disturbance and risk of catastrophic ecosystem state changes. Recent publications can help local land managers and stakeholders better assess, discuss, and plan fuel break treatments (e.g., Maestas et al. 2016a, Moriarti et al. 2015, Shinneman et al. 2018) and the Actionable Science Plan (USDOI 2016) prioritizes the need for further scientific understanding of these tradeoffs and impacts. Recently finished and ongoing USGS/BLM efforts include developing a synthesis of available information on the ecological effects and effectiveness of linear fuel breaks (Shinneman et al. 2018) and conducting new research to inform the strategic placement of fuel breaks and understand the conditions under which fuel breaks are likely to benefit populations. One aspect that needs additional consideration is the need for maintaining connectivity among GRSG populations and intact sagebrush habitats (Crist et al. 2017a).

The Fuels Treatment Effectiveness Monitoring (FTEM) program is used by BLM and others to capture and document fuels treatment effectiveness on wildland fire behavior. Numerous fuels management treatments (e.g., controlled burning, mastication, etc.) implemented on BLM-administered lands have interacted with wildfires. While FTEM has not captured all treatments that intersected with wildfires, FTEM results show qualitatively that treatments can help reduce the size of many human-caused ignitions, assist in providing opportunities to stop or slow the spread of the wildfire, and provide for greater firefighter safety. The FTEM is currently being updated to a geospatial platform that will assist in quantifying under what conditions fuel treatments and fuel breaks change fire behavior using spatial analyses in conjunction with the qualitative information collected. In addition, this update will improve data entry processes and allow wildland fire management agencies to know where information was or was not collected.

E. FIRE REPORTING
Federal and state agencies do not have a coordinated reporting system that summarizes the fire season or the spread of invasive plants and their true impacts on GRSG habitats.

UPDATE
Currently, there is an active system of coding fire start and end date, location, fire cause, size, management, jurisdiction, spatial boundaries, fire progression, etc. This information is collected across all state, county, city, and federal agencies in a fluid data exchange environment called the Interagency Fire Occurrence Module (IRWIN) that provides near real-time access to fire occurrence reports and geospatial data. In addition, there are numerous fire reporting systems (Wildland Fire Management Information, Wildland Fire Decision Support System, Monitoring Trends in Burn Severity (MTBS), and GeoMAC) that are also being used by the agencies. Ninety percent

of fire reporting is captured using this IRWIN application and the remaining 10% through data entry. An application in development called INFORM that will leverage IRWIN by bringing in data already captured in computer aided dispatching and resource ordering to minimize the amount of data entry (the remaining 10% not captured by IRWIN). This application plans to be released late 2018.

For calculating the amount of sage-grouse habitat burned annually, national geospatial analysts with the BLM have developed a process to track acres of GRSG, Gunnison sage-grouse *(C. minimus)*, and Bi-State habitats burned and post these data depending on National Fire Preparedness Levels: PL1-PL2 is updated monthly, PL3 is biweekly and PL4-PL5 is weekly. Total acreage burned is provided at the end of the fire season. Maps and tabular data are continually updated during the fire season, and made available to multiple mailing lists and agency leads. This information can be used to determine the cumulative effects of fire on sage-grouse habitats within and between seasons as well as regionally.

Federal and state agencies have coordinated reporting systems that are used to summarize the fire season, but do not have an automated process to summarize the cyclic impact of wildland fires on the spread of invasive plants, invasive plants on the spread of wildland fires, and their combined effects on GRSG habitats. All responsible agencies should examine this problem and develop appropriate solutions.

F. WILDFIRE RESOURCE ADVISORS (NEW)

Once fire escapes the initial attack, fire-fighting organizations must make informed decisions regarding tactics and implementation of

suppression planning measures that takes into account GRSG conservation needs (i.e., protecting key GRSG habitat). Often times Incident Management Teams (IMTs) lack local knowledge of the terrain, road network, landowners and habitats in the fire-impacted area. As a result, operational decisions are made that may not effectively consider or implement the pre-approved habitat protection measures. While Resource Advisors are commonly a part of the Incident Command structure, there is not a widespread practice in place that routinely includes state wildlife agency biologists and local ranchers as consultants to provide real-time local input into fire suppression activities.

Resource Advisors are assigned to fires that

"Once fire escapes the initial attack, fire-fighting organizations must make informed decisions regarding tactics and implementation of suppression planning measures that takes into account GRSG conservation needs (i.e., protecting key GRSG habitat)."

exceed initial attack to provide further input to proposed suppression strategy and tactics. A program should be developed where these state and private experts receive "Fire Safety Training", red-carded, and are made available to be part of Incident Command structure to help the IMT make informed suppression decisions. Synergistic cooperation of private and government suppression activities can be greatly aided by pre-fire collaborative planning processes that include RFPAs. At times there appears to be a lack of consistency in the implementation of the agreed to suppression planning measures and the use of the tactical decision support tools (e.g., GRSG maps), especially when firefighting personnel are brought in from outside of the geographic area.

POST-FIRE LANDSCAPE AT KING HILL AREA OF CRITICAL ENVIRONMENTAL CONCERN

PHOTO CREDIT: BUREAU OF LAND MANAGEMENT

A process is already in place for BLM that facilitates the consistent distribution of these tools, plans, and apriori agreements to all firefighting resources assigned to the suppression task. All incoming suppression resources and IMTs are briefed on the importance of GRSG habitat, tools, and maps available, as well as BMPs when working in GRSG habitat. Despite these inconsistencies, the BLM currently strongly encourages units to utilize mobile technology (tablets, phones, etc.) to have access to this information, including BMPs, areas of fuels treatment and location of GRSG habitat to use during suppression efforts. The DOI and USFS should continue to expand on this important effort.

4. SEEDING STRATEGIES

A. SEEDING VS. TRANSPLANTING TRADE-OFF ANALYSIS

There is no analytical process that looks at the cost/benefit trade-offs of applying seed versus transplanting live seedlings (mainly for shrubs and forbs).

UPDATE

The USGS and BLM are collaborating on a database, the Land Treatment Digital Library (LTDL), that is capable of tracking data on costs and success for transplanting projects, but to date no analyses have been conducted to determine these trade-offs (which is dependent on the BLM files containing accurate cost estimates). More recent treatments may provide better information. The USGS and BLM are collaborating on a project, (SageSuccess) that is examining the successes of seeding and transplanting projects that used big sagebrush across the Great Basin. This project should be able to identify soil, topographic or climatic causes of sagebrush revegetation successes. The cost information stored in the LTDL and the sagebrush revegetation success information from SageSuccess could be combined to determine these trade-offs. These studies and databases could be used as templates for collecting similar information on other revegetation species. More emphasis needs to be placed on using finer scale remote sensing to monitor the success of sagebrush seeding and seedling projects after a period of time when the shrubs are detectable in the aerial photographs.

B. SEEDING SUCCESS PREDICTIONS

The complex set of variables that control-seeding success is poorly understood and there are no accurate predictive meteorological data/models to identify years when the potential for seeding success is higher or lower.

UPDATE

Progress is being made in both understanding the variables that drive seeding success for some critical plant species and in forecasting seeding success. This work needs to continue because it is not ready for application in field projects. The success of big sagebrush seeding is being investigated in the USGS/BLM SageSuccess Program, using a list of BLM seeding projects to relate environmental and physical site conditions in explaining sagebrush-seeding success. The BLM and USGS are also using a soil water model (SoilWat) to determine the importance of soil moisture on sagebrush seeding success. This project is about one to two years from completion. The ARS, and university scientists are developing a predictive model for managers to determine the probability of seeding success based on weather data. An early version of the model is being tested with historical data to refine and test the model. This project is about two years from completion. The specific mechanisms linking environmental variables to seedling establishment are not well understood and will require substantial research effort.

C. POST-FIRE PERENNIAL NATIVE PLANT SURVIVAL AND SITE RECOVERY

There is an inadequate understanding of the post-fire density and cover of surviving perennial native plants that should trigger seeding which depends on fire intensity, site potential (Ecological Site), the vegetation composition and relative abundance of perennial natives and

invasive annual grasses, and pre-fire temperature and precipitation regimes. The necessary research and management information needs to be developed to establish seeding guidelines for land managers.

"Research conducted in the Great Basin indicates that about 20% cover of native perennial grasses and forbs are required after fire or vegetation management treatments to prevent significant increases in cheatgrass."

UPDATE

Research conducted in the Great Basin indicates that about 20% cover of native perennial grasses and forbs are required after fire or vegetation management treatments to prevent significant increases in cheatgrass (Chambers et al. 2014c). Moreover about 10 native perennial grasses per m^2 are needed to keep medusahead wildrye populations low (Davies 2008) in relatively warm and dry Wyoming big sagebrush (*A. t. wyomingensis*) ecosystems. As expected, the density of seeded native perennial plants that

CHEATGRASS INFESTATION

PHOTO CREDIT: JENNIFER STRICKLAND, USFWS

establishes after cheatgrass control treatments is directly related to the reduction in density of cheatgrass (Mazzola et al. 2010). Establishment of sagebrush following fire increases over the environmental gradients (e.g., elevation and precipitation) that characterize sagebrush ecosystems, and is related to the cover of perennial native grasses and forbs (Chambers et al. 2017b). For managers to effectively use this information to guide post-fire seeding, the available data on the relationships among pre-fire plant community composition and post-fire composition for the dominant sagebrush ecological types needs to be synthesized. Then, research and management studies need to be conducted in those areas where gaps remain to establish the density and cover of surviving native perennial grasses and forbs needed to promote ecosystem recovery. Cover of perennial plants is a variable measured by BLM AIM and NRCS Natural Resources Inventory (NRI), but perennial grass density may not be currently measured. However, if it was measured, it could contribute to providing these data when fires occur in the future. This information is essential for developing guidelines for when and where seeding is needed; necessary to assist managers in making a seed or no seed determination after a wildfire (Miller 2015); and should be incorporated into the appropriate Ecological Site Descriptions (ESDs).

5. RANGE-WIDE GEOSPATIAL ANALYSES AND MAPPING

A. ECOLOGICAL MAPPING
Agencies lack comprehensive, range-wide maps of high resolution vegetation data, comprehensive soil surveys, ecological condition, and fine-scaled measures of site R&R, to assist managers in: 1) prioritizing sagebrush conservation and restoration opportunities at a broad-scale, and 2) planning and implementing effective management practices, pre-and post-

fire planning, fuels treatments, and restoration activities at the local or project scale. These maps and surveys are the basis for the R&R decision support tools required to implement a sound conservation and restoration strategy for the Sagebrush Biome.

UPDATE
Much work has been completed in this area. The IRFMS (USDOI 2015) and an Actionable Science Plan (IRFMSASPT; USDOI 2016) were developed to help prioritize and direct science information needs across the Sagebrush Biome. Additionally, the geospatial products and R&R decision support tools developed by the WG, the FIAT prioritization process adopted by BLM and USFS, as well as other recently completed prioritization and monitoring processes (e.g., GRSG fire risk assessments, HAF), are widely used. The DOI has led the development of an overarching Science Framework (Chambers et al. 2017a, Prentice et al. in progress) that provides a core set of geospatial data, maps, and models on GRSG populations, vegetation cover, ecosystem threats, and soil temperature and moisture regimes characterized according to R&R on an ecoregional basis. These are available to the agencies and public through the USGS (https://www.sciencebase.gov/catalog/
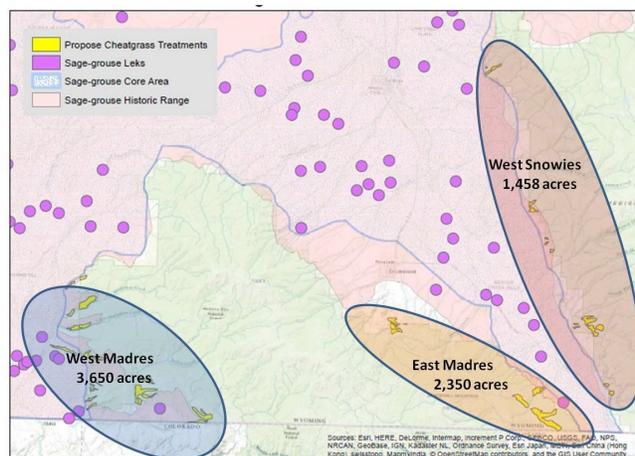
Carbon County Cheatgrass Treatment Areas

PHOTO CREDIT: WYOMING GAME AND FISH DEPARTMENT

item/576bf69ce4b07657d1a26ea2) and BLM Landscape Approach Data Portal (https://landscape.blm.gov). As a foundation to the Science Framework (Chambers et al. 2017a), the NRCS compiled soil moisture and temperature maps that relate directly to ecosystem resilience to disturbance and resistance to invasive annual grasses for the GRSG and Gunnison sage-grouse range, worked with regional scientists and managers to categorize this information based on relative R&R, and developed a web-based tool that provides soils information to evaluate R&R at project scales. The NRCS is now extending this information across the Sagebrush Biome. Information on how to interpret the maps has been described by Maestas et al. (2016b). Information on how to interpret the maps has been incorporated into a field guide for selecting appropriate treatments in sagebrush and juniper and piñon ecosystems (Miller et al. 2014), and a field guide and handbooks for assessing post-wildfire recovery and restoration decisions in sagebrush and

While comprehensive, range-wide maps of ecological conditions do not currently exist, there have been significant advances made in developing the components necessary to produce those maps. Higher resolution vegetation cover data (all shrubs, sagebrush shrubs, herbaceous vegetation, litter, and bare ground by one-percent intervals) based on remotely sensed and field data have been developed by USGS and will be available on ScienceBase. Higher resolution geospatial data for piñon and juniper cover is available across the GRSG range (http://map.sagegrouseinitiative.com/). A highly accurate piñon and juniper landscape cover layer has been developed by USGS for the Bi-state range and the State of Nevada (Coates et al. 2017).

There is much work yet to be done to completely address this gap. For example, the NRCS in conjunction with other agencies (BLM, USFS, USFWS, and National Park Service) lacks the field staff and funding to complete and approve the soil surveys and ecological site descriptions. The

"Currently, there is a lack of spatially explicit maps of invasive annual grasses or other invasive plant species."

juniper and piñon ecosystems in the Great Basin (Miller et al. 2015, Pyke et al. 2015a, b, 2017). Land Use Plan Amendments (LUPAs) have been completed that allow these maps and the R&R concepts to be applied in a management setting. Also, a decision support tool that provides overlays of the geospatial data developed for the Science Framework (Chambers et al. 2017a) should be available soon. There have been significant advances made that will be available in 2018 regarding ecological condition, including USGS mapping of sagebrush vegetation components and NRCS mapping of conifer distribution.

FIAT efforts need to be implemented and regularly updated and additional decision support tools need to be developed at the site scale. The BLM's AIM strategy and HAF data are available for analysis, and adaptive management decision support. It is recommended that NRCS or designated representatives from other agencies develop a 10-year plan to complete soil descriptions and develop or determine ecological site descriptions for these newly described soils. Older soil surveys need to be updated to current standards.

B. NONNATIVE PLANT SPECIES MAPS AND RISK ASSESSMENTS

Currently, there is a lack of spatially explicit maps of invasive annual grasses or other invasive plant species. Wildfire/invasive plant species risk assessments that incorporate GRSG habitat are needed at management scales across the Sagebrush Biome to aid in targeting invasive plant management and wildfire pre-suppression, suppression and rehabilitation efforts.

UPDATE

Recently, geospatial data for wildfire risk across the Sagebrush Biome have become available, but geospatial data for cheatgrass vary in resolution and the area included (Boyte and Wylie 2015, 2016, 2017; Boyte et al. 2016a, b; Boyte et al. 2017; Downs et al. 2016). The probability of large (>300 ac) wildfire has recently been updated and vetted by the agencies (Short et al.

"Studies have demonstrated that fire can have long-term effects (>10 years) on sagebrush communities, but that the effects differ across the environmental gradients that characterize sagebrush ecosystems."

2016). These data have been used to develop a fire risk assessment for GRSG breeding habitat that considers the probability of large wildfire, the probability of GRSG breeding habitat, and relative R&R (Crist et al. 2017b, Appendix 10 in Chambers et al. 2017a).

Various map products have been developed by the Pacific Northwest National Lab and USGS to predict the cover and extent of cheatgrass based on the Normalized Vegetation Index (NDVI), and climate, biophysical, and field data. The cover and extent of cheatgrass (0-2% cover; and >2% cover) was mapped by the Pacific Northwest Lab (Downs et al. 2016). This was a one-time effort

that underestimates cheatgrass cover in the eastern portion of the GRSG range that could use additional ground-truthing and recalibration rangewide. Near-real time cheatgrass cover for the Great Basin and the majority of the GRSG range has been developed using remotely sensed data and is reported yearly (Boyte and Wylie 2015, 2017; Boyte et al. 2016b). Because of the link between cheatgrass cover and wildfire the following year, it is a useful predictive tool that can be used for fire management and restoration planning in those areas where it exists. Various efforts are also underway to examine the change in cheatgrass cover over time (both increases and die-offs) at more localized scales (Boyte and Homer, USGS work in progress; Boyd et al. 2017; Xian et al. 2015). There continues to be a need to refine and periodically update the geospatial data layers for cheatgrass.

Recently, the USDA Rocky Mountain Research Station has developed a Rangeland Vegetation Simulator that includes cheatgrass and fire interactions. However, additional creative tools are needed for evaluating fuel continuity of invasive annual/wildfire risk and the potential for restoring areas following cheatgrass die-offs. Additional efforts are needed to provide comprehensive, range-wide maps of invasive annual grasses other than cheatgrass and of other invasive plants. It is essential to keep all products up to date, and develop decision support tools to improve access to these data and maps.

6. SHORT- AND LONG-TERM FIRE EFFECTS ON GRSG AND HABITAT

Studies have demonstrated that fire can have long-term effects (>10 years) on sagebrush communities, but that the effects differ across

RADIO COLLARED HEN SAGE-GROUSE

PHOTO CREDIT: DAWN DAVIS, USFWS

modeled GRSG demographic rates (e.g., Blomberg et al. 2013, Kane et al. 2017), a coordinated large-scale effort to understand regional differences in GRSG demographics and the long-term effects of fire on those rates is needed. Finally, there should be a long-term commitment to actively monitor GRSG populations, survival, nest success, movements and habitat use for many years (>5) following wildfire.

the environmental gradients that characterize sagebrush ecosystems (Miller et al. 2013). Thus, studies are needed to inform short- and long-term impacts of fire on GRSG demography and habitat use across large landscapes.

UPDATE
This remains an ongoing need that was prioritized within the Actionable Science Plan (IRFMSASPT; USDOI 2016). Resistance and resilience concepts were used to model recovery potential and demonstrated the long-term negative effects of cumulative burned area on GRSG populations in the Great Basin (Coates et al. 2016). Additionally, Coates et al. (2016) highlighted the need for large reductions in area burned per year to improve long-term GRSG population trajectories for the Great Basin. The USGS is currently expanding this work range-wide and is working with the WG to develop recovery trajectories to increase application of the model results. Although several studies have

7. DROUGHT AND CLIMATE ADAPTATION (*NEW*)

There is insufficient information and guidelines on drought and climate adaptation to effectively manage sagebrush ecosystems in a warming climate. Management actions that enable adaptation to drought and climate change and promote resilience to disturbance are becoming increasingly important in the Sagebrush Biome. Drought adaptation measures with shorter-term and longer-term horizons have been identified for rangelands and forests across the western United States (see Joyce et al. 2013; Briske et al. 2015; Finch et al. 2016). Also, the DOI Landscape Conservation Cooperatives (LCCs) and USDA Climate Hubs are working to make drought adaptation information available to managers

across the Sagebrush Biome. However, the fate of both the LCCs and Climate Hubs is uncertain. A concerted effort needs to be made by the agencies to ensure that drought adaptation information is tailored to sagebrush ecosystems and land uses (including wild horse and burro management), that both decision makers and field level employees are receiving this information, and that this information is being incorporated into land use and project planning.

Climate adaptation will require long-term strategies. In recent decades temperatures have increased, growing seasons have lengthened, and in many areas the timing and amount of precipitation has changed across the Sagebrush Biome (Kunkel et al. 2013a,b, c). Snowpacks are declining in many areas (Mote and Sharp 2016), droughts are becoming more severe (Cook et al. 2015; Prein et al. 2016), climate suitability for cheatgrass is likely to increase (Bradley et al. 2016), and the length of the fire season and duration of extreme fire weather is increasing (Littell et al. 2009; Abatzoglou and Kolden 2013; Westerling et al. 2014; but see also McKenzie and Littell 2017). Despite this, the federal land management agencies have been slow to

implement climate adaptation. The most frequent barriers to climate adaptation identified by federal land agency employees are lack of relevant information on climate change at ecoregional to field office/district scales, budget constraints, and lack of specific agency direction (Archie et al. 2012). Scientific guidance and agency direction is needed to enable climate adaptation planning and implementation across agencies and scales in sagebrush ecosystems. While some climate downscaling has been completed (e.g., Abatzoglou and Kolden 2013; Bradford et al. 2017 in Chambers et al. 2017a; BLM Rapid Ecoregional Assessments [https://landscape.blm.gov/geoportal/catalog/REAs/REAs.page]), increased research is needed to provide useful downscaled climate projections and their interpretations at ecoregional scales. Researchers and managers need to work together to develop climate adaptation management strategies and guidelines for the individual ecoregions (WAFWA Sage Grouse Management Zones; Stiver et al. 2006) as climate change will have differential effects. The necessary agency direction for developing and implementing these strategies and guidelines needs to be provided. See this link for a set of climate tools being developed by the Conservation Biology Institute. https://consbio.org/products/projects/collaboration-create-climate-tools.

INVASIVE PLANT—MEDUSAHEAD

PHOTO CREDIT: LESLIE J. MEHRHOFF, UNIVERSITY OF CONNECTICUT, BUGWOOD.ORG

RECOMMENDATION SUMMARY
TOP 5 GAPS

1. CAPACITY AND STRUCTURE FOR INVASIVE PLANT MANAGEMENT (*NEW*)

RECOMMENDATIONS

A. Program capacity and necessary structure for invasive plant management is needed at all levels (private, county, state, federal and tribal). This support needs to be long-term, reliable, and dedicated. Addressing the severely limited capacity for invasive plant prevention, control and the implementation of early detection and rapid response, control and management, regulatory activities, and associated native plant restoration operations should be a focused effort across the Sagebrush Biome.

B. Funding and commitments for invasive plant species management should focus on key species regardless of its status (federal or state) as a noxious weed. Noxious weed designations should be re-visited if they do not include key species, such as cheatgrass and medusahead.

C. The Western Invasive Plant Management: An Action Plan for the Sagebrush Biome," that includes a set of priority action items (including sub-actions and timelines) to address the major barriers for invasive plant management at local, state, and federal levels, should be adopted and implement by state and federal agencies.

D. Actions need to be prioritized and implemented for the prevention, management, and control of invasive annual grasses before, during, and after wildfire. Until these activities are prioritized, the battle with the pervasive invasive annual grass/fire cycle in the sagebrush ecosystem will continue without resolution, especially in the Great Basin.

E. New and effective communication efforts should focus on invasive plants and the

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TOP 5 GAPS

1. CAPACITY AND STRUCTURE FOR INVASIVE PLANT MANAGEMENT (*NEW*)

2. LONG-TERM RESTORATION FUNDING

3. SEED AVAILABILITY AND RESTORATION METHODS

4. PUBLIC INVOLVEMENT

5. LIVESTOCK GRAZING

critical threats they pose to the Sagebrush Biome.

2. LONG-TERM RESTORATION FUNDING

RECOMMENDATIONS

A. Long-term sustainable commitment of funds for restoration of resilient and resistant plant communities is necessary within all appropriate federal and state agencies to reverse the continuing loss of sagebrush plant communities that threatens the Sagebrush Biome and the native plants and wildlife it supports. Additionally, more efforts to restore rangelands for multiple use opportunities (e.g., the Fuels Reduction and Rangeland Restoration PEIS) should be initiated.

Increased/continued coordination of restoration funds is critical to success.

B. To address the year-to-year variability in fire season costs (and acres burned) a more flexible and sustainable budget process is needed for ES and BAR (Emergency Stabilization and Burned Area Rehabilitation).

C. Multiple species considerations, risk of increasing invasive annual grasses, adequate coordination with livestock operators, and addressing free-roaming equids should be evaluated and made part of the restoration funding discussion.

3. SEEDS, RESTORATION METHODS, AND EQUIPMENT

GREATER SAGE-GROUSE HEN

PHOTO CREDIT: WYOMING GAME AND FISH DEPARTMENT

RECOMMENDATIONS

A. Full implementation of the Seed Strategy (PCA 2015) is necessary, including strong executive leadership support, staff coordination among public agencies and private businesses, and sustained/dedicated financial support.

B. Increasing the number and availability of native plant species available on the commercial market is crucial to implement rehabilitation and restoration projects that utilize genetically appropriate native seed.

C. Research and development efforts similar to what has occurred in the Great Basin (e.g., Great Basin Native Plant Project), is needed in the eastern portion (CO, MT, ND, SD and WY) of the GRSG range.

D. Dedicated funding is needed for SOS and seed-collecting teams located throughout the range of sage-grouse for native plant materials development.

E. Understanding genetic variation and seed transfer guidance, through research that develops seed zones, is another critical aspect of achieving success throughout the Sagebrush Biome.

F. Actions are needed to expand and add new partners among the private and public sector to accelerate the pace and scale of genetically appropriate native seed available for restoration.

G. Programs like the SOS and "Sagebrush in Prisons Project," should be continued and expanded where appropriate.

H. Research and development of prescriptions, strategies, and technologies (including equipment) to improve the success of seeding should be pursued.

4. PUBLIC INVOLVEMENT

A. COOPERATIVE WEED MANAGEMENT AREAS (CWMAS)

RECOMMENDATIONS

1. Federal agencies should actively engage in identifying funding supporting and expanding CWMAs across the Sagebrush Biome.

2. CWMAs should be universally included in setting wildland fire and invasive plant management planning and restoration priorities across agencies and scales.

3. Policy and procedural roadblocks to completing agreements with the CWMAs and transferring federal or state dollars to either the group or individual members within the CWMA should be resolved. Increasing funding flexibility is key to success, and can be facilitated through Cooperative Agreements and Memorandums of Understandings, to reduce the complexities and redundancies affecting the business practices of CWMAs.

4. The state Departments of Agriculture and federal agencies responsible for invasive and noxious weed management should work together to clarify the regulatory discrepancies on invasive/noxious plant definitions and develop a system that facilitates a unified approach and coordinated funding for common priorities to effectively combat invasive plant species.

B. RANGELAND FIRE PROTECTION ASSOCIATIONS (RFPAS)

RECOMMENDATION

1. Rangeland Fire Protection Associations have been established in Idaho, Oregon, and Nevada with great success. All sagebrush states should adopt similar programs and remove legal barriers that prevent their establishment.

MALE GREATER SAGE-GROUSE IN FLIGHT

PHOTO CREDIT: WYOMING GAME AND FISH DEPARTMENT

5. LIVESTOCK GRAZING

RECOMMENDATIONS

A. The Interagency Targeted Grazing Team should be fully supported to continue with their goals and studies conducted by partners, in addition to collecting, evaluating and sharing monitoring data to evaluate treatment efficacy.

B. Targeted grazing demonstration projects should consider different ecosystem types, differing grazing management strategies (e.g., rate, frequency, and timing) and economic efficiencies, and should use appropriate protocols for implementing treatments, sample design, data collection, and analysis and reporting data. Targeted grazing guidelines should also consider free-roaming equids, wildlife species (e.g., pronghorn, mule deer), and the effects on their habitats.

C. Increased research emphasis on the effects and proper application of both pre- and post-fire grazing is needed to better manage fuel reduction, fire rehabilitation, and restoration activities. The underlying components and processes of effective grazing management needs to be identified, understood, and documented and resulting guidelines be distributed to the agencies and private landowners.

D. More rigorous/credible studies regarding the effects of free-roaming equids on fire rehabilitation and restoration activities and the spread of invasive plants are needed. Information on interactions between free-roaming equids, livestock and sagebrush dependent wildlife species are needed.

RECOMMENDATION SUMMARY
ADDITIONAL GAPS

1. IMPORTANCE OF THE SAGEBRUSH BIOME

RECOMMENDATIONS

A. Internal and external communications and educational efforts about the importance of sagebrush ecosystems to human economies and social systems and the wildlife habitat and associated species that the Sagebrush Biome supports should continue and increased where appropriate.

B. Additional efforts like the NRCS-SGI should be developed and supported. All constituent groups (e.g., sportsmen and women, livestock organizations, conservation focused NGO's) should be encouraged to join these efforts. More formal recognition should be given to current active groups and programs.

2. STRATEGIC RESOURCE MANAGEMENT, POLICY, AND DECISION SUPPORT TOOLS

A. CONSISTENT FRAMEWORKS AND STRATEGIES

RECOMMENDATIONS

1. To apply the decision support tools that use R&R ecological concepts more broadly, models and spatial information similar to that available for GRSG is needed for other species at-risk within the Sagebrush Biome.

2. A FIAT tool should be developed and implemented for the eastern portion of the Sagebrush Biome to facilitate GESG habitat restoration and conservation.

3. Additional work is needed to develop and maintain an effective education programs including a training component for land managers on using strategic, multi-scale approaches for maintaining sagebrush ecosystem resilience to disturbance and resistance to invasive plants. Moreover, coordination and partnerships are a critical factor to being successful in managing the Sagebrush Biome. Thus, more work and emphasis is needed in this area.

B. ADAPTIVE MANAGEMENT AND IMPLEMENTATION AND EFFECTIVENESS MONITORING.

RECOMMENDATIONS

1. A firm commitment to investing in long-term monitoring and adaptive management is essential to facilitating success in long-term conservation and sustainability of the Sagebrush Biome.

2. Coordination of monitoring activities and associated research, and increased use of remote sensing is needed, including consideration of multiple spatial scales. Participating agencies should implement common protocols and databases to demonstrate the strength gained from a coordinated approach and continue to support efforts like SageDAT, AIM and the Actionable Science Plan (USDOI 2016).

3. A commitment to implementing adaptive management should be made. Hence, a review of federal agency policies and other barriers that hinder adaptive management should be initiated to identify and remove constraints to effectively addressing the invasive annual grass/ fire cycle.

C. LANDSCAPE DECISION SUPPORT TOOLS

RECOMMENDATION

1. An expanded toolbox of available information to help fire managers, resource managers and stakeholders weigh risks and facilitate informed decision-making should

ADDITIONAL GAPS

1. **Importance of the Sagebrush Biome**
2. **Strategic Resource Management, Policy, and Decision Support Tools**
   a. **Consistent Frameworks and Strategies**
   b. **Adaptive Management and Implementation and Effectiveness Monitoring**
   c. **Landscape Decision Support Tools**
   d. **Management Coordination**
   e. **Conflicting Policies Among all Agencies**
3. **Wildland Fire Prevention, Suppression, and Fuels Management for GRSG**
   a. **Focused Western Rangelands Fire Protection**
   b. **Fire Prevention**
   c. **Fire Suppression**
   d. **Fuels Management**
   e. **Fire Reporting**
   f. **Wildfire Resource Advisors (*NEW*)**
4. **Seeding Strategies**
   a. **Seeding vs. Transplanting Trade-off Analysis**
   b. **Seeding Success Predictions**
   c. **Post-fire Perennial Native Plant Survival and Site Recovery**
5. **Range-wide Geospatial Analyses and Mapping**
   a. **Ecological Mapping**
   b. **Nonnative Plant Species Maps and Risk Assessments**
6. **Short and Long-term Fire Effects on GRSG and Habitat**
7. **Drought and Climate Adaptation (*NEW*)**

COLLECTING SAGEBRUSH SEED

PHOTO CREDIT: USFWS

continue to be developed. A road map for tool selection should also be developed.

D. MANAGEMENT COORDINATION

RECOMMENDATIONS
1. Efforts like the BLM IPOW are designed to act as a "work plan" for all levels of the organization. All levels of the organizations must be made aware and be engaged to implement the conservation direction.

2. There is a need to provide training across and within agencies (between and among the various departments and fields of expertise) to remove barriers and create a, shared management understanding for the Sagebrush Biome.

E. CONFLICTING POLICIES AMONG AGENCIES

RECOMMENDATION
1. All federal and state agencies should continue to identify communication barriers and adaptively work to resolve them.

Agencies require two-way, vertical communication with sufficient decision space provided to field staff for effectively dealing with local situations.

3. WILDLAND FIRE PREVENTION, SUPPRESSION, AND FUELS MANAGEMENT FOR GRSG

A. FOCUSED WESTERN RANGELANDS FIRE PROTECTION

RECOMMENDATION
1. DOI agencies should continue a landscape-scale approach to fire and land management and further enhance collaborative, science–based approaches to management activities within the Sagebrush Biome.

B. FIRE PREVENTION

RECOMMENDATION
1. The DOI and USFS should continue to support and build on efforts similar to the IRFMS(USDOI 2015). Furthermore, funds

should be provided for fire education and prevention messages aimed at promoting GRSG habitat conservation, protection, and restoration.

C. FIRE SUPPRESSION

RECOMMENDATION

1. Federal agencies need the ability to provide for a comprehensive wildland fire funding. From the Omnibus Bill (2018), a new fire suppression funding mechanism that adjusts federal spending caps to accommodate fire suppression needs will start in 2020. A "disaster cap allocation" for wildfires will start at $2.25 billion and then increase to $2.95 billion in 2027. Also, the wildfire suppression line item is capped at the USFS at the FY 2015 level, which will slow the migration of non-fire funding to the fire programs at the beginning of each fiscal year. Additional resources are required to plan and implement fuel treatment programs for fire suppression operations, and post-fire ES and BAR to reduce the duration of wildfire impacts on sagebrush and GRSG. Strategically restoring degraded sagebrush communities to a more resilient and resistant state is essential.

D. FUELS MANAGEMENT

RECOMMENDATIONS

1. More efforts to restore rangelands for multiple use opportunities should be initiated.

2. Research is needed to understand the effects of fuels management practices (e.g., fuel breaks) on habitat and wildlife.

3. Research results to better understand connectivity requirements among GRSG populations and intact sagebrush habitats

should be incorporated into fire suppression strategies.

4. Continue to improve reporting mechanisms to track effectiveness of fuel treatments (e.g., fuel reductions and fuel breaks) for reducing the spread of fire in the Sagebrush Biome. A first step should include development of geospatial information on the location of all fuel reduction treatments and fuel breaks, and include attributes on the type of fuel break (i.e., mowed, green strip, brown strip), level of maintenance, etc. Additional information should be added to the FTEM database to support effectiveness assessments.

E. FIRE REPORTING

RECOMMENDATION

1. Federal and state agencies need an automated and coordinated reporting system to summarize the fire season. This system needs to summarize the impact of wildland fires on the spread of invasive plants, as well as the effect of invasive plants on the spread of wildland fires, and their combined effects on GRSG habitats.

F. WILDFIRE RESOURCE ADVISORS (*NEW*)

RECOMMENDATIONS

1. In addition to Resource Advisors, the state wildlife agency biologists and local experts (e.g., tribes) should be included to provide local input during fire suppression activities.

2. State and general public experts should receive Fire Safety Training, be red-carded, and be included in Incident Command structure to help the IMT make informed suppression decisions.

3. Fire suppression agencies should continue to build databases for mobile technology (e.g., tablets, phones, etc.) to have access to

Resource Advisor information and software that provides the information (Wildland Fire Decision Support System; WFDSS), including BMPs, areas of fuels treatment, and location of GRSG habitat during suppression efforts.

4. SEEDING STRATEGIES

A. SEEDING VS. TRANSPLANTING TRADE-OFF ANALYSIS

RECOMMENDATIONS

1. An accurate trade-off analysis of the costs and success for transplanting versus direct seeding projects is needed.

2. Finer scale remote sensing is needed to monitor the success of sagebrush seeding and seedling projects until shrubs are detectable in aerial photographs.

B. SEEDING SUCCESS PREDICTIONS

RECOMMENDATION

1. Research into the specific mechanisms linking environmental variables (e.g., long-range weather predictions) to seedling establishment is needed.

C. POST-FIRE PERENNIAL NATIVE PLANT SURVIVAL AND SITE RECOVERY

RECOMMENDATIONS

1. Research is needed to understand the relationships among pre-fire plant community composition and post-fire composition for the dominant sagebrush ecological types.

BLACK SAGEBRUSH SEEDS

PHOTO CREDIT: BLM WY050, SEEDS OF SUCCESS.

2. Research and management studies are needed to establish the density and cover of surviving native shrubs, perennial grasses and forbs necessary for ecosystem recovery.

3. During inventories and monitoring projects, a robust sampling protocol should be employed. Additionally, the perennial grass density and cover should be measured to understand the effects of future fires. This information together with remote sensing data is essential for developing guidelines for when and where seeding is needed.

5. RANGE-WIDE GEOSPATIAL ANALYSES AND MAPPING

A. ECOLOGICAL MAPPING

RECOMMENDATIONS

1. The Soil Survey Geographic Database (SSURGO 1:12,000 – 1:63,360) soil mapping coverage and ecological site descriptions in the Great Basin needs to be completed to effectively use the R&R products.

2. The FIAT efforts should be implemented and regular updates of decision support tools at the site scales should be completed as needed.

3. The NRCS or designated representatives from other agencies should develop and implement a 10-year plan to complete soil surveys and develop ecological site descriptions for these newly described soils. Older soil surveys need to be updated to current standards for the Sagebrush Biome.

B. NONNATIVE PLANT SPECIES MAPS AND RISK ASSESSMENTS

RECOMMENDATIONS

1. Comprehensive, current range-wide maps of all invasive annual grasses and associated ecological conditions are needed. Associated decision support tools to improve access to these data and maps need to be developed.

2. Continuous refinement and ground-truthing of geospatial data layers for cheatgrass across the entire Sagebrush Biome is necessary to conduct effective fire risk assessments.

3. Creative tools are needed for evaluating fuel continuity of invasive annual/wildfire risk and the potential for restoring areas following cheatgrass die-offs.

6. SHORT AND LONG-TERM FIRE EFFECTS ON GRSG AND HABITAT

RECOMMENDATIONS

1. Additional studies are needed to inform short- and long-term impacts of fire on GRSG demography and habitat use across large landscapes, including a coordinated, large-scale effort to understand regional differences.

2. Long-term commitment to actively monitor GRSG populations, survival, nest success, movements and habitat use for many years (>5) following wildfire is needed.

7. DROUGHT AND CLIMATE ADAPTATION (*NEW*)

RECOMMENDATIONS

1. Sufficient information and guidelines on drought and climate adaptation to effectively manage sagebrush ecosystems in a warming climate should be vetted and synthesized and made available to managers and decision makers at all levels to facilitate the use of tools like the R&R publications. This information should be tailored to

sagebrush ecosystems and land uses (including wild horse and burro management), and the information incorporated into land use and project planning.

2. Scientific guidance and agency direction and support is needed to enable climate adaptation planning and implementation across agencies and scales in sagebrush ecosystems.

3. Additional research is needed to provide downscaled climate projections and their interpretations at ecoregional scales. Researchers and managers need to work together to develop climate adaptation management strategies and guidelines for the individual ecological regions and the WAFWA Sage Grouse Management Zones (Stiver et al. 2006).

SAGEBRUSH HABITAT DIVERSITY

PHOTO CREDIT: ELIZABETH MATERNA, USFWS

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DISCLAIMERS

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Additionally, the findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife Service or other Department of Interior agencies.

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